

abstract book



SETAC North America 28th Annual Meeting
11-15 November 2007

Society of Environmental Toxicology and Chemistry

28th Annual Meeting in North America

Urban Environmental Issues: Impacts on Ecological Systems

11–15 November 2007 • Midwest Airlines Center, Milwaukee, Wisconsin, USA



Abstract Book

SETAC North America 28th Annual Meeting

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This book is comprised of the abstracts of the presentations for the platform, interactive platform, and poster sessions of the 28th Annual Meeting in North America of the Society of Environmental Toxicology and Chemistry (SETAC), held at the Midwest Airlines Center, Milwaukee, Wisconsin, 11–15 November 2007. The abstracts are reproduced as accepted by the Scientific Program Committee and appear in numerical order. In each abstract, the Presenting Author's name is underlined.

This book contains an Author Index that cross-references the corresponding abstract numbers. A Session Index to all the presentations is also included.

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The Society of Environmental Toxicology and Chemistry (SETAC), with offices currently in North America and Europe, is a nonprofit, professional society established to provide a forum for individuals and institutions engaged in the study of environmental problems, management and regulation of natural resources, education, research and development, and manufacturing and distribution.

Specific goals of the society are:

- Promote research, education, and training in the environmental sciences.
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- Participate in the scientific interpretation of issues concerned with hazard assessment and risk analysis.
- Support the development of ecologically acceptable practices and principles.
- Provide a forum (meetings and publications) for communication among professionals in government, business, academia, and other segments of society involved in the use, protection, and management of our environment.

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1 New territory: Toxicity test methods to assess contaminated boreal forest soil. L. Van der Vliet, R. Scroggins, J. Princz, Biological Methods Division, Environment Canada, Ottawa, Ontario, CANADA; M. Moody, Saskatchewan Research Council, Saskatoon, Saskatchewan, CANADA. Boreal forested and northern regions account for over 50% of Canada's land mass, yet there are currently no standardized soil toxicity test methods suitable for the assessment of contaminants in forest soils. This has been recognized as a significant data gap, given the number of resource-related industries operating within these regions (e.g., petroleum, mining and forestry). To address this need, Environment Canada, together with the Saskatchewan Research Council, has been working towards the development of a suite of applicable terrestrial toxicity test methods. Our approach to the development of boreal forest-specific test methods focuses on two aspects: (i) use of ecologically-relevant species, and (ii) modification of the soil testing system to mimic the boreal forest environment. The groups of organisms that we are currently working with are boreal forest plants, mites, springtails and earthworms. Most invertebrate species were field-collected at different sites across Canada. We are researching the optimum culturing conditions for these species in the lab, but in some cases, sustaining populations of these organisms in the lab may not be feasible. Where lab cultures have been established, preliminary testing with field-collected site soil has begun. Unlike agricultural (tilled) soil, the distinct and separate layers of forest soil are vital to understanding and differentiating the biological activity in this ecosystem. A key component of the site soil collection was maintaining the different layers of forest soil through collection by horizon. Individual layers were separately mixed in the lab, and then re-assembled inside the test units in proportions that mimic those found in the field. To date, site soils tested include reference ("clean") forest soils collected in Saskatchewan, reference soils collected in Alberta, and hydrocarbon- and salt-impacted soils collected in Alberta. For invertebrates, the biological endpoints investigated have focused on reproduction and adult survival. The data collected from preliminary experiments can be used to determine: (i) "baseline" reproduction in uncontaminated soil, (ii) if these new test organisms are sensitive to the contaminants present, and (iii) how their sensitivity compares with standard test species.

2 Biological Testing of Soil using Boreal Forest Plants. M. Moody, Sask. Research Council, Saskatoon, Saskatchewan, Canada; J. Princz, R. Scroggins, Biological Methods Division, Environment Canada, Ottawa, Ontario, Canada. In 2003, the need for toxicity tests using boreal forest species was recognized as a priority for Environment Canada; in response to this initiative, the Saskatchewan Research Council has been directly involved with the development of standardized toxicity tests using six boreal forest plant species. Initial test method development involved the selection of ecologically-relevant plant species, followed by an assessment of plant growth in a variety of reference forest soils, including sensitivity towards to boric acid, a standard reference toxicant, and metal and petroleum hydrocarbon (PHC) contaminated forest soils. Further development has included an investigation of the pH tolerance of the test species, in addition to the use of these new tests in the assessment of field-collected weathered PHC and brine-impacted soils using bulk-collected soils and intact soil cores. The soils were collected in impacted areas in northern Alberta, and of which the test data derived from these soils and forest plant species are presented. The intact soil cores were collected to provide a comparison in plant growth relative to traditional soil dilution tests using the bulk-collected soils. To assess the performance of the test species in a control or reference soil, intact soil cores were also collected from two reference locations in Saskatchewan. Trembling aspen, goldenrod and white spruce growth was investigated by planting 1 or 2 seeds in the upper 3 mm of the soil and incubating them under standard test conditions for the same duration as toxicity tests using the bulk-collected soils. The pH tolerance of the six boreal plant species was investigated at pH 4 to 7 in a standard formulated artificial soil. The observed inhibited growth of trembling aspen, goldenrod and black spruce at low soil pH is contrasted with the observed stimulation of jack pine growth at pH extremes. At least two seed sources from across Canada for each of the plant species were also investigated to identify significant variations in germination, emergence and growth that could potentially affect test measurements and data interpretation. Two seed sources that performed similarly were obtained for five of the six species.

3 The use of the soil nematodes, *Caenorhabditis elegans*, for soil toxicity testing. P.L. Williams, College of Public health, University of Georgia, Athens, GA. Free-living soil nematodes are abundant soil organisms that feed on bacteria and other microbes within the soil matrix and play

significant roles in nutrient cycling and dynamics. Their important ecological functions make them ideal fauna for toxicity testing. Our laboratory has used several nematode species but principally works with *Caenorhabditis elegans*. This species has been thoroughly studied and is easy to culture. It reproduces in high numbers with a short life cycle and requires small amount of soil for testing (*C. elegans* have used lethality as an endpoint, we are developing methods for assessing sub-lethal effects from chemical contaminants in the soil. These endpoints include behavior and fluorescence detection with transgenic strains containing GFP. In addition to sensitivity, another advantage of using sub-lethal endpoints is that they do not require the tedious counting of individual organisms or the difficult approach of obtaining high recovery percentages from the soil exposure matrix. The current status of the development of these new approaches, along with advantages and limitations, will be presented.

4 Review of toxicological endpoints for arbuscular mycorrhizal fungi in culture and soil columns. D. G. Hillis, P. K. Sibley, K. R. Solomon, Department of Environmental Biology, University of Guelph, Guelph, ON, Canada; P. Antunes, J. N. Klironomos, Department of Integrative Biology, University of Guelph, Guelph, ON, Canada. Most plants, including the majority of crop species, form a beneficial symbiosis with arbuscular mycorrhizal fungi (AMF), which improves plant nutrient uptake, tolerance to drought, pathogenic and toxic stressors as well as improved seedling establishment and soil stability. A suite of pharmaceuticals have been screened for toxicological effects on the AMF, *Glomus intraradices*, using a *Daucus carota* root organ culture bioassay. A few compounds elicited fungicidal effects at concentrations well below the concentration needed to produce phytotoxic responses in culture. One such compound was the bacteriostatic antimicrobial compound, doxycycline, which was selected for soil column experiments. As anticipated, the soil column experiment did not produce a phytotoxic response in *Daucus carota* at soil concentrations up to 10 000 µg/kg. Both functional and structural mycorrhizal endpoints are currently being evaluated from the soil column experiment. As the use of mycorrhiza in ecological risk assessment is still within its infancy, a review of AMF toxicological endpoints will be evaluated. This review will be based on the experimental results and will evaluate which endpoints are most sensitive and whether functional endpoints can be predicted based on structural responses or vice versa. The temporal requirements to efficiently but accurately evaluate AMF in culture and columns will be discussed. Extrapolation between culture and whole plant systems as well as an exploration as to whether mycotoxic responses in AMF may change based on the associated plant species will also be discussed.

5 Should we avoid the use of Avoidance tests in site specific risk assessment? T.M. Natal da Luz, S. Chelinho, J.C. Niemeyer, J.P. Sousa, Zoology of Coimbra University, IMAR, Coimbra, Portugal; X. Domene, Universitat Autònoma de Barcelona, CREA, Barcelona, Spain; J.C. Niemeyer, Universidade Federal da Bahia, UFBA, Bahia, Brazil; J. Römbke, ECT Oekotoxikologie GmbH, Flörsheim, Germany. Avoidance tests with *Eisenia andrei* and *Folsomia candida* are being commonly used as screening tools in lower tiers of site specific risk assessment schemes. Avoidance is a sensitive and ecologically relevant response. Moreover, tests are conducted over 24 or 48h and are extremely cheap. Together with the existence of ISO guidelines (one ready as final draft and another under discussion), they are appealing tools to be used during the screening phase. However, when the avoidance tests are used with site contaminated soils, in spite of the contaminant presence, the avoidance behaviour of the test organisms can be influenced by soil properties (i.e., confounding factors like organic matter content and texture). This can be problematic particularly when using a reference soil (either an artificial or site soil) with different properties of the test soils. Therefore, an evaluation of the feasibility and usefulness of this type of bioassays in site specific assessment and an optimization process in order to allow their application in ecological risk assessment of particular sites are needed. In this contribution we present the advances achieved with the development and optimization of avoidance tests with these two test species, in particular the evaluation of the influence of several confounding factors in conditioning the avoidance response. With this purpose, several avoidance tests were performed: (i) with 9 artificial manipulated soils to evaluate the influence of texture and organic matter content in the avoidance behaviour, and (ii) with a gradient of reference natural Mediterranean soils to evaluate the influence of natural soil properties in the avoidance response. Results showed that earthworms are more sensitive to soil properties than collembolans, and

Generalized Linear Models derived for each species showed that organic matter and texture variables are most important in defining the avoidance response. These models were then used to rule out the influence of these confounding factors in a real case scenario (a site ERA in the tropics), and to focus on the portion of the response explained by the contaminants. Based on this approach, hints on how to analyze, interpret and integrate avoidance data in ERA schemes are given.

6 Toxicokinetics of Cadmium or Hexachlorobenzene in Potworms: Preliminary Results of an International Bioaccumulation Ring Test for Terrestrial Oligochaetes.

R.G. Kuperman, Environmental Toxicology, U.S. Army Edgewood Chemical Biological Center, Aberdeen Proving Ground, MD; P. Egeler, D. Gilberg, T. Moser, J. Römbke, ECT Oekotoxikologie GmbH, Flörsheim am Main, Germany; T. Natal da Luz, S. Chelinho, J. Sousa, IMAR-Centro do Mar e Ambiente, Universidade de Coimbra, Coimbra, Portugal; M. Amorim, Centre for Environmental and Marine Studies, Universidade de Aveiro, Aveiro, Portugal. An international ring test was performed to standardize and validate a method for the assessment of bioaccumulation of chemicals in terrestrial oligochaetes from spiked artificial and natural soils. Fourteen laboratories from seven countries contributed to this international effort. Enchytraeids (potworms; *Enchytraeus albidus*, *E. crypticus*) were used to determine bioaccumulation kinetics of cadmium as the chloride salt, or ^{14}C -labelled hexachlorobenzene, each used as model substances. Kinetics and biota-soil accumulation factors were determined by nonlinear regression analyses. Preliminary results from tests with potworms showed that soil properties can affect uptake of chemicals by potworms from spiked soils, and that bioaccumulation kinetics can be consistently assessed using this standardized methodology. The project was funded by the German Federal Environmental Agency (R&D no. 204 67 458).

7 Use of different tools for effect assessment in *Enchytraeus albidus* (Oligochaeta): Newly developed microarray, stress biomarkers and traditional toxicity tests.

M.J. Amorim, C.F. Howcroft, A. Soares, Biology, CESAM & Dpt. Biology, Centre for Environmental and Marine Studies, University of Aveiro, 3810-193 Aveiro, Aveiro, Portugal; C. Gravato, L. Guilhermino, University of Porto, CIMAR-LA/CIMAR & ICBAS - Centro Interdisciplinar de Investigação Marinha e Ambiental, ICBAS - Instituto de Ciências Biomédicas de Abel Salazar, Porto, Portugal; W. De Coen, Department of Biology - E.B.T., University of Antwerp, Groenenborgerlaan 171 - U7, B-2020 Antwerp, Antwerp, Belgium; J. Römbke, ECT Oekotoxikologie GmbH, Flörsheim, Germany. Traditionally, in soil Environmental Risk Assessment (ERA), several biological tests are commonly performed, e.g. the standardized protocol with *Enchytraeus albidus* (ISO No 16387, 2003; OECD 202, 2004), providing information about effects induced at individual and population levels. However, so far very little is known about the effects induced by different toxicants on these organisms at the molecular level. In the present study, *E. albidus* was exposed during 48h to different stress conditions (toxic substances: Cu, phenmedipham and different OECD artificial soil types) to discriminate stress of unfavourable soil properties from toxic stress from chemicals. The following tools were used for this purpose: (1) microarray analysis, (2) biomarkers and traditional endpoints, such as (3) population effects: avoidance, survival and reproduction. Recently a DNA microarray (1) was developed for this test species, based on a normalised cDNA library. Effects were studied at the mRNA level to derive stress markers. Hybridization revealed downregulation of several genes of interest with homology to known sequences and a distinction between soil stress and chemical stress. Genes affected by chemical stress were mainly related to oxidative stress, response to infection and behavioural changes. The effects on the anti-oxidant system were also studied by analysing the following biomarkers (2) in the whole body of *E. albidus*: lipid peroxidation (LPO), total glutathione (TG), and superoxide dismutase (SOD), catalase (CAT), glutathione reductase (GR), glutathione peroxidase (GPx) and glutathione S-transferase (GST) activities. Different soil properties influenced the analysed biomarkers: TG was significantly decreased at low pH; GPx was significantly increased at low organic matter content; LPO was significantly increased at higher clay content. Phenmedipham induced a slight TG decrease and GPx increase. Copper induced significant increases in enzymatic antioxidants, such as CAT, GPx and GR.

8 Assessment of Contaminant Bioavailability and Environmental Quality of Soils using a Multi-Marker Approach. P. Robidoux, V. Bérubé, G.I. Sunahara, Biotechnology Research Institute, National Research Council Canada, Montreal, Quebec, Canada. Simultaneous contamination of soil

by various substances (contaminant mixtures) presents a challenge for risk assessment. Chemistry analyses give the level and type of contaminants. Toxicity tests assess the effects of bioavailable compounds to selected species using standard important endpoints (survival, growth, fertility). However, conventional toxicity tests give limited toxicological information and do not consider variability (e.g., temperature, humidity) of current and future field conditions. Improvement of standard assays by adding alternative biological endpoints (cellular, biochemical, molecular biomarkers) can help to understand the toxicity observed and give the appropriate information for the selection of biological parameters for other tier assessment levels (e.g., field mesocosm assays, field studies) where standard chronic endpoints can not be used. Use of selected biomarkers alone gives appropriate information on chemical stress, range and class of contaminants, and health status. This paper presents case studies, advantages and limitations of an integrated approach including earthworm toxicity tests and a suite of biomarkers and chemical analyses. Parameters such as lysosomal membrane fragility of cœlomocytes (neutral red retention time) can be used to assess the chemical stress whereas the antioxidant system (catalase and superoxide dismutase activity) and detoxification metabolism (glutathione S-transferase activity, metallothionein), as well as the immune activity and the contaminant uptake are used to assess the bioavailability of contaminants and the health status of the exposed organisms.

9 Biomarkers - Then, Now, and the Future. P.V. Hodson, School of Environmental Studies, Queen's University, Kingston, Ontario, Canada.

The concepts, approaches, and tools for assessing ecological effects of pollution have evolved from simplistic models of the 1960's to complex programs of environmental effects monitoring. Early studies of biomarkers were based on clinical tests, assuming they would diagnose chemical stresses, their potential cause, and their ecological effects. Current approaches are much more realistic, combining assays of chemical exposure with arrays of bioindicators that range from the molecular to the ecological. Their successful application depends heavily on a detailed knowledge of the mechanisms that link environmental chemistry with modes of toxic action, population biology, and ecosystem function. This includes the recognition of multiple and interacting stressors, and environmental factors that control baseline conditions, natural variability, and chemical fate and effect. Monitoring programs will be most successful when they are an integral part of an overall strategy of environmental management. They should be designed around the risk assessment paradigm and apply the criteria of eco-epidemiology to test associations between cause-and-effect. They are most convincing when they use multiple lines of evidence to strengthen those associations. Most importantly, they must communicate and interpret the results to the public as a basis for rational social and economic decisions. Our future challenges are to link 'omics' to physiological and ecological impacts, to develop approaches for assessing complex mixtures, and to transform research tools into standard methods. In addition to normal environmental variation, we must also cope with shifting baselines due to climate change.

10 The Biomarker Delusion. M. Hanson, Environment and Geography, University of Manitoba, Winnipeg, Manitoba, Canada. Biomarkers are used extensively in ecotoxicology and risk assessment, with little regard as to their utility, validation or actual need. In fact, no biomarker is currently capable of meeting the basic requirements of an "early warning system for imminent effects"; and though they are capable of "implying the presence of a significant pollutant", they do it so poorly that it can be argued they are not worth the effort. To illustrate this point, two of the most common and longest used biomarkers, vitellogenin and acetylcholinesterase, will be critiqued as to their ability to predict future effects or distinguish the presence or absence of a toxicant in field situations. In reality, they are currently incapable of predicting effects at a population, community or ecosystem-level. While they may be used to determine the presence or absence of classes of compounds, they are not indicating specific chemicals or their concentrations in the environment, making their utility highly suspect relative to current analytical techniques. Prior to any investigation that wishes to incorporate biomarkers into the study design, the researchers should ask themselves how the addition of a specific biomarker will improve understanding of the system under investigation, does it actually do what they think it does and how will the biomarker help risk assessment. They might be surprised by the answers they get.

11 Analysis of CYP1A Biomarker Measurements in Fish – Exposure or Effect? J.T. Oris, Department of Zoology, Miami University, Oxford,

OH; A.P. Roberts, Department of Biological Sciences, University of North Texas, Denton, TX. Measuring induction of the CYP1A enzyme system has become a common biomarker of aromatic hydrocarbon exposure in fish, but there has been little systematic analysis of the statistical properties of this biomarker system. Also, there is a need to examine whether CYP1A induction can be used as a bioindicator of deleterious effect in the presence of polycyclic aromatic hydrocarbons. The present study analyzed measurements from 94 peer-reviewed publications in an attempt to examine the statistical characteristics of this biomarker in response to PAH exposure. CYP1A induction measured by catalytic activity, protein levels, and mRNA levels was analyzed. Variance structure, effect size determination, dose-response modeling, and general conclusions about the utility of the CYP1A system as an indicator of exposure or effect were examined. An informal survey asking the question 'What is biologically significant induction of CYP1A in fish?' was conducted with practicing scientists in academia, government, and business. Conclusions from this analysis included: (1) the most appropriate endpoint for cross species and cross study examination was to express response levels relative to control or reference values, (2) relative EROD activity provided the best measure of the level of exposure to aromatic hydrocarbons within specific chemical classes (eg, PAHs), and (3) there was general agreement in the literature and among a group of well-established researchers in this field that CYP1A induction provides a good indicator of exposure to aromatic hydrocarbons but is not currently appropriate as an independent indicator of effect.

12 An Integrated Biomarker Approach for Assessing Chemical Exposure and Effects in Estuarine Fish from NJ Waters. S.M. Bugel, Department of Environmental Sciences, Rutgers University, New Brunswick, NJ; J. Hillegass, Joint Graduate Program in Toxicology, Rutgers University, Piscataway, NJ; A. Akintobi, L.A. White, K.R. Cooper, Department of Biochemistry & Microbiology, Rutgers University, New Brunswick, NJ; G. Buchanan, New Jersey Department of Environmental Protection, Trenton, NJ. The major findings from a field biomonitoring study of approximately 400 Mummichogs (*Fundulus heteroclitus*) and 61 White Perch (*Morone americana*) samples from New Jersey are presented. Mummichogs were collected from Newark Bay, Piles Creek, Union Beach, Sandy Hook and Tuckerton. White Perch were collected from the Passaic River, Hackensack River, Delaware River and Tuckerton. Field sites were selected to represent a contaminant gradient with elevated concentrations in Newark Bay to the reference location at Tuckerton. The studies were designed to examine a suite of biomarkers in these fish and determine which if any correlated with anthropogenic inputs. Complex mixtures of compounds present in the NY-NJ Harbor Estuary may or may not cause pathoneumonic (specific) lesions. Biomarkers investigated including classical toxicological evaluations (histopathology, organ to body weight ratios), biochemical endpoints (CYP1A1, metallothionein, vitellogenin) and chemical analysis (bile fluorescence) for specific polycyclic aromatic hydrocarbons (PAHs). The major findings for CYP1A1, vitellogenin, PAH bile fluorescence and histopathology are presented. These biomarkers were the most reliable for establishing exposure and biological effects. Fluorescence effectively measured and identified compounds in bile. Naphthalene was the most abundant PAH, followed by pyrene and benzo[a]pyrene. More contaminated sites had significantly higher bile PAH loads. For example, in one collection, Newark Bay naphthalene concentrations were two fold higher than the reference site while pyrene and benzo[a]pyrene were 4 and 6 fold higher respectively. There was high variation in CYP1A1 data among and between sites, some of which had a significant increase in CYP1A1 expression. Vitellogenin data showed differences between sites and between genders. Females generally had 30-fold higher induction. Hepatic lesions included extensive trematode damage, bile duct hyperplasia and neoplastic lesions (hepatocarcinomas). Due to the complicated nature of multichemical exposures it is important to use a battery of endpoints when assessing the health of a fish population.

13 Stress Proteins in Fish from Kuwait Bay. M.U. Beg, N. Al-Jandal, K. Beg, S.A. Butt, E. Al-Hassan, M. Al-Husaini, Environmental Sciences Department, Kuwait Institute for Scientific Research, Safat, Kuwait. Heat shock proteins (HSP70) play a significant role in adaptation to temperature and have been proposed as an indicator of cellular stress. Since water temperature in Kuwait's marine area varies from 13° to 35°C from winter to summer HSP70 was determined in gills, liver and muscle tissues of 3 varieties of native fish species captured between October 2004-June 2006 from highly stressed Kuwait bay and outside the bay area. The data revealed some common

effects of location and season on all the three varieties and some effects specific to the type of fish. The fish from outside the bay area, in general, contained comparable levels of HSP70 in liver and gill tissues and the levels in muscle were mostly lower. In winter months, higher HSP70 was found in mullet and sea bream but not in bottom dwelling tonguesole from Kuwait Bay area. The most common response in the three fish species was higher HSP70 levels in winter months that were contrary to our expectation. Inverse relation between HSP70 levels in fish and water temperature obtained in our study may be due to genetic adaptation in fish to hot climatic conditions of this region or higher HSP70 synthesis in winter months in our study may also be a function of other stressors like changes in pollutant levels, oxygen levels, conductivity and salinity of surrounding water. The current study provided broad information about the induction of HSP70 in three varieties of fish under ecologically relevant habitat conditions and seasonal variations exerting influence by mixed pollution and variable thermal stress.

14 Hematologic and Blood chemistry Changes After Induction of vitellogenin in male Rainbow Trout exposed to ethinyl estradiol. S. Hook, I.R. Schultz, Batelle PNWD MSL, Sequim, WA. Vitellogenin is a common biomarker for exposure to estrogenic compounds in male oviparous animals. It has been shown to be a very sensitive indicator of exposure to xenoestrogens, yet has not been conclusively linked to any adverse changes in organism health. In past studies, we used cDNA microarrays to study changes in hepatic gene expression in male trout following exposure to ethinylestradiol. We observed that proteins normally produced in the liver and excreted into blood (such as hemoglobins and blood coagulating agents) were down regulated as vitellogenin was being produced. We hypothesized that induction of vitellogenin in male fish increased the viscosity of the blood, causing a compensatory response that led to down regulation of normal protein constituents. We subsequently tested this hypothesis by exposing male trout to ethinylestradiol, and sampling blood over the same time points that the array data were taken. For each blood draw, total protein content, hematocrit and red blood cell number determined. The changes in blood constituents in male fish exposed to xenoestrogens has important implications for the health of salmonids, which undergo metabolic stress immediately prior to spawning. These fish may become more susceptible to anoxia and injury as the hemoglobin content of the blood is lowered.

15 Brain Biochemistry and Behavior in Bass: The Bigger Picture. K. Gaworecki, N. Ellis, S.J. Klaine, Institute of Environmental Toxicology, Clemson University, Pendleton, SC; A.P. Roberts, Institute of Applied Sciences, University of North Texas, Denton, TX. A variety of biomarkers, including biochemical changes, are currently used to characterize organismal response to contaminant exposure. While biomarker responses have been well correlated with contaminant exposure, their usefulness as indicators of ecological fitness has been questionable. Since organisms' behaviors may provide insight into ecological fitness, it may be beneficial to compare behavioral and biochemical responses to contaminant exposure. A predator-prey behavioral bioassay was developed and used to characterize the effects of aqueous contaminant exposure on hybrid striped bass (*Morone saxatilis* x *M. chrysops*) and their ability to capture prey (*Pimephales promelas*). Bass were either exposed to diazinon, an organophosphate pesticide that inhibits brain acetylcholinesterase activity, or fluoxetine, a selective serotonin reuptake inhibitor that increases serotonin levels at the synapse. The assay consisted of a six-day exposure period followed by a six-day recovery period in 80 L of water. Each bass was exposed in a separate aquarium, fed fathead minnows every third day of the test, and time to prey capture was recorded for each feeding. After each feeding, five bass per treatment were harvested, and brains were extracted for biochemical analyses. Exposed fish exhibited a concentration- and duration-dependent decrease in ability to capture prey. Following a brief recovery period, organisms' ability to capture prey began to improve. Biochemical activities (AChE activity and serotonin levels) also showed similar concentration- and duration-dependent changes. However, significant changes in brain biochemistry occurred prior to any quantifiable behavioral change. These results suggest that biochemical biomarkers, while sensitive indicators of exposure, may not reflect compromised ecological fitness.

16 Ecotoxicogenomic Approaches to Biomarker Discovery in *Daphnia magna*. H.C. Poynton, S. Chan, J. Varshavsky, A. Loguinov, C. Vulpe, Nutri. Sci. and Toxicology, UC Berkeley, Berkeley, CA; A. Kennedy, X. Guan, SpecPro, Vicksburg, MS; J. Steevens, E. Perkins, US Army Engineer Research and Development Center, Vicksburg, MS. The emergence of genomic tools and their integration into ecotoxicology is raising new

possibilities in environmental monitoring and predictive toxicology. In particular, the ability to screen thousands of genes or proteins in a single experiment provides unprecedented opportunities to discover novel biomarkers of exposure and effect. Using a 5000 clone cDNA microarray for the invertebrate indicator species, *Daphnia magna* we have found several candidate biomarkers of exposure to the metals and ordnance related compounds (ORCs). We have confirmed their differential expression over a range of sublethal concentrations using real time PCR. Many of these biomarkers appear to be linked to possible modes of action including effects to digestion, oxidative stress, immune function, and molting. Recent efforts in our laboratory have focused on determining if the gene expression changes seen in the biomarkers lead to whole organism outcomes that can suggest effects to populations. These studies include how chronic metal exposure affects the expression level of the biomarkers and also the physiological responses suggested by the gene expression changes. For example, we are investigating time dependent gene expression changes in immune related genes during Cu exposure and also phenoloxidase activity as a measure of immune system function. The use of ecotoxicogenomic techniques has great potential to reveal new biomarkers that may better link molecular responses to ecological consequences.

17 Monitoring long-term stress in grizzly bears, a new use of protein microarray technology. R.I. Carlson, D.M. Janz, Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; M.R. Cartet, Canadian Co-operative Wildlife Health Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; G.B. Stenhouse, Foothills Model Forest and Alberta Sustainable Resource Development, Hinton, Alberta, Canada. Grizzly bear (*Ursus arctos*) populations in Alberta, Canada, are potentially threatened by human activities, particularly increased access into grizzly bear habitat as a result of resource extraction activities (mining, oil and gas, and forestry), municipal development, and recreation. We hypothesize these activities are causing long-term stress in some grizzly bears. Although short-term stress can be beneficial to animals in coping with immediate stressors such as predator avoidance, long-term stress can have negative effects on an individual's health status, including immune function, reproduction and growth. Our primary research objective is to evaluate effects of landscape structure and change on the health of resident grizzly bears. As one component of our research initiative, we are developing an antibody-based protein microarray to detect long-term stress in grizzly bears. Specifically, the microarray will detect increased or decreased expression of a suite of stress-activated proteins. We are collecting skin and muscle samples from grizzly bears, determining stress protein patterns in these samples, and integrating these results with other health data, such as measures of growth, and immune and reproductive functions to provide an overall health index. After corroboration using field data, this proteomic technique will provide an essential tool for early warning of potential health problems in grizzly bears that may arise as a result of human activities. Further, as this technique is based on evolutionary conserved stress proteins, the microarray may potentially be used to evaluate long-term stress in other wildlife.

18 Considerations in the analysis of 1,2-dibromo-4-(1,2-dibromoethyl)cyclohexane and identification in beluga (*Delphinapterus leucas*) from the Canadian Arctic. G.T. Tomy, K. Pleskach, Department of Fisheries and Oceans, Winnipeg, Manitoba, Canada; G. Arsenault, B. Chittim, R. McCrindle, B. Yeo, Wellington Laboratories Inc., Research Division, Guelph, Ontario, Canada; C.H. Marvin, E. Sverko, Health Canada, Food Research Division, Ottawa, Ontario, Canada; S. Tittlemier, Environment Canada, Burlington, Ontario, Canada. A gas chromatography mass spectrometric (GC/MS) based method for the analysis of 1,2-dibromo-4-(1,2-dibromoethyl)cyclohexane (TBECH), has been developed for the two main diastereomers (α 1 and α 2) present in the technical mixture. Careful selection of GC-capillary column length is critical in resolving the two isomers: a column length of 30m (0.25 μ m film thickness) results in incomplete separation of the two isomers while a 10m column results in baseline separation. While electron capture negative ion (ECNI) MS is more sensitive than electron ionization (EI), no characteristic ions in the ECNI mass spectrum of TBECH was evident, and because the α 1-diastereomer co-eluted with BDE-15 on the short column, more specificity was required. In EI, the dominant ions in the mass spectrum corresponded to a loss of HBr and Br from the molecular ion. The biggest peak in this ion cluster (m/z 266.9) was used for quantitation and the second biggest peak (m/z 264.9) was used for confirmation. Beluga (*Delphinapterus leucas*) extracts of animals from

the Canadian arctic were quantified using low resolution (LR) MS and high resolution (HR) MS run at a resolving power of 10 000 (ions monitored: m/z 266.9908 and 264.9228). The LRMS technique gave numbers that were 1.5 to 2 times greater than that of HRMS measurements suggesting a small interference arising at nominal mass. Observed concentrations as measured by HRMS ranged from 6.5 to 8.7 ng/g (lipid weight).

19 Novel Flame Retardants in Air, Sediment, and Tree Bark from the Great Lakes. R.A. Hites, X. Qiu, M. Venier, Indiana University, Bloomington, IN. Atmospheric samples were collected at five sites on the shores of the Great Lakes: in downtown Chicago, at Sleeping Bear Dunes on the northeastern shore of Lake Michigan, in downtown Cleveland, at Eagle Harbor on the northern-most shore of the upper peninsula of Michigan, and at Sturgeon Point 30 km south of Buffalo. During the period October 2003 to December 2006, the average atmospheric concentrations of total PBDEs were 5 pg per cubic meter (pg/m^3) at the remote site at Eagle Harbor, 7 pg/m^3 at the rural sites at Sturgeon Point and Sleeping Bear Dunes, 70 pg/m^3 in Chicago, and 490 pg/m^3 in Cleveland. Among the PBDEs congener groups, the trend were deca $\approx$ penta > octa. Total PBDEs atmospheric concentrations seem to be related to human population density near the sampling sites. Other flame retardants routinely measured in our samples include 1,2-bis(2,4,6-tribromophenoxy)ethane (TBE), decabromodiphenyl ethane (DBDPE) and Dechlorane Plus (DP, a highly chlorinated flame retardant). Average TBE atmospheric concentrations ranged from 0.09 pg/m^3 at Eagle Harbor to 4 pg/m^3 in Cleveland. The overall average DBDPE concentration at all five sites was 24 pg/m^3 . The atmospheric concentrations of DP were highest at Sturgeon Point, which is near this compound's production site in Niagara Falls, New York. A simple dilution model nicely describes the distribution of DP concentrations in tree bark samples from the northeastern United States and pinpoints DP's source in Niagara Falls. This source seems to have especially contaminated sediment in Lake Ontario; for example, the highest concentration of DP in sediment from Lake Ontario was about 10 times higher than that from Lake Erie and about 50 times higher than that from Lake Michigan. In sediment cores from Lake Ontario, the surficial concentrations were 120, 14, 6.7, and 2.8 ng/g dry weight for DP, BDE-209, TBE, and PBDE(3-7) (tri through hepta-BDEs), respectively. In this case, the concentration of DP far exceeds that of the brominated flame retardants combined.

20 Hexabromocyclododecane Isomers and Degradation Products of Over the Past Two Decades in the Eggs of Herring Gulls (*Larus argentatus*) from Across the Great Lakes. R.J. Letcher, L.T. Gauthier, S. Chu, C.E. Hebert, Environment Canada, National Wildlife Research Centre, Science and Technology Branch, Ottawa, Ontario, Canada. Hexabromocyclododecane (HBCD) is presently a controversial, current-use, high volume production, additive brominated flame retardant, and has been shown to be a global contaminant in abiotic and biotic compartments in the environment. HBCD technical mixtures are comprised mainly of the γ -HBCD isomer ($\sim$ 80%) with lesser proportions of the α - and β -HBCD isomers. Although α -HBCD is the dominant isomer in the tissues of vertebrates studied so far, few studies have examined isomer-specific HBCDs in avian species, and reports in the eggs of top predator avian species are rare. In the present study we examined the spatial and temporal (1982-2006) trends of γ -, α - and β -HBCD patterns and concentrations, as well as possible debromination degradation products, in the eggs of herring gulls (*Larus argentatus*) from seven colonial sites spanning the Laurentian Great Lakes of North America (Agawa Rock, Lake Superior; Gull Island, Lake Michigan; Channel-Shelter Island, Lake Huron; Fighting Island, Detroit River; Niagara River, above the falls; Toronto Harbour, Lake Ontario). In general, γ - and α -HBCD were quantifiable whereas the β -HBCD isomer was low or not detected (<0.01 ng/g ww) in the herring egg samples. For 2004 collections, the sum of the γ - and α -HBCD concentrations ranged from 0 to 4.5% of the sum of the BDE-47, -99 and -100 concentrations. For 2004, the two highest concentrations of α -HBCD in the gull eggs were found at the two most westerly of the Great Lakes sites, Agawa Rock and Gull Island colonies (20 and 12 ng/g ww, respectively). Our findings indicate that mother herring gulls are exposed to HBCD isomers via their diet, there is in ovo transfer to their eggs, ratios among isomer changed over time, and that the HBCD concentration have been increasing at all sites over time.

21 Current levels of the top market demand brominated flame retardants (TBBPA, HBCDs, and PBDEs) in humans and marine predators from the United States. B. Johnson-restrepo, K. Kannan, Environmental Health Science, School of Public Health -State University

of New York, Albany, NY; K. Kannan, Wadsworth Center, New York State Department of Health, Albany, NY; B. Johnson-restrepo, Environmental and Computational Chemistry Group at Department of Chemistry, University of Cartagena, Cartagena, Bolivar, COLOMBIA; D.H. Adams, Cape Canaveral Scientific, Inc., Melbourne Beach, FL. Concentrations of tetrabromobiphenyl A (TBBPA) and α -, β -, and γ - isomers of hexabromocyclododecane (HBCD) were determined by liquid chromatography-tandem mass spectrometry (LC-ESI-MS/MS) in human adipose tissues obtained from New York City, and marine top-level predators - bottlenose dolphin, bull shark, and Atlantic sharpnose shark collected from Florida coasts. The overall mean concentrations (mean $\pm$ SD) of TBBPA and HBCD were 0.0479 ± 0.102 and 0.333 ± 0.571 ng/g lipid wt in human tissues, 1.2 ± 3 and 7.38 ± 18 ng/g lipid wt in bottlenose dolphin blubber, 9.5 ± 12 and 77.7 ± 128 ng/g lipid wt in bull shark muscle, and 0.9 ± 0.5 and 545 ± 88 ng/g lipid wt in Atlantic sharpnose shark muscle. Overall mean concentrations of HBCD were 5-10 fold higher than mean TBBPA concentrations, in all of the samples analyzed. The highest concentrations of TBBPA and HBCD were detected in the bull shark muscle at concentrations of 35.6 and 413 ng/g, lipid wt, respectively. TBBPA and HBCD concentrations were significantly correlated in human adipose tissues and bottlenose dolphin blubber tissues, but not in bull shark muscle tissues. In the human samples, the concentrations of HBCD were 3-4 orders of magnitude lower than the concentrations of polybrominated diphenyl ethers (PBDEs) previously reported for the same set of tissue samples. Concentrations of HBCD in human samples from the U.S. were 1-5 fold lower than the concentrations reported from European countries. HBCD concentrations in bottlenose dolphin from the U.S. were 1-2 orders of magnitude lower than the concentrations reported for other cetacean species from Europe. The present report is the first to determine levels of TBBPA and HBCD in humans, bottlenose dolphins, and sharks from the US.

22 Shift of PBDE mixtures within a coastal bottlenose dolphin population in relation to life history and dietary exposure. J.E. Yordy, A. Guichard, J. Kucklick, NIST, Charleston, SC; J.E. Yordy, Medical University of South Carolina, Charleston, SC; R. Wells, B. Balmer, Chicago Zoological Society, c/o Mote Marine Laboratory, Sarasota, FL; L. Schwacke, Cooperative Center for Marine Animal Health, NOAA, Charleston, SC; T. Rowles, Marine Mammal Health and Stranding Response Program, NMFS, Silver Spring, MD. Bottlenose dolphins (BNDs) are long-lived, piscivorous marine mammals which represent apex predators for many coastal ecosystems. As a result, they are vulnerable to accumulating heavy burdens of persistent organohalogen contaminants (POCs), including current-use flame retardant compounds such as the polybrominated diphenyl ethers (PBDEs). Total concentrations of POCs in marine mammals are strongly influenced by diet, gender, and life history traits (i.e., age and reproductive state); however, less is known about how these parameters impact congener specific patterns and contaminant mixtures. To evaluate the role of life history and diet on PBDE concentrations and mixtures in BNDs, blubber (n=107) and milk samples (n=20), along with 3 known BND prey species of fish (n=45), were collected from Sarasota Bay, FL and were analyzed by GC/MS for 28 PBDE congeners. Total PBDE concentrations in BND blubber ranged from 20 ng/g -1500 ng/g, and no relationships between age or body length and PBDE concentrations (ng/g lipid) were detected. However, for both male and female BNDs, as age/length increased, blubber PBDE patterns shifted to contain a greater proportion of higher brominated congeners. Adult female PBDE patterns appeared to be strongly influenced by the selective offloading of lower brominated PBDEs during lactation as evidenced by both blubber and milk congener patterns. For male BNDs, shifts in PBDE mixtures correlated significantly with body length. As the relative proportion of PBDE 47 declined ($R^2=0.38$; $p<0.001$) with length, the proportions of PBDEs 100, 153 and 154 ($R^2=0.37$, 0.41, 0.24; $p<0.001$) increased. Shifts in PBDE patterns with length in male BNDs may be the result of congener-specific differences in metabolism or biomagnification and the influence of diet on PBDE accumulation in BNDs is currently being explored with the analysis of prey species.

23 Tissue Distribution of Polybrominated Diphenyl Ethers in Freshwater and Seawater Fish. E.Y. Zeng, Y. Guo, X. Meng, H. Tang, State Key Laboratory of Organic Geochemistry, Guangzhou Institute of Geochemistry, Guangzhou, China; Y. Guo, X. Meng, H. Tang, Graduate School, Chinese Academy of Sciences, Beijing, China. Fish tissues from three different fish farming types (freshwater farmed, seawater farmed, and seawater wild fish), including skin, gills, gastrointestinal tract (GIT), liver and muscle,

were analyzed for polybrominated diphenyl ethers (PBDEs). In general, the dry weight based concentrations of $\Sigma 10$ PBDEs (sum of BDE-28, -47, -66, -85, -99, -100, -138, -153, -154, and -183) in fish tissues followed the sequence of liver > gill > skin > GIT and muscle. The BDE congener profiles varied with fish species. For example, seawater fish contained higher abundances of BDE-99 and lower abundances of BDE-28 (relative to $\Sigma 10$ PBDEs). BDE-209 was detected in 37.4% of the total 187 samples, and this ratio may have actually been underestimated because the reporting limit for BDE-209 was considerably higher than those for other congeners. BDE-209 was the dominant BDE congener in skin and GIT, and less abundant in gills, muscle and liver. Except for skin, no significant difference in BDE-209 lipid-normalized concentrations was observed among fish tissues. These results suggest that BDE-209 is highly bioaccumulative in the fish species under investigation, somewhat inconsistent with the results from most previous studies that reported low bioaccumulative potential of BDE-209. This difference may have been partly due to the much higher detection limits for BDE-209, which was not adequately considered in many previous studies. Combined with the likelihood that BDE-209 can be debrominated into lower brominated congeners that tend to be more toxic than BDE-209, the high bioaccumulative potential of BDE-209 could pose prolonged health risk to the ecological environment as BDE-209 is still in use worldwide. Keywords: Polybrominated diphenyl ethers; Fish tissue; Bioaccumulative potential; BDE-209

24 Polybrominated Diphenyl Ethers in Peregrine Falcon (*Falco peregrinus*) Eggs from Northeastern U.S. D. Chen, M.J. LaGuardia, E. Harvey, R.C. Hale, Virginia Institution of Marine Science, Gloucester Point, VA; M. Amaral, U.S. Fish and Wildlife Service, Concord, NH; K. Wohlfort, National Wildlife Federation, Montpelier, VT. Little data have been published on polybrominated diphenyl ethers (PBDEs) in North American birds. Over 100 addled peregrine falcon eggs from nests in Massachusetts, Connecticut, Vermont, New Hampshire and Rhode Island were analyzed for PBDEs. Eggs were obtained from April 1996 to June 2006. BDE-153 and -99 were the dominate congeners in the majority of samples, similar to other recent studies on terrestrial raptor species around the world. However, we also observed significant contributions by hepta (BDE-183), octa (-197 and -196), nona (-207) and deca (-209) congeners. In a few samples, BDE-183 was the dominant congener, with concentrations exceeding 10 mg/kg lipid weight. BDE-197, -196 and -207 were detected in over 75% of total samples, with levels up to 10, 5 and 4 mg/kg, respectively. In addition, three other octa and nona congeners (BDE-201, -203 and -208) were frequently encountered. BDE-209 was detected in more than 60% of samples. Extremely high BDE-209 levels (> 13 mg/kg lipid weight) were found in the eggs collected from one of the most frequently occupied nesting sites in New Hampshire, a cliff in a state park. These results indicated that BDE-209 can be bioaccumulated in terrestrial birds of prey to substantial levels and transferred to eggs. The nona congeners detected may be derived from the metabolism of BDE-209 within the birds or their prey items, or photochemical/microbe-mediated degradation of BDE-209 under specific environmental conditions.

25 Polybrominated diphenyl ethers (PBDEs) in the food chain of the European hedgehog (*Erinaceus europaeus*). E. Vermeulen, H. D'Havé, L. Bervoets, R. Blust, W. De Coen, Biology, Universiteit Antwerpen, Antwerpen, Belgium; N. Van den brink, Alterra, Wageningen, Netherlands; A. Covaci, H. Neels, Toxicological Centre, Universiteit Antwerpen, Antwerpen, Belgium. Polybrominated diphenyl ethers (PBDEs) are commonly used as flame retardants in a variety of polymer resins and plastics. Exposure experiments with lab-grown animals (e.g. rats) showed that PBDEs affect behaviour, liver functioning and the thyroid hormone signalling pathway. However, little is known about the impact of PDBEs on animals in their natural environment, although concentrations measured in the environmental compartments soil and air, and few higher animal species are perturbing. We measured PBDEs in the three-step food chain of two residential park areas situated in the Antwerp region (Belgium). The parks are not exposed to direct contamination with PDBEs. In each park, the concentrations of seven PDBE congeners were assessed in soil and earthworms (prey items) of different habitat types. These concentrations were linked to those observed in hedgehogs (predators), of which the foraging strategy was assessed by GPS tracking. This approach allows us to elucidate the accumulation of PDBE congeners that vary in persistence through the food chain.

26 National Coastal and Estuarine Assessment of PBDEs using Mussels and Oysters. G.G. Lauenstein, K. Kimbrough, J.D. Christensen,

National Centers for Coastal Ocean Science, National Oceanic and Atmospheric Administration, Silver Spring, MD. The National Oceanic and Atmospheric Administration's Mussel Watch Project has quantified persistent organic pollutants in mussels and oysters from around the US since 1986. In 2004, the first national assessment of polybrominated diphenyl ethers (PBDEs) was performed. The analysis of the samples from 2004 represents half of all the sites monitored by the project since the biennial sampling cycle requires two years to complete one national sampling effort. To confirm the findings of the 2004 analyses the same sites were again quantified for PBDEs the next year that the same sites were collected, 2006. To determine historical levels of PBDEs archived samples from 1996, that correspond to the 2004 and 2006 sites were also analyzed. Thirty-eight of the possible 209 congeners were quantified. Detection limits were in the low ng/g (dry weight) range. Deca-PBDE was not quantified. For all congeners, the majority of reported values was below the detection limit. Non-urban areas only infrequently had PBDE concentrations above the detection limit while urban areas frequently had total-PBDE concentrations in the 10-200 ng/g range and one urban area had a total-PBDE concentration over 1000 ng/g, in 2004. Follow-up work is planned for the site with the highest total-PBDE concentrations and for the remainder of Mussel Watch sites not yet characterized for PBDEs.

27 Non-destructive analysis of feathers for trace metals. B. Kaimal, R. Hannigan, Graduate Program in Environmental Sciences, Arkansas State University, Jonesboro, AR. Various methods are used to analyze trace metals in bird feathers. Most of these methods are destructive consuming the entire sample and allowing no replicate analyses or additional analyses for isotopes etc. Trace analysis by ICP-MS or ICP-AES/OES requires digestion of the feather samples which is time consuming, tedious, costly and potentially dangerous. We developed a standard method using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) for detection and quantification of trace elements in feathers. These data will be used to study migratory pathways of birds. LA-ICP-MS requires no sample preparation and the same sample can be used multiple times and for different analytical procedures thus expanding the information one can retrieve from a single feather. This method is extremely useful for studying endangered species or museum samples where the sacrifice of the birds or sampling large quantities of feathers is not possible. LA-ICP-MS analysis of feathers can be used for intelligent data analysis to trace the origins of the animals as with birds through chemical fingerprinting. Trace analysis is based on the premise that the chemistry of the feather will be influenced by the chemistry of the food the birds eat. Thus, the feathers will reflect the chemistry of the environment (soil, climate, water etc.) in which it was grown. LA-ICP-MS can also be used to detect pollutants (e.g., Mercury) in the environment using bird feathers as biomarkers. Here we present the results of a method development study for LA-ICP-MS analysis of feathers. Using a laboratory reference standard comprised of trace element doped keratin trace elements in feathers was quantified. These data were compared to LA-ICP-MS measurements without the use of a matrix matched standard. Our data clearly demonstrate that with the use of the appropriate matrix matched standard LA-ICP-MS provides meaningful trace element concentration in feathers.

28 New Developments in LC/MS/MS, GC/MS, and GC/MS/MS Methods and Sample Preparation Using Solid Phase Extraction for the Analysis of Pesticides and their Degradation Products in Air and Water Samples. R. Raina, M. Etter, L. Sun, P. Hall, Chemistry & Biochemistry, University of Regina, Regina, Saskatchewan, Canada. New developments in LC/MS/MS, GC/MS, and GC/MS/MS methods for the analysis of a range of pesticides in air and water samples will be presented. Pesticides include organochlorines (OCs), organophosphorus pesticides (OPPs), phenoxyacid herbicides, N-methyl carbamates, N-trihalomethylthio fungicides, and other selective pesticides. New LC tandem MS methods for active ingredients and their degradation products such as for OPPs and phenoxyacid herbicides will be presented. A new large volume injection GC method with a cold on-column inlet and negative chemical ionization-mass spectrometry detection for thermally unstable fungicides, and a comparison of selective ion monitoring (SIM) and selective reaction monitoring (SRM) methods with both electron impact and negative chemical ionization for numerous OCs, OPPs, and other selective pesticides will be illustrated. Examples of existing off-line SPE methods for sample preparation/clean-up will be discussed with future direction to on-line SPE methods for both GC and LC applications.

29 Interlaboratory Study of US EPA Draft Method 1668A for PCBs in Natural Waters. J.A. Zimbron, GE Global Research, Niskayuna, NY; D.R.

Blye, Environmental Standards, Valley Forge, PA. US EPA Draft Method 1668A uses high resolution gas chromatography and high resolution mass spectrometry to detect trace concentrations of PCB congeners. Commercial laboratories report Minimum Levels in water as low as 10 picog/L for individual congeners, based on the method-suggested sample volume of 1 L, and 20 µL final extract volume. Surface water quality standards issued by various regulatory agencies are in the low 100s pg/L for total PCBs or lower. Thus, the method is generally not sensitive enough for monitoring total PCB concentrations with respect to the water quality standards. A primary method modification to increase sensitivity has been field collection of large sample volumes (up to thousands of liters of water) into XAD resin for subsequent extraction. An Interlaboratory Study of US EPA Draft Method 1668A for PCBs was conducted using natural waters to estimate measurement error under the following two applications: (a) analysis of grab samples, and (b) analysis of high-volume field sample collected with XAD resin. River water samples were collected from two locations where previously measured PCB concentrations differed by approximately two orders of magnitude (a higher and a lower concentration location). A grab (4 L) sample and a high-volume (~1000 L) sample using XAD were collected from the higher concentration location. A high-volume (~1000 L) sample using XAD was collected from the lower concentration location. Grab samples and extract splits from the high-volume samples (equivalent to ~100 L) were sent in triplicate to three commercial laboratories for PCB analysis using Method 1668A. Laboratory study results for the higher concentration location for both the grab samples and high-volume sample split extracts were significantly different (confidence limit of 95%). Results of the high-volume sample split extracts for the lower concentration location were not significantly different. Laboratory-specific detection limits varied widely among the three laboratories. None of the laboratories met all of the method QA/QC criteria (e.g., chromatographic resolution, extraction standard recoveries, OPR recoveries, etc.). The concentrations of total PCBs in laboratory and field blanks were significant relative to the concentrations in samples and suggest large background PCB sources from sampling equipment and laboratory contamination.

30 Simultaneous analysis of polybrominated diphenyl ethers in biological and environmental samples with gas chromatograph/electron capture detector and ion trap mass spectrometer. D. Wang, Department of Zoology, Fisheries and Illinois Aquaculture Center, Carbondale, IL; D. Wang, Q. Li, Department of Molecular Biosciences and Bioengineering, University of Hawaii at Manoa, Honolulu, HI; S. Atkinson, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks, AK; S. Atkinson, A. Hoover-Miller, Alaska SeaLife Center, Seward, AK; W.L. Shelver, USDA-ARS, Biosciences Research Laboratory, Fargo, ND. The mass range limit of some gas chromatograph/mass spectrometers (GC/MS) prohibits the sensitive analysis of higher brominated diphenyl ethers (BDEs). A gas chromatograph/electron capture detector (GC/ECD) can sensitively determine higher BDEs. In this study, a method that splits GC eluents with a post column splitter into an ECD and ion trap mass spectrometer (ITMS) (1:10, ECD:ITMS) was developed to determine polybrominated diphenyl ethers (PBDEs) in biological and environmental samples. The ion trap temperatures, ionization mode, MS-MS parameters (e.g., excitation amplitude and stability parameter) were optimized for the quantitation of mono- to hepta-BDEs with stable isotopic dilution techniques, while ECD was used for the determination of octa- to deca-BDEs. After accelerated solvent extraction followed by silica gel and alumina column clean-up, average recoveries of PBDEs from spiked sand samples were 52-112% with relative standard deviations (RSDs) of 1-24% and those from spiked lard samples were 44-126% with RSDs of 7-26%. Average recoveries ranged from 51% to 130% for 13C-labeled PBDEs spiked in the real and matrix samples. The method detection limits were congener specific and were 0.18-120 pg/g of the PBDEs in animal tissue samples, and 0.56-17 pg/g in soil and indoor dust samples. Application of the method showed that the concentration of each PBDE congener ranged from not detected (nd) to 24 ng/g in the dry soil sample, nd-759 ng/g in the indoor dust, nd to 15 ng/g wet weight in the Alaskan harbor seal blubber sample, and nd to 16 ng/µL of the 24 identified of 42 total breakdown products from BDE-209 after zerovalent iron treatment for 40 days. Results obtained by this method were comparable to those by GC/high resolution MS. GC/ECD-ITMS coupled with a short column (15 m) has successfully overcome the mass limitation of many GC/ITMSs on the market for the analysis of this emerging class of PBDE pollutants.

31 Large-Volume Injection LC-ESI/MS: Development and Application to Fluorochemicals and Illicit Drugs in Municipal Wastewater. A. Chiaia, J.A. Field, Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR. Large-volume injection (≥ 900 microliters) is a sample concentration technique that, while not new, has received little attention by environmental-analytical chemists. Large-volume injection eliminates the need for off-line pre-concentration techniques as solid-phase extraction (SPE), which is commonly used for the concentration of polar organic chemicals, many of which are emerging contaminants. Direct injection of large volumes (≥ 5 mL) of aqueous samples onto reverse-phase columns is a robust method of sample introduction that results in detection limits at the ng/L level. Changes to existing hardware are needed such as the installation of a 900 microliter analytical head and loop extension and a 900 microliter needle. In addition, a 1,400 microliter seat capillary is installed after the injection point/needle and before the analytical column. In addition, 6 mL autosampler vials are used along with an appropriately-sized sample tray that fits within the autosampler unit. Optimization of the methodology consisted of analysis under pseudo-isocratic conditions in which the mobile phase composition is constant but injection of the large aqueous volume interrupts the isocratic flow. Analytes are focused in this mode but are then 'bumped off' by the mobile phase such that no separation is achieved. To achieve separation and save time with large-volume injections performed under gradient conditions, it is critical to use a 'by-pass' mode, which diverts the solvent away from the injector and its attendant tubing volume. Higher sample withdraw/injection speeds and column flow rates (500 mL/min) also are used to reduce analysis times. To compensate for higher flow rates and to maintain peak shape, the source and desolvation temperatures of the tandem mass spectrometer are increased from 125 to 150 °C and from 250 to 350 °C, respectively, in order to compensate for higher flow rates. Routine analysis of wastewater samples by this methodology requires centrifuging environmental samples at 32,000 rpm for 10 minutes, which is then followed by spiking with appropriate stable-isotope internal standards. Examples of fluorochemicals and illicit drugs analysis with injection volumes from 900 – 2,300 microliter will be shown. In addition, the reproducibility and accuracy of the method will be demonstrated and examples of the application of this methodology will be given.

32 A Fully Validated LC/MS/MS Method for Analysis of Trace Level Fluorotelomer Alcohols. M. Hamilton, B. Surridge, M. Woudneh, D. Hoover, Axys Analytical Services Ltd., Sidney, British Columbia, Canada. Fluorotelomer alcohols (FTAs) are a class of fluorinated organic chemicals used as intermediates in the manufacture of other fluorinated organic chemicals and as finished chemical products. It has recently been reported that FTAs are susceptible to long-range atmospheric transportation to remote regions. Evidence suggests photochemically induced reactions lead to the conversion of FTAs to perfluorinated carboxylic acids. Clearly, reliable validated methods of quantifying FTAs are required to further investigate the behaviour and fate of FTAs. A fully validated LC/MS/MS method for the analysis of FTA homologues 4:2 to 16:2 in water will be reported. Conditions for optimal cleanup and extract enrichment by solid phase extraction (SPE) will be discussed. Calibration solutions are prepared from a commercial perfluoroalkyl alcohol product as well as from individual analytical standards of 6:2, 8:2, and 10:2 telomer alcohols. Isotopically labeled analogues of the 6:2, 8:2, and 10:2 alcohols are used for internal standard quantification of all target compounds. The LC/MS/MS method features acquisition of multiple transitions for each compound for definitive identifications. Method validation data including linear range, precision and method detection limit using EPA protocols will be reported. Application of this method to the analysis of a variety of water samples will be demonstrated.

33 Simultaneous Characterization of Perfluoroalkyl Carboxylate, Sulfonate and Sulfonamide Isomers by Liquid Chromatography-Tandem Mass Spectrometry. J.P. Benskin, M. Bataineh, J.W. Martin, Laboratory Medicine and Pathology, University of Alberta, Edmonton, Alberta, Canada. A comprehensive method was developed to simultaneously separate and detect perfluorinated acid (PFA) and PFA-precursor isomers using liquid chromatography - tandem mass spectrometry (LC-MS/MS). A linear perfluorooctyl (PFO) stationary phase and acidified mobile phase increased separation efficiency, relative to alkyl stationary-phases, for the many perfluoroalkyl carboxylate (PFCA), perfluoroalkyl sulfonate (PFSA), and perfluorooctyl sulfonamide (PFOSA) isomers, and in combination with their distinct MS/MS transitions allowed full resolution of most

isomers in standards. Using the absence of '9-series' and '0-series' product ions, several perfluorooctane sulfonate (C8F17SO3, PFOS) isomers were structurally elucidated. In human serum, only perfluorooctane sulfonamide (C8F17SO2NH2, FOSA) and PFOS consisted of significant quantities of branched isomers, whereas PFCAs were predominantly linear. Interferents that co-elute with the m/z 499/80 transition of PFOS on alkyl stationary phases were simultaneously separated and identified as taurodeoxycholate isomers; removal of which permitted the use of the more sensitive m/z 80 product ion and a resulting 20-fold decrease in PFOS detection limits compared to the m/z 499/99 transition (0.8 pg versus 20 pg using m/z 80 and 99, respectively). Interferences in human serum which cause a 10 to 20-fold over-reporting of perfluorohexane sulfonate (C6F13SO3, PFHxS) on alkyl stationary phases were also simultaneously separated from linear PFHxS and identified as endogenous steroid sulfates. PFOSA isomers, generated with human microsomes, had different rates of metabolism, suggesting that the perfluoroalkyl branching pattern can indeed affect the biological properties of perfluoroalkyl substances. This fact, and for reasons of improved accuracy and sensitivity, investigators are urged to utilize more efficient separation methods capable of isomer characterization in perfluoroalkyl research.

34 Activity-directed analytical tools based on hormone receptor-affinity extraction for isolating dissolved EDCs from complex mixtures. L. Kimberley, L. Ferguson, Chemistry, University of South Carolina, Columbia, SC. Analysis of endocrine-disrupting compounds (EDCs) in natural waters has been challenging due to their structural diversity and typically low concentrations. While there are few common structural characteristics of EDCs, these compounds share a common mechanism of toxic action – deleterious interaction with the endocrine system of exposed organisms (e.g. binding and transactivation or inhibition of nuclear hormone receptor proteins). EDCs typically occur in the presence of a complex mixture of organic contaminants and natural organic matter (e.g. in wastewater). In recent years, sensitive and selective analytical methods based on electrospray mass spectrometry have been developed for identifying and quantifying several important classes of EDCs in the environment, including steroid estrogens and alkylphenol ethoxylate surfactants and their metabolites. However, despite the availability of sensitive analytical methods for determining known EDCs in environmental samples, there remains a need to perform endocrine activity-directed analysis of complex environmental mixtures (such as wastewater) in order to identify the compounds in these mixtures having the highest potential for causing endocrine stress in exposed organisms. Development of such bio-effects directed analytical tools will be necessary in order to realistically define and characterize the suite of EDCs available for exposure in complex mixtures. In addition, there is a need to develop rapid analytical screening tools to assess the presence and concentration of known EDCs in water and wastewater. To address this need, our laboratory is developing novel bioanalytical tools based on immobilized recombinant nuclear hormone receptors for extracting receptor-active compounds from complex wastewater samples prior to mass spectrometric identification and quantitation. To date, we have focused on purification and immobilization of recombinant human estrogen receptor alpha (ER α) on controlled-pore glass beads. These beads are then utilized in receptor-affinity extraction chromatography to purify ER-binding xenoligands from wastewater and sewage-impacted surface water extracts prior to identification and quantitative analysis by HPLC-MS/MS (Q-TOF and triple quadrupole mass spectrometry). Results from these analysis will provide valuable information to assess potential for xenoestrogen exposure in highly complex environmental samples.

35 Analysis of Ethinylestradiol and Its Metabolites in Bioreactors with Nitrifying Bacteria. D.S. Aga, C. Klein, J. Skotnicka-Pitak, Chemistry, University at Buffalo, Buffalo, NY; N. Love, W.O. Khunjar, Civil and Environmental Engineering, Virginia Tech, Blacksburg, VA; W.F. Harper, T. Yi, Civil and Environmental Engineering, Auburn University, Auburn, AL. The fate of 17 α -ethinylestradiol (EE2) during nitrification was investigated using pure culture of *Nitrosomonas europaea*, a representative autotrophic ammonia oxidizing bacterium (AOB). The appearance of biotransformation products were monitored using liquid chromatography with ion-trap mass spectrometry (LC-IT/MS) and with a single quad MS analyzer. Results using radiolabelled standards confirmed that sorption of EE2 onto biomass is an important mechanism that must be considered when describing the fate of EE2 during nitrification. While there is a need for exhaustive extraction to desorb the EE2 from the biosolid, the amount of matrix effect is also considerably increased, which necessitates extensive sample clean-up prior to

LC/MS analysis. Enhanced sorption to predominantly heterotrophic cultures versus ammonia oxidizing cultures was also observed at the concentrations utilized in these experiments. During batch incubation with *N. europaea*, 98% of EE2 was transformed. Three metabolites designated EM1 (*m/z* 340), EM2 (*m/z* 340), and EM3 (*m/z* 385) were detected over 28.5 days of incubation with EM1 and EM2 being generated after 5 days of incubation. EM3 was detected between 8 days and 20 days but was observed to dissipate between day 20 to day 28.5. Both EM1 and EM2 were detected over the entire course of the experiment and were less polar than EE2. On the other hand, EM3 was much more polar than EE2 and appears to be carboxylated. In order to detect these metabolites by LC-IT/MS, derivatization with dansyl chloride was necessary. This limits the method to allow detection only of the metabolites where the phenolic group is conserved. Experiments are underway to elucidate the structures of these novel metabolites using LC/MS with high accurate mass measurements.

36 Challenges in the Derivation of Guidelines for Pesticides in Canadian Surface Waters. M. Demers, E. Sabo, K. Potter, C. Mimeault, Environment Canada, National Guidelines and Standards Office, Gatineau, Quebec, Canada; P. Jiapizian, Science and Technology Programs Coordination, Environment Canada, Gatineau, Quebec, Canada. Canadian Water Quality Guidelines (CWQG) for the protection of aquatic life are meant to protect all forms of aquatic life and all aspects of the aquatic life cycles, including the most sensitive life stage of the most sensitive species over the long term. In order to derive a guideline which is protective of all species over indefinite exposure periods, CWQGs are preferentially based on chronic or long-term toxicity tests. However, as many current use pesticides are designed to be relatively non-persistent, much of the toxicity data available for pesticides is in the form of acute or short-term LC50s. An additional limit to the toxicity data available occurs because a significant portion of toxicity tests are conducted on the formulated products, which may contain a small percentage of active ingredient. Since the identity of the other chemicals in the formulated product is often trade secret information, and monitoring data for pesticides is collected in terms of the active ingredient, we typically accept only the toxicity studies for which the active ingredient constitutes a significant portion of the product tested. This often results in a diminished toxicity dataset which is often smaller than our data requirements to derive a guideline using a species sensitivity distribution curve (SSD). In addition, because several of the modern day pesticides are designed to target specific organisms and pests, the incorporation of SSDs to derive guidelines may result in bimodal distributions (distinct clusters of sensitive and tolerant species) that are not well suited to the SSD method. In the new protocol for CWQGs, we have addressed some of these concerns with the development of short-term or acute guidelines. In addition, we are also exploring several options to address some of the issue described above. This presentation builds some of the current work we have done on pesticides, and will highlight some of the current approaches we are investigating which may help circumvent the above concerns.

37 Evaluation of Time- and Concentration-Dependent Toxic Effect Models for Use in Aquatic Risk Assessments. R.J. Erickson, Mid-Continent Ecology Division, U.S. Environmental Protection Agency, Duluth, MN. Various models have been proposed for describing the time- and concentration-dependence of toxic effects to aquatic organisms, which would improve characterization of risks in natural systems. Selected models were evaluated using results from a study on the lethality of copper to juvenile fathead minnows that examined effects under continuous exposures of various durations and under pulsed exposures. Models were parameterized based on continuous exposure tests, and model assumptions were evaluated based on their goodness-of-fit to these tests. Predictions for pulsed exposure tests were made, and used to further evaluate model assumptions and compare model performance. These evaluations demonstrated good utility of these models, and showed better performance using models with multiple toxicity processes and with a deterministic, rather than a stochastic, approach for differences among individual organisms. For the types of exposures of interest in typical aquatic risk assessments, risk prediction differences among models were small, so that complex models might not be needed. This abstract does not necessarily reflect USEPA policy.

38 BLM Extension to Marine and Freshwater Microalgae Requires Better Mechanistic Understanding of Cellular Detoxification Processes. J. Levy, B. Angel, J. Stauber, Centre for Environmental Contaminants Research, CSIRO Land and Water, Bangor, New South Wales, Australia; J. Levy, B. Angel, D. Jolley, Department of Chemistry, University of Wollongong,

Wollongong, New South Wales, Australia; J. Stauber, Department of Biology and Chemistry, City University, Kowloon, Hong Kong, China. Extension of the Biotic Ligand Model (BLM) to predict chronic toxicity has been hampered by the lack of mechanistic studies on metal uptake, toxicity and detoxification processes, particularly in marine biota. Few studies have investigated metal-cell binding and uptake in marine microalgae, despite their importance as sensitive indicators of environmental change. We have investigated the effect of both biotic and abiotic factors on copper uptake and toxicity to marine algae. Algal sensitivity to copper was not related to taxonomic group, cell size or metal partition coefficients. Copper adsorption and internalisation in three algal species with different sensitivities to copper were further investigated. The diatom *Phaeodactylum tricornutum* was particularly sensitive to copper, with a 72-h IC50 of 8 µg Cu/L, compared to the green algae *Tetraselmis* sp. (72-h IC50 47 µg Cu/L) and *Dunaliella tertiolecta* (72-h IC50 530 µg Cu/L). At these IC50 concentrations, *Tetraselmis* sp. had much higher intracellular copper than *P. tricornutum* and *D. tertiolecta*, suggesting that *Tetraselmis* sp. effectively detoxifies copper within the cell. By contrast, at the same external copper concentration (50 µg/L), *D. tertiolecta* appears to better exclude copper by having slower copper internalisation rates and lower internal copper concentrations at equivalent extracellular concentrations, especially when changes in cell size in response to copper are taken into account. These results suggest that model prediction of copper toxicity to marine biota will require, not just an understanding of water quality parameters and copper-cell binding, but also knowledge of cellular detoxification mechanisms. We also used flow cytometry to monitor the growth rate of *Tetraselmis* sp. in the presence of field-collected marine biofilms. The toxicity of copper was reduced compared to *Tetraselmis* sp. alone.

39 Development of An Algal Component to the USEPA Interspecies Correlation Estimation (ICE) Program. S. Belanger, J. Brill, S. Dyer, D. Versteeg, Central Product Safety, Procter & Gamble, Cincinnati, OH. ICE (Inter-species Correlation Estimation) is a program developed by USEPA to relate acute toxicity of a chemical for one species to that of another. ICE allows the user to input a toxicant effect value for a surrogate species and thus predict the effect value for many other species potentially filling in data gaps for a variety of environmental assessment purposes. Dyer et al. (2006) extended the use of ICE to environmental risk assessment by generating species sensitivity distributions for fish and invertebrates based on such inter-species correlations. The current ICE program is data poor for algae, exposing an analysis gap. To address this need, we have developed an initial ICE for algae. A robust algal database was constructed by collecting phytotoxicity data from publically available databases (USEPA AQUIRE, ECETOC AHA, journal literature etc.) and combining these with internal data from Procter & Gamble. The initial database encompassed over 17,000 records. A hierarchical evaluation scheme resulted in 1400 unique chemicals of wide ranging modes of action and inherent toxicity with 520 species of algae. The most common algae were: Chlorophyta (green algae, 43%) followed by Bacillariophyta (diatoms, 26%) and Cyanophyta (blue-green algae, 20%). The most common green algae in the database include species in the genera *Chlamydomonas*, *Chlorella*, *Dunaliella*, *Psuedokirchneriella*, and *Scenedesmus*. Most common blue-green algae include *Anabaena*, *Anacystis*, *Mycrocystis* and *Nostoc* species and frequenting the diatoms are *Cyclotella*, *Navicula*, *Nitzschia*, *Phaeodactylum* and *Skeletonema* species. Individual studies were subsequently evaluated for robustness using a quality criteria scoring system in order to generate species pair associations per chemical as needed for the ICE assessment. This presentation will summarize the nature of the algal ICE database including an assessment of biological and statistical endpoints, chemical coverage, and initial interspecies relationships. The potential utility in the overall USEPA ICE effort and value for environmental risk assessment will also be discussed.

40 The effects of fluctuating copper exposures on the marine amphipod, *Melita plumulosa*. B.M. Angel, S.L. Simpson, Land and Water, CSIRO, Sydney, New South Wales, Australia; D.F. Jolley, Geoquest, University of Wollongong, Wollongong, New South Wales, Australia. Contaminant concentrations in aquatic systems are seldom constant due to the erratic nature of inputs and environmental processes. Despite this, data from continuous contaminant exposure toxicity tests are used to derive environmental guidelines. The knowledge gap regarding the effects of fluctuating contaminant exposure currently impedes the development of guidelines that better conveys this variability in exposure. This study investigated the effects of variable dissolved copper exposures on mortality in the juvenile estuarine amphipod, *Melita plumulosa*. The effects of single copper

pulse concentrations and durations were studied, plus for multiple pulses, the effect of pulse frequency and interval between pulses. The results were used to derive effects thresholds, understand latency of effects, and possible recovery from copper exposures. In 10-day tests, amphipod mortality generally increased in response to increasing pulse concentration and duration, although not in a proportional manner. For single pulses of copper an exponential relationship was observed between exposure concentration and the duration of copper exposure required to cause significant toxicity. For all copper exposures, latency of effects (delayed mortality) was observed for 3-6 d post-exposure. The amphipods did not exhibit differences in mortality when exposed to multiple 24 h copper pulses with recovery intervals of 0-144 h between them, indicating irreversible toxicity. For exposures with the same time-averaged copper concentration (load), less frequent pulses with longer exposure durations elicited greater mortality than more frequent pulses with shorter exposure durations. Severe mortality occurred for single and multiple 24-48 h pulses with concentrations approximately double the 10-day LC50 of 150 µg/L (for continuous exposure), and there was no significant difference in the amphipod mortality when the exposure was 1, 2 or 3 of these pulses. This may indicate that the majority of the toxic effects are elicited by the initial exposure (pulse), or that sensitive organisms were removed by exposure to the initial pulse. This study demonstrates that the response of *Melita plumulosa* to copper pulses is not linear, with mortality dependent on the exposure concentration and duration, and frequency for multiple pulses.

41 Acute Toxicity of Herbicide Mixtures to *Ceriodaphnia dubia* and *Pimephales promelas*. V.L. Tatum, NCASI, Newberry, FL; D.L. Borton, W.R. Streblow, NCASI, New Bern, NC; J.P. Shepard, Mississippi State University, Starkeville, MS. Herbicides may be applied in forest ecosystems for a variety of reasons, including control of invasive plants, habitat enhancement, and control of competing vegetation in managed timberlands. Many modern herbicides are selective in their actions, so are sometimes applied as mixtures to achieve control of multiple plant species. Although forest herbicides are applied to terrestrial ecosystems and require buffer zones around bodies of water, in some forest landscapes, small wetlands or streams are not required to be protected by buffers and may be difficult to see and avoid. Thus, the potential toxicity of herbicide mixtures to fish and aquatic invertebrates is of interest, and although the toxicity of individual herbicides is generally well-studied, there is less information on toxicity of herbicide mixtures to these organisms. In this study, we determined the acute toxicity of 23 different commonly used herbicide mixtures to *Ceriodaphnia dubia* and fathead minnows (*Pimephales promelas*), and characterized the mixture interactions using Marking's Additive Index. Mixtures were prepared that contained the estimated environmental concentrations (EECs) in water bodies based on the conservative assumptions that (1) the mixture would be applied at the label's maximum allowable rate for each component; (2) the mixture would be applied directly to the surface of a 6-inch deep pond; and (3) there would be no dissipation of mixture components following application. Under the conditions of this study, the herbicide formulations Accord Concentrate (glyphosate), Arsenal AC (imazapyr), Chopper (imazapyr), Escort (metsulfuron methyl), Oust XP (sulfometuron), and Velpar L (hexazinone) were not associated with appreciable acute toxicity to fathead minnows or *C. dubia* when used alone or in mixtures with each other and various surfactants and adjuvants. Herbicides mixtures for which Additive Indexes could be calculated exhibited primarily antagonistic or simple additive toxicity. In the few cases where synergistic toxicity was observed, the degree of synergism was slight, never exceeding approximately twice the effect estimated based on additive toxicity. Based on the results of this study, enhanced acute aquatic toxicity due to synergistic mixture effects does not appear to be a significant concern for applications of the herbicide mixtures most commonly used in forestry.

42 Toxicity in embryos and cleutheroembryos of medaka: endpoints and considerations for animal alternatives research. D.E. Hinton, R. Hardman, B. Yuen, S. Kullman, S. Law, D. Howarth, Nicholas School, Duke University, Durham, NC. The remarkable clarity of the embryo medaka (*Oryzias latipes*) is highly suited for detailed and rapid analysis of abnormal development caused by exposure to a variety of compounds. Using the newly developed, see-through medaka, with all four pigment alleles in the recessive form, the clarity of embryos is extended through all subsequent life stages. Precise and detailed imaging of development, response to toxic agents, and follow up alterations occurring in serial, non-invasive imaging of later life stages are all possible using this model system. The duration of

the cleutheroembryonic stage of development is precisely determined using non-invasive, in vivo analysis. We shall present detailed imaging of control and exposed embryos and review embryonic/cleutheroembryonic toxic endpoints for use in tests of these non-protected life stages. The strengths and challenges of such an animal alternative approach will be covered in detail including a consideration of the species currently under use internationally.

44 Phytotoxicity of leaf leachates on the aquatic macrophyte *Lemna minor*. S. Kamara, S. Pflugmacher, Inland fisheries - Biochemical regulation, Leibniz Institute of Freshwater Ecology and Inland Fisheries, Berlin, Berlin, Germany. Natural (e.g. senescence) and anthropogenic (land clearing for cultivation or construction) activities often lead to deposition of leaf litter into proximate aquatic bodies. They then decompose and release substances that interact with aquatic biota. The *Lemna* Growth Inhibition Test (OECD 221 draft guidelines) is the most standardized bioassay used for ecotoxicological testing of chemicals. They are particularly useful as an alternative to the standard Algal Inhibition Test (OECD 201) when testing coloured leaf leachates as light absorption does not affect growth of floating *Lemna* colonies. Aim of this study was to investigate the potential toxicity of oak (*Quercus robur*) and reed (*Phragmites australis*) leachates on the growth, photosynthesis and pigment system of *Lemna minor*. Different dissolved organic carbon (DOC) concentrations were used to conduct biotests according to the OECD 221 guidelines. We present evidence that during decay, allelochemicals are released that could interfere with photosynthesis and hence inhibit growth rate of macrophytes. The effects from reed at the highest tested DOC concentration was even stronger than that of oak extracts, which are known for their high tannin and phenolic contents.

45 Use of TIE concepts to identify the dietary toxicity of metals in marine sediments. T. Micevska, S. Simpson, Centre for Environmental Contaminants Research, CSIRO, Bangor, New South Wales, Australia; T. Micevska, W. Maher, Division of Health, Design and Science, University of Canberra, Canberra, Australian Capital Territory, Australia. Toxicity is often observed in sediments containing a number of contaminants. Although it is often suspected that metals are not the causal agents, proof of their non-toxicity is required. Through the use of toxicity identification and evaluation (TIE), sediment associated toxicants can potentially be identified. This paper demonstrates the efficacy of TIEs for sediments containing different metal loads and metal speciation using the acute survival of estuarine amphipods *Melita plumulosa*. TIEs were used to identify toxicants in four grossly metal-contaminated and toxic marine sediments (A-D). Consistent with toxicity from metals, TIE manipulations using the metal chelating resin SIR300 were significantly more effective at reducing toxicity than XAD-4 and zeolite which, bind organics and ammonia, respectively. Amphipod survival was 0±0 and 50±4%, respectively, for sediments A and B that contained high metal loads (140, 2450, 590 and 220, 3830, 850 mg/kg Cu, Zn, Pb, respectively) and high dissolved zinc concentrations (10.9 and 0.41 mg/L). The addition of SIR300 to sediments A and B increased amphipod survival to 83±10 and 81±3%. Increased survival was demonstrated to be due to lower dissolved zinc concentrations (<0.06 mg/L) measured in the overlying and pore water. For sediments C and D that contained 570 and 1500 mg Cu/kg, and measurable dissolved copper concentrations (0.02 and 0.05 mg/L), amphipod survival was 12±2 and 0±0%, respectively. The addition of SIR300 resulted in dissolved copper concentrations below water-only effect thresholds for the amphipod however, toxicity was only partially ameliorated (48±8% and 18±6% survival). The addition of food to sediment C increased survival to 35±7%, despite resulting in slightly greater dissolved copper concentrations. The reduction in toxicity achieved is due, in part, to the amphipods feeding on the added food, but the absence of significant dissolved copper suggests that residual toxicity may be from ingestion of copper-contaminated sediment. New TIE manipulations were developed to isolate the effects from dietary exposure involving combinations of feeding, sediment-organism isolation, and selective placement of SIR300. These new techniques are demonstrated to be useful for delineating toxicity occurring from aqueous and dietary exposure of metals in sediments.

46 Developing Robust Sediment Guidelines for Copper. D. Strom, S. Simpson, Centre for Environmental Contaminants Research, CSIRO Land and Water, Sydney, New South Wales, Australia; D. Strom, D. Jolley, Department of Chemistry, University of Wollongong, Wollongong, New South Wales, Australia. An absence of toxicity is frequently observed in sediments with metal concentrations many times greater than the Sediment Quality Guidelines (SQGs). To improve SQGs, a mechanistic understanding

of the relationship between sediment properties (e.g. particle size, acid-volatile sulfides, organic carbon, pH) and metal-exposure pathways (dissolved metal uptake and particle ingestion) is required for a range of benthic organisms. This study presents the results of the 10-day acute toxicity of copper to an amphipod, *Melita plumulosa* and bivalve, *Spisula trigonella* for numerous sediments with varying metal-binding properties. For sediments with measured dissolved copper concentrations (overlying waters and pore waters) below the water-only effects threshold, concentration-response relationships based on particulate copper concentrations implied that the majority of toxicity to the amphipod occurs through ingestion of copper-contaminated sediment. The EC50 of *M. plumulosa* varied over two orders of magnitude, ranging between 200 and 20000 mg/kg for sediments with a low (non-sulfidic and sandy) to very high (sulfide minerals) copper binding affinity. Although similar patterns of toxicity were observed for *S. trigonella* across the varying sediment types, dissolved copper was identified as the primary exposure route. Concentration-response relationships for *M. plumulosa* based on particulate copper in the $<63 \mu\text{m}$ fraction of the sediment resulted in a narrowed range of EC50s, ca. 600-800 mg/kg for all low sulfide sediment-types tested, improving the range by a factor of five. Sulfide and organic carbon in sediments were demonstrated to ameliorate the effects of dietary toxicity to *M. plumulosa* up to 2000 mg/kg. However, at greater particulate copper concentrations, dissolved copper released from copper-sulfide oxidation and copper saturated organic carbon resulted in toxicity for both the amphipod and bivalve. Sediment pH had a minor effect on dissolved copper toxicity. These results, and the importance of characterising exposure pathways, are discussed in the light of developing more appropriate SQGs.

47 Significance of metal storage by prey and digestive solubilization in predators to metal trophic transfer in coastal environments. W.G. Wallace, Biology, CUNY/College of Staten Island, New York, NY; W.G. Wallace, D. Goto, Program in Biology, CUNY/Graduate School, New York, NY. Urban estuarine and coastal ecosystems in the New York/New Jersey Harbor Estuary (NY/NJ-HE) are chronically exposed to various potentially toxic metals due to human activities. In this study, mummichogs (*Fundulus heteroclitus*) were used as a model predator in a typical benthic food chain in NY/NJ-HE to evaluate the importance of two key factors that may influence metal trophic transfer to higher trophic-level predators; 1) prey metal compartmentalization and 2) predator digestive processes. The gut contents of mummichogs from the field were examined to determine typical prey items. *Palaemonetes* spp., *Leptocheirus plumulosus*, *Cyprinodon variegatus*, *Gammarus mucronatus*, *Chironomidae*, and *Nereis virens* were chosen as representative prey to be radiolabeled with Cd-109 and CH3Hg-203. Cytosolic proteins and organelles fractions (collectively trophically available metals – TAM) were isolated from prey to estimate the potentially available portion of metals in prey. Additionally, prey organisms were incubated in vitro with gut fluid extracted from mummichogs to estimate the solubilizable metals in prey. TAM in prey and metals solubilized from prey were compared with metal assimilation efficiencies estimated through feeding experiments. TAMs in most prey organisms were relatively similar for both Cd-109 and CH3Hg-203 (58% – 71%). The solubilizable metals, however, were relatively variable ranging from 65% to 85% for Cd-109, and from 46% to 70% for CH3Hg-203. These results were similar to the CH3Hg-203 assimilated by mummichogs (52% – 89%), while Cd-109 was assimilation was significantly lower (6.2% – 9.3%) than both TAM and solubilizable metals in all prey. These results suggest a highly biologically driven mechanism controlling CH3Hg cycling in coastal environments.

48 Assimilation and subcellular distribution of dietary Cd and Hg by grass shrimp, *Palaemonetes pugio*, collected along an environmental impact gradient. D.R. Seebaugh, W.G. Wallace, Department of Biology, Graduate School and University Center, City University of New York, New York, NY; W.G. Wallace, Department of Biology, College of Staten Island, City University of New York, Staten Island, NY. Chronic exposure to impacted field conditions can lead to population differences in metal accumulation, toxicity and genetic resistance. This study investigated intraspecific variation in the assimilation and subcellular partitioning of dietary Cd and Hg by grass shrimp (*Palaemonetes pugio*) collected along an environmental impact gradient within the New York/New Jersey Harbor Estuary. Grass shrimp were collected from five differentially-impacted salt marshes surrounding Staten Island, New York, pulse-fed radiolabeled (Cd-109 or Hg-203) amphipods (*Gammarus lawrencianus*) and subjected to Cd or Hg assimilation efficiency (AE) analysis. Depuration of Cd by grass shrimp was

characterized by a two-stage loss, with an initial rapid loss of unassimilated Cd from the release of radiolabeled fecal strands. AE-Cd% was estimated as the y-intercept of the linear regression of the physiological loss component of the retention curve (time > 24 h). A gradient in AE-Cd% was observed among grass shrimp from the study sites with values ranging from ~56% to ~78%. AE-Cd% was greater for grass shrimp from collection sites adjacent to a heavily-polluted waterway (the Arthur Kill) than for shrimp from a relatively 'clean' site. Differences in rates of physiological Cd loss were not observed. Following AE analysis, grass shrimp were subjected to subcellular fractionation to determine the percentages of assimilated metal associated with five operationally-defined fractions: heat-stable proteins (HSP - e.g., metallothionein-like proteins), heat-denatured proteins (HDP - e.g., enzymes), organelles (ORG), insoluble components (INS - e.g., metal-rich granules), and cellular debris. These data were used to reconstruct subcellular compartments containing trophically-available metal (TAM-Cd% = HSP% + HDP% + ORG%), metal-sensitive fractions (MSF-Cd% = HDP% + ORG%) and biologically-detoxified metal (BDM-Cd% = HSP% + INS%). Considerable variation in the percentages of assimilated Cd associated with the MSF and BDM compartments resulted from population differences in the partitioning of Cd to HDP and HSP. The fraction of Cd available to predators (TAM-Cd%) was similar for grass shrimp from each population (~65% to ~73%). Data collection for grass shrimp pulse-fed dietary Hg is in progress.

49 Copper accumulation kinetics in aquatic insects. D. Cain, M. Croteau, S. Luoma, USGS, Menlo Park, CA. The development of predictive models of species sensitivity to metals would augment current risk assessment protocols which often have difficulty in clearly identifying the effects of metals from other potential environmental stressors. We are using the biodynamic bioaccumulation model in a comparative context as one means of inferring species-specific differences in metal sensitivity among freshwater aquatic insects, a large and diverse group of taxa that have been applied as monitors of metal exposures and indicators of community-level effects. The biodynamic model quantifies species- and metal-specific influx and efflux in the form of rate constants, and implicitly assumes that metal toxicity ensues when the rate of influx exceeds the rates of metal excretion and detoxification. The recent development of stable isotopes as tracers for the experimental determination of the rate constants used by the model has enabled studies of Cu kinetics, an element that is a principal contaminant in many streams contaminated with mining wastes. Here, we report the first Cu influx rates (derived from aqueous exposures to the stable isotope Cu-65) for three mayfly species. The mayflies, *Nixe* sp., *Rhithrogena* sp. (Heptageniidae), and *Drunella* sp. (Ephemereclidae) were selected for study because of their differences in metal bioaccumulation and metal sensitivity indicated from field and laboratory studies. Rate constants of uptake, k_u (expressed as L/g dry weight/d) varied approximately 6-fold among these species. Uptake was slower in the heptageniid mayflies, *Nixe* sp. ($k_u 4.0 \pm 0.8$) and *Rhithrogena* ($k_u 2.6 \pm 1.2$), than in the ephemereclid, *Drunella* sp. ($k_u 12.1 \pm 1.06$). The rate constant for *Drunella* is particularly high relative to the few other species for which data are available. We discuss these results within the context of implementing the full biodynamic model to infer species sensitivity to Cu exposure.

50 Explaining species-specific differences in Cu accumulation using biodynamics. C.L. Brown, M. Croteau, A. Stewart, S.N. Luoma, U.S. Geological Survey, Menlo Park, CA. Copper concentrations differ significantly among two co-existing bivalve species in the San Francisco Bay/Delta. *Corbula amurensis*, an euryhaline species that tolerates salinities from 1-32 ppt, accumulates lower Cu concentrations ($14 - 34 \mu\text{g g}^{-1}$) than *Corbicula fluminea* ($35 - 195 \mu\text{g g}^{-1}$), a freshwater species that can tolerate salinities up to 14 ppt. We determined whether these species-specific differences in Cu concentrations are due to different exposures (i.e., dissolved Cu concentrations, food source, trophic position), or to physiological differences (i.e., dissolved uptake rates, loss rates, ingestion rates, assimilation efficiencies). Stable nitrogen and carbon isotope data suggest that the two species appear to have different food sources: *C. amurensis* feeds on the flood tide (saline water food source) and *C. fluminea* feeds on the ebb tide (freshwater food source). These differences in diet are likely to explain, in part, species-specific differences in Cu concentrations. We also conducted biodynamic experiments to determine rate constants for Cu uptake and loss. Dissolved uptake rate constant (k_u) for Cu was higher for *C. amurensis* than for *C. fluminea* ($1.76 \text{ L g}^{-1} \text{ d}^{-1}$ vs. $0.224 \text{ L g}^{-1} \text{ d}^{-1}$, resp.). Therefore, species-specific Cu uptake from solution cannot explain the differences in Cu concentrations observed between these two species in the field. The efflux rate constant (k_e) for Cu is

10-times higher in *C. amurensis* than in *C. fluminea* (0.035 d^{-1} vs. 0.004 d^{-1} , resp.). Thus, *C. amurensis* loses Cu at a faster rate than *C. fluminea*, which explains, in part, the lower Cu concentrations in *C. amurensis*. The food ingestion rate of *C. amurensis* is 10-times higher than that of *C. fluminea* ($0.370 \text{ g g}^{-1} \text{ d}^{-1}$ vs. $0.028 \text{ g g}^{-1} \text{ d}^{-1}$, resp.), yet Cu concentrations in *C. amurensis* are lower than those in *C. fluminea*. This suggests that *C. fluminea* feeds on food items more contaminated in Cu than those consumed by *C. amurensis*, or that *C. fluminea* assimilates Cu more efficiently than *C. amurensis*, or both. Rate constants of loss and uptake are crucial factors to consider when explaining species-specific differences in metal concentrations.

51 A biodynamic understanding of dietborne metal uptake by a freshwater invertebrate. M. Croteau, S.N. Luoma, USGS, Menlo Park, CA. Aquatic organisms are exposed to dissolved and particulate metals. Dietborne uptake usually prevails in nature, but the physiological processes governing metal bioaccumulation from diet are not fully understood. Here, we characterize dietary copper, cadmium and nickel uptake by a freshwater gastropod both in terms of biodynamics and membrane transport characteristics. We use enriched stable isotopes to trace newly accumulated metals from diet, determine food ingestion rate (IR) and estimate metal assimilation efficiency (AE). Single tracer exposure elicits metal influx rates comparable to those found upon multi-tracer exposure. Metal influx rate constants from food (kuf) increased in the order of $\text{Ni} \leq \text{Cd} \leq \text{Cu}$. The relatively high kuf for Cu probably reflects the high abundance of Cu binding sites, while the greater affinity of Cd transporters seems to influence kuf more than does the greater number of Ni binding sites. Transporter characteristics vary also widely between exposure routes. For example, Cu binding sites are 10-times more abundant when inferred from dietborne exposures compared to upon waterborne exposures. Although kufs are 1000-times lower than influx rate constants from solution (kuw), biodynamic modeling showed that diet is the major Cd, Cu and Ni source in nature. AE varied slightly among metals and exposure concentrations (84-95%). Food IR was $0.146 \pm 0.018 \text{ g g}^{-1} \text{ d}^{-1}$ for most exposures. Snails exposed to exceedingly high metal concentrations accumulated some ^{53}Cr , an inert tracer assumed to be not bioavailable. This suggests that snails presumably stopped processing the ingested food during depuration. The radical decline in IR upon extreme exposures indicates that feeding inhibition could act as a biologically relevant endpoint for dietary metal toxicity in *Lymnaea stagnalis*.

52 Dominance of dietary intake of metals in marine elasmobranch and teleost fish. N.S. Fisher, T. Mathews, Marine Sciences, Stony Brook University, Stony Brook, NY. Metal accumulation in marine fish is a global public health concern, because the consumption of seafood provides the largest dose of many metals to humans. While water quality criteria rely solely on aqueous exposures of metals to fish in developing safety guidelines, we tested the idea that marine fish obtain an important fraction of their metals from their diet. Using radiotracers of six metals (Am, Cd, Cs, Co, Mn, Zn) differing in biological and geochemical properties, we considered the accumulation of these metals from diet and from the aqueous phase in two marine fish species, the teleost *Psetta maxima* and elasmobranch *Scyliorhinus canicula* in controlled laboratory experiments. We estimated steady state metal concentrations and calculated the relative contributions of dietary and aqueous intake in both species using a predictive bioaccumulation model. For both species >60% and often >90% of Mn, Co, Cd, Zn derives from dietary intake in these species; modest interspecific differences were also noted. In contrast, Am was obtained predominantly from the aqueous phase and Cs varied considerably depending on prey selection. Model predictions of steady state tissue metal concentrations are well within the range of field measurements for these species. Our findings underscore the importance of including dietary exposure in establishing appropriate water quality criteria and in risk assessments for metals in aquatic ecosystems.

53 A Modeling Assessment of Bivalve Cu Accumulation and Effects. P. Paquin, R. Mathew, HydroQual Inc., Mahwah, NJ; R. Dwyer, International Copper Association, New York, NY; M. Salazar, S. Salazar, Applied Biomonitoring, Kirkland, WA; R. Santore, HydroQual Inc., East Syracuse, NY. A bivalve bioaccumulation model that incorporates physicochemical and biochemical features that are unique to metals is being developed. The general framework has been used to simulate uptake of Cu, a highly regulated essential metal, from food and water. It incorporates allometric relationships for several important physiological processes including filtration, growth and dissolved metal uptake rates. The model development effort has made use of a whole body (WB) kinetic model, a physiologically-based pharmacokinetic

(PBPK) model and an intracellular speciation (ICS) model. Collectively, these models provide a basis for simulating metal accumulation at the site of action of toxicity (i.e., at the target organ or target enzyme level). A combination of laboratory and field studies have been used to calibrate the model. The WB model was applied to a composite dataset consisting of caged bivalve (*M. galloprovincialis*) results from several marine settings, including San Diego Bay. The ICS model, which represents intracellular metal binding and detoxification processes, and metal accumulation by a metabolically active fraction, has been calibrated to laboratory test data. The calibrated ICS model is used to predict Cu levels in a high molecular weight (HMW) cytosolic fraction, used as a surrogate for the target biotic ligand (i.e., the site of action of toxicity), under longer-term field conditions. The predicted results are compared to a laboratory-derived dose-response relationship between *Mytilus* survival and Cu in a HMW cytosolic fraction. The analyses that are presented are used, in combination with the field study results, to provide support for an effects assessment for Cu in caged bivalves in San Diego Bay.

54 Designing Small Molecules for Biodegradability. R.S. Boethling, E. Sommer, D. DiFiore, Office of Pollution Prevention and Toxics, US EPA, Washington, DC. Under the Pollution Prevention Act of 1990 it is the policy of the United States that pollution should be prevented or reduced at the source whenever possible. One way to accomplish this is to design safer chemicals. Chemicals that persist in the environment remain available to exert toxic effects and may bioaccumulate. It is shown by means of examples how molecular design for biodegradability has--or might have--avoided unnecessary environmental damage. The examples are alkylbenzene sulfonates, dialkyl quaternaries, chelants/sequestrants, drilling base fluids, vegetable oil-based functional fluids, ionic liquids, antiseptics/disinfectants, musk fragrances, gasoline oxygenates, and alkylphenol ethoxylates. Since microbial degradation is the major loss mechanism for most organic chemicals in soil, water and sewage treatment, biodegradability should be viewed as integral to product design. The relationship between molecular structure and biodegradability is understood well enough to be implemented more broadly in chemical design. Several models and databases, discussed briefly here, are also available and reliable enough to assist. Finally, the analysis illustrates some of the challenges in designing safer chemicals in the real world, where "green" usually comes only in shades of gray and conflicting demands almost always lead to compromise.

55 Designing Environmentally Friendly Industrial Chemicals. J.V. Nabholz, OPPT, EPA, Washington, DC. The Office of Pollution Prevention and Toxics' (OPPT) New Chemical Program (NCP) has advised the chemical industry on designing more environmentally friendly chemicals since the mid-1980s. Under Section Five of the Toxic Substances Control Act (TSCA) the chemical industry is required to notify the Environmental Protection Agency (EPA) of their intent to manufacture and/or import a new chemical into the US 90 days prior to manufacture and/or importation. Since 1979 over 40,000 Pre-Manufacturing Notifications (PMN) have been submitted. The NCP sees everyone's chemicals. Since TSCA does not require pre-notification toxicity testing, the NCP relies on structure activity relationships (SAR) to predict the aquatic toxicity of new chemicals. This requires that chemicals be sorted into SAR chemical classes and/or categories. When a new chemical presents a potential unreasonable risk toward the environment, the notifier of the PMN must manage that potential risk prior to manufacture and/or importation. One management option available to the notifier is to re-design the new chemical so it is either less toxic, less bioaccumulative, and/or less persistent. The NCP has assisted notifiers in re-designing their new chemicals after submission of their PMN based on the NCP's experience in assessing thousands of prior PMNs. In addition, the NCP has offered to assist notifiers in chemical design/re-design prior to notification through the OPPT's Pre-Notice Communication Program (PC). Examples on OPPT's advice on how to design/re-design industrial chemicals to make them more environmentally friendly will be presented for every major class of industrial chemicals including (1) polymers, (2) surfactants, (3) dyes, (4) inorganics, (5) organometallics, (6) organic chemicals with excess toxicity, and (7) neutral organic chemicals or chemicals with baseline toxicity. Major re-design mechanisms will include but not be limited to: (1) molecular weight (MW), (2) effective cross-sectional diameter (CXDe), (3) octanol/water partition coefficient (Kow), (4) melting point, (5) water solubility, (6) acid substitutions, (7) changing molecular charge, eg, cationic to amphoteric, (8) elemental distances between moieties, (9) adding easily degradable moieties,

(10) chelation, (11) strong ion pairs, and (12) mitigation of toxicity by environmental agents, such as, total organic carbon and hardness.

56 The influence of speciation on reactivity of chelating agents: implications for their use and design. B. Nowack, Empa-Materials Science and Technology, St. Gallen, Switzerland. The behavior and the effects of chelating agents in the environment have received considerable attention. Chelating agents belong predominantly to two different groups: the aminopolycarboxylates and the polyphosphonates. These chelating agents are under scrutiny due to their influence on metal availability and mobility and in particular due to their persistence in the environment. This presentation shows that chelating agent adsorption, metal mobilization, reactive transport, photodegradation, chemical degradation and biodegradation are substantially affected by the chelated metal ion. The different reactivities of the metal-complexes have to be considered when assessing the reactions of chelating agents in technical systems and the environment. Knowing the speciation of chelating agents is therefore crucial for predicting their fate. Despite this importance, only a few speciation measurements have been reported and model calculations have been frequently used instead. These calculations are, however, complicated by slow metal-exchange reactions that result in a non-equilibrium speciation and by the presence of naturally occurring ligands that compete with the chelating agents for available metals. The implications of metal speciation for the design of new chelating agents will be discussed.

57 How Safe are Low Toxicity Drilling Fluids? M. Gagnon, Environmental Biology, Curtin University, Perth, Western Australia, Australia. Synthetic-based drilling fluids (SBFs) introduced into the petroleum exploration industry in the 1990s have faster biodegradation rates than previous drilling fluids while preserving technical properties, and therefore presented a pollution prevention opportunity. Another advantage is that SBFs have low acute toxicity. The present study investigated the effects of chronic exposure of *Pagrus auratus*, a marine fish, to SBFs for 28 days in a semi-static system. Fish were exposed to three fluid systems, being ester-based (E), internal olefin-based (IO) and linear alpha-olefin based fluids. Condition factor, liver somatic index, hepatic detoxification (EROD activity), biliary metabolites, DNA damages and stress proteins were determined at the completion of the exposure period, and compared to unexposed fish. While IO induced only biomarkers of exposure (EROD activity, biliary metabolites), LAO induced both biomarker of exposure and of effects (EROD activity and stress proteins). However, E caused biologically significant effects in the condition factor, liver somatic index and DNA damage in addition to trigger biliary metabolites accumulation. The results demonstrate that while the acute toxicity of SBFs might be low, chronic exposure of fish to weathering cutting piles has the potential to affect fish health. While ester-based SBFs have a rapid biodegradation rate in the environment, they caused the most pronounced effects on fish health. The study illustrates the advantages of the case-by-case approach to drilling fluid management adopted in Western Australia, and highlights the importance of considering the receiving environment in the selection of SBF to be discharged onto the seabed.

58 Combining Experiments and Modeling to Evaluate the Toxicity of a Novel Green Chemical to Freshwater Planktonic Communities. K.J. Kulacki, D.T. Chaloner, G.A. Lamberti, Biological Sciences, University of Notre Dame, Notre Dame, IN; R.J. Bernot, Biological Sciences, Murray State University, Murray, KY. Room-temperature ionic liquids (ILs) are non-volatile organic chemicals that are being developed as "greener" replacements for harmful industrial solvents (e.g., benzene). While single-species toxicity tests can reveal the sensitivity of specific organisms to ILs under defined conditions, combining more realistic experiments with meaningful models can increase the applicability of results to natural freshwater communities. In such communities, individual and interactive effects of ILs on producers and consumers are likely to be important. We studied the effects of the IL 1-butyl-3-methylimidazolium Bromide (bmimBr) on: (1) growth rates of the algae *Scenedesmus quadricauda* and *Chlamydomonas reinhardtii*; (2) competition between the two algae; and (3) feeding rates of the cladoceran grazer *Daphnia magna* on both algae. Algal growth rates declined when exposed to ILs, with *S. quadricauda* more sensitive to bmimBr than *C. reinhardtii* (96-h EC50: 4.06 mg/L and 1070 mg/L, respectively). *Daphnia magna* feeding rates increased with higher IL concentrations. We combined these results with data for IL effects on algal carrying capacity and *D. magna* mortality and reproduction to parameterize a model predicting the effects of bmimBr on planktonic communities. This model included competition between the two algae, as well as predation by *D. magna* on both algae. The model showed

that even low concentrations of bmimBr in an aquatic ecosystem could have disproportionate community-level effects, primarily via direct effects on *D. magna* mortality and *S. quadricauda* growth. These results suggest that information is needed concurrently on all major food web components, including sub-lethal and chronic endpoints, in order to accurately predict the impacts of ILs on aquatic communities. By combining results from standard toxicological bioassays and multi-species tests into predictive mathematical models, we gain a powerful tool to further assess the "greenness" of chemicals in complex natural environments.

59 Lethal and sublethal effects of ionic liquids on zebra mussels (*Dreissena polymorpha*). D.M. Costello, G.A. Lamberti, Biological Sciences, University of Notre Dame, Notre Dame, IN; J.L. Larson, Biological Station, University of Oklahoma, Kingston, OK. Ionic liquids (ILs) are non-volatile solvents being designed to replace volatile organic compounds in industrial applications. However, ILs may enter and be retained in aquatic ecosystems, where little is known about their effects. Zebra mussels (*Dreissena polymorpha*) are invasive, ecologically important, bivalves in many lakes and streams and are being used with increasing frequency in toxicological studies. The effects of ILs on zebra mussels were studied using three approaches: (1) 96-hour acute toxicity assays, (2) a short-term feeding assay, and (3) a short-term nutrient release assay. Acute toxicity assays examined three imidazolium-based ILs [1-butyl-, 1-hexyl-, and 1-octyl-3-methylimidazolium bromide (bmimBr, hmimBr, and omimBr, respectively)] and three pyridinium-based ILs [1-butyl-, 1-hexyl-, and 1-octyl-3-methylpyridinium bromide (bpyrBr, hpyrBr, and opyrBr, respectively)]. Alkyl chain length and toxicity were positively related, while the cation base had little effect on toxicity. The IL omimBr was most toxic (LC50 = 21.8 mg/L) and was subsequently used in the feeding and nutrient release assays. The feeding experiment consisted of individual mussels exposed to one of 6 omimBr concentrations and fed cultured green algae. Zebra mussel feeding rates declined with increasing omimBr concentration and approached zero at 10 mg/L (~LC15). In the nutrient release assay, we starved individual mussels for 24 hours and then exposed them to one of 4 omimBr concentrations for 4 hours. Total nitrogen, soluble reactive phosphorus, and dissolved organic carbon were measured before and after IL exposure. As with feeding rate, increased concentrations of omimBr reduced release rates of total nitrogen and phosphorus. Overall, toxicity of ILs is similar to the industrial solvents they are intended to replace. Additionally, this study highlights the importance of considering sub-lethal effects when designing green chemicals.

60 Biodegradable imidazolium derived ionic liquids: Antimicrobial activity and synthetic applications. N. Gathergood, S. Morrissey, D. Coleman, B. Pegot, Chemistry, Dublin City University, Dublin, Ireland; O. Cahill, B. Quilty, D. Ferguson, School of Biotechnology, Dublin City University, Dublin, Ireland; M. Garcia, Surfactant Technology, IIQAB-CSIC, Jordi, Spain; S. Bouquillon, T. Courant, Chemistry, Université de Reims Champagne-Ardenne, Reims, France. Recent studies in Dublin have shown that a series of imidazolium based ionic liquids with low antimicrobial activities has been prepared. The preparation and application of these solvents in selective hydrogenation reactions will be discussed. Biodegradation data for the series of ILs will be presented, with several new ionic liquids classified as 'readily biodegradable'. An example will also be shown of a closely related structure which is a potent biocide.

61 Biodegradable by Design: The Why and the How. T. Federle, Central Product Safety, The Procter & Gamble Company, Cincinnati, OH. Biodegradation combined with other processes (i.e. transport, sorption, volatilization, etc.) control the fate of chemicals released to the environment. Biodegradation reduces a chemical's dispersion, decreases its environmental concentration, results in higher and constant environmental safety factors and prevents accumulation and persistence. This presentation examines the role that biodegradability plays in making a chemical's use safe and sustainable. It reviews the characteristics of chemicals that affect their biodegradability and provides real world examples on how this knowledge can be used to design biodegradability into new molecules. Four deliberate strategies have been successfully used in the design of new biodegradable molecules from existing chemicals: 1) removing structural features that block biodegradation, 2) introducing labile 'weak-links' at strategic locations within a molecule to facilitate microbial attack, 3) repackaging proven chemical functionality into a more biodegradable form and 4) introducing structural features into existing biodegradable molecules to enhance performance. Actual examples will be

shared as to how each of the strategies has been put into practice along with the biochemical basis behind their success

63 Perspectives on the use of Net Environmental/Risk Benefit Analysis for Making Integrated Human Health and Ecological Risk Management Decisions. T. Iannuzzi, D. Ludwig, ARCADIS, Annapolis, MD; N. Bonnevie, N. Weinberg, ARCADIS, Portland, ME; B. Locey, ARCADIS, Novi, MI; D. Jones, ARCADIS, Knoxville, TN. A review of remedial action plans for contaminated sites and systems (both land-based and aquatic) throughout the United States suggests that clean-up and restoration decisions under various regulatory applications (e.g., Comprehensive Environmental Response, Compensation and Liability Act [CERCLA], Resource Conservation and Recovery Act [RCRA], state-led initiatives) are still based on either human health or ecological risks, but rarely both. After nearly a quarter century under the current risk assessment paradigm, a clear and effective path for holistically evaluating risk-benefit strategies has not yet been achieved. In this presentation, we explore the application of the Net Environmental Benefits Analysis (NEBA) framework for assembling and applying the technical tools necessary to integrate the decision-making process for human health and ecological risk managers. Net environmental benefits are the gains in environmental services attained by remedial actions, minus the adverse environmental impacts caused by those same actions. For many complex contaminated sites, particularly in urban settings, it can be difficult to achieve a balance between societal needs and ecosystem functionality, however, they do not need to be exclusive of one another. By utilizing a common set of principles (such as those under the NEBA framework), we can explore risk management decisions that maximize the overlap between human health, societal use and ecological benefits, thereby providing the most cost- and net-benefit. Existing risk assessment tools will be discussed in the context of the NEBA framework, and select case studies will be used as examples of process application.

64 Global perspective on the integration of human health and ecological risk assessment. J.R. Clarkson, B. Locey, S. Sager, ARCADIS U.S., Baton Rouge, LA; K. Baker, H. Hayward, ARCADIS, Newmarket, United Kingdom. For at least a decade, integration of human health and ecological risk assessment methodologies in the United States has been discussed, but not many substantive measures have been put into regulatory context. This presentation will review integration strategies that have been adopted in Europe, North America, South America, Asia and the Pacific Rim, and highlight similarities and differences in the integration approaches adopted. Whilst the level and method of integrating human health and ecological risk assessment varies between countries, examples of successful integration can be found globally. The method used to integrate the two risk assessment disciplines is often dependent on many diverse factors, such as country-specific legislation, consideration of migration of constituents or spreading risk, environmental sensitivity of receptors, etc. A number of countries have been identified with screening levels developed based on the risks to both human health and ecological receptors. The Netherlands is one example, where the national screening levels integrate the risks to human health and ecological receptors, with preservation of the environment for the future key to the assessment process. An alternative approach is adopted in the United Kingdom, whereby a similar framework has been defined for assessing both ecological and human health risks, thus allowing an integrated assessment to be undertaken on a site by site basis. Human health and ecological risk assessment methodologies differ across the world and these differences, individually and collectively, can result in orders of magnitude differences in risk estimates and clean up goals. This direct influence on remedial decisions makes the need for integration of human and ecological health risk assessment critical. Therefore, it is beneficial to understand the integration strategies that exist globally.

65 A Theory and Framework for Environmental Assessment. G.W. Suter, S.M. Cormier, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH. Ecological and environmental assessment practices have not been as successful as they should be. We believe that this is in part because they lack a basis in theory and a framework that includes all of the important environmental assessment and management processes. We propose a theory that derives nineteen principles from three axioms -- assessments inform environmental management decisions, assessments are science based, and there is one resolution to each environmental problem. We propose a framework for environmental assessment that is organized in terms of two dichotomies. One distinguishes

problem detection from problem resolution. The other distinguishes environmental epidemiology from risk management. These two dichotomies create a 2x2 matrix, in which movement of information from among cells defines an assessment and management cycle. The unit assessments within that framework have a common structure: planning, analysis and synthesis. In a companion poster, that framework is applied to three cases: management of a biologically impaired river, remediation of a contaminated site, and reregistration of a pesticide. We believe that this theory of environmental assessment can lead to clear assessment practices that compel beneficial and confident environmental management.

66 Ecological Screening Levels for Volatile Organic Compounds in Soil Gas. J. Conder, ENVIRON International Corporation, Irvine, CA; J. Wells, ENVIRON International Corporation, Emeryville, CA; M. Sorensen, ENVIRON International Corporation, Atlanta, GA. Inhalation of volatile organic compounds (VOCs) from subsurface soil gas can represent a potential route of exposure for burrowing animals at VOC-impacted sites. There are no ecological screening levels (ESLs) for many VOCs. Using exposure and effects modeling for a representative burrowing mammals, Botta's pocket gopher (*Thomomys bottae*), ESLs were developed for 18 VOCs. Exposure to soil gas in burrows was conservatively assumed to be constant. Toxicity reference values were developed from inhalation toxicity studies with rodents. ESLs ($\mu\text{g/L}$) were: 150,000 (1,1,2-trichlorotrifluoroethane), 3.7 (1,1-dichloroethene), 35 (1,2,4-trimethylbenzene), 35 (1,3,5-trimethylbenzene), 15 (carbon disulfide), 570 (cis-1,2-dichloroethene), 180 (ethylbenzene), 210 (isopropanol), 1.9 (methyl bromide), 82 (methyl ethyl ketone), 97 (methyl isobutyl ketone), 5.5 (methylene chloride), 30 (styrene), 640 (trichloroethene), 23,000 (trans-1,2-dichloroethene), 5,700 (vinyl acetate), 5.3 (vinyl chloride), and 320 (tetrachloroethene). These ESLs should not be used as cleanup criteria, but are potentially useful for screening-level assessments. Only 8 of the ESLs (1,1-dichloroethene, carbon disulfide, ethylbenzene, isopropanol, methyl bromide, methyl ethyl ketone, methyl isobutyl ketone, and styrene) were more conservative (lower) than human health-based screening criteria and risk-based target concentrations based on residential subsurface vapor intrusion. Whereas this is partly surprising given the more direct exposure pathway for the inhalation of VOCs in soil gas in burrows, the application of higher uncertainty factors and choice of different, more sensitive toxic endpoints in human health risk modeling (carcinogenicity, biomarkers, etc.) likely results in greater conservatism for many of the human health screening levels.

67 Comparative assessment of chemicals impacts on ecosystems and human health using the USEtox model. O. Jolliet, Department of Environmental Health Sciences, School of Public Health, University of Michigan, School of Public Health, Ann Arbor, MI; M. Hauschild, IPL, Technical University of Denmark (DTU), Lyngby, Denmark; M. Huijbregts, D. van de Meent, Department of Environmental Science, Radboud University, Nijmegen, Netherlands; M. Margni, R. Rosenbaum, CIRIAG, Ecole Polytechnique de Montreal, Montreal, Quebec, Canada; T. McKone, School of Public Health, University of California Berkeley, Berkeley, CA; M. MacLeod, Institute for Chemical and Bioengineering, ETH Zurich, Zurich, Switzerland; D. van de Meent, RIVM, Bilthoven, Netherlands. USEtox is a multimedia fate and exposure model developed to consistently compare the environmental impacts of chemicals on human health and ecosystems. Within the SETAC-UNEP Life Cycle Initiative, an international comparison of six models first enabled us to identify the crucial fate, exposure and effect issues that made models differ. A parsimonious (as simple as possible but as complex as needed) and transparent consensus model was then created within a matrix framework, containing only the most influential model elements. Covering more than 2000 substances, USEtox provides human toxicity and aquatic ecotoxicity characterization factors -- a comparative measure of the impact per kg emitted substance into (urban) air, freshwater and agricultural soils. The present study applies the model to analyze the major factors affecting both human toxicity and ecotoxicity, with illustrations for key chemicals. The fate part relates emission flows to masses in the environment (e.g. transport to water and residence time in water) and is common to both human- and ecotoxicity assessment, with typically 5 orders of magnitude variations between chemicals. For human toxicity, exposure factors multiply by fate to yield the intake fraction -- the fraction of the emission that is taken in by the human population. Intake fractions typically range from 10⁻² for POPs and metals that bioconcentrate in the food chain down to 10⁻⁸ for the inhalation of shortly degraded VOCs. Effect measures for both human- and exo-toxicity are based on the best estimate of the hazard concentration that generates

50% of response for humans and 50% of species affected or disappeared for ecosystems. As a whole the characterization factors vary by 12 orders of magnitude for human health and 10 for ecotoxicity. A regression analysis shows that for an emission to water, there is a highly significant ($P < 0.0001$) but low correlation ($R^2 = 0.14$) between human- and ecotox characterization factors, mainly linked to the common fate.

68 Keeping Human Health And Ecological Risk Assessments Segregated. L.V. Tannenbaum, U.S. Army Center for Health Promotion and Preventive Medicine, Aberdeen, MD. The interest in making advances in the integration of human health and ecological risk assessment is impressive, and reflects a desire shared by many, to discover a broader, all-encompassing approach to understanding the potential toxicological effects of chemicals in the environment. Although the human health and ecological risk assessment processes may have common features, this should not summarily be taken to mean that integration is the idealized, sought-after goal. It could rather be that in the drive to achieve integration, key differences between the two processes are being overlooked, and further, that these differences contraindicate the pursuit of an integrated assessment scheme. The subject material will be discussed in a context of Superfund-type sites

69 Incorporating Ecological and Social Costs and Benefits into a Land Redevelopment Tool. K. Black, P. Black, T. Stockton, Neptune and Company, Lakewood, CO; A. Vega, U.S. EPA, Cincinnati, OH; R. Argus, Tetra Tech, EM Inc., San Diego, CA. Redevelopment of previously used lands is a very important focus in both the US and Europe. The US EPA, jointly with their German counterparts, have developed a free web-based program to encourage the preferential use of 'brownfields' over 'green space', thus saving pristine lands from development. Sustainable Management Approaches and Revitalization Strategies - electronic (SMARTe) is fast becoming a popular tool for site redevelopment projects. SMARTe (www.smarte.org) includes a decision analysis support system that allows users to select multiple potential future uses for a site and compare the costs and benefits of each. In site revitalization, there is clearly an economic concern. Projects for which the bottom line isn't viable won't find funding. Beyond the purely economic issues, both social and environmental/ecological aspects are taken into account when comparing possible future land uses. While the decision analysis system exists and is being used now, the valuing of ecological aspects of revitalization projects is currently largely left to the user. SMARTe 2008 (available to the public in October of 2007) will contain a very useful human health risk calculator. In the future, an ecological risk calculator will be added. The SMARTe development team is now working towards a tool to help users better integrate these risks into the decision analysis, and to define the ecological and social costs and benefits in the same units as the economic costs and benefits. In this presentation, SMARTe will be shown in its current state. This will be followed by discussion of the status of the ecological valuing tool, presentation of the sources of information being used to create the tool, and ideally, will conclude with group discussion on the merits of various approaches to valuing the ecological impacts of site revitalization. At the writing of this abstract it is unclear whether in November this tool will still be in the very early stages, or will be nearing completion. Either way, we would value the opportunity to present it to the SETAC community and to gain input into its final structure from this group.

70 Integrative Environmental Assessment via MIRA: Decision making using Public Health and Ecosystem Indicators. C. Stahl, A. Cimorelli, M. Nicholson, C. Mazzarella, U.S. EPA Region III, Philadelphia, PA. Informing environmental decision making is easier when using the Multi-criteria Integrated Resource Assessment (MIRA) approach. In this case study, MIRA provides a framework for environmental analysts and decision makers to assess where the highest risk areas are in the U.S. Mid-Atlantic region by using public health and ecosystem indicators. MIRA organizes user-identified criteria and allows users to learn about the values applied to the importance of those criteria in producing the risk perspective. Included in the case study analysis are more than 120 indicators determined to be relevant to the assessment of public health and ecosystem risk. These indicators include air quality (ozone, fine particulate matter, mercury, acid deposition), water quality (drinking water, nitrogen/phosphorus loading), habitat parameters (landcover, species population), and stressors such as agriculture and hazardous waste sites. Expert judgment is used to determine the scientific significance of the data, while value judgments from decision makers are used to determine which criteria are relatively more important. By including both kinds of judgments, MIRA bridges the science-policy interface; creating

separate places in the analysis for expert judgment and for value judgments. In this case study, we will demonstrate the feasibility of integrating public health and ecosystem indicators into a single environmental analysis. Additionally, we will demonstrate how this kind of integrated analysis can support environmental policy decision making.

71 Risk Assessment and Decision Analysis for Non-chemical Stressors: Summary of the NATO Workshop. I. Linkov, E. Bennett, Intertox Inc., Cambridge, MA; E. Ferguson, J. Stevens, Army Corps of Engineers, Vicksburg, MS; J. Figueira, Technical University Lisbon, Lisbon, Portugal; G. Kiker, University of Florida, Gainesville, FL; R.J. Wenning, Environ Inc., Emeryville, CA. Population growth, needed economic growth, and social pressures for improved infrastructure coupled to the need for human and ecological health protection and environmental security make environmental decision-making a difficult task when balancing human health and ecological impacts with societal benefits. Environmental security has emerged as an increasingly important concern of governments and their defense establishments because of these trends that have the potential to threaten stability. Risk Assessment has emerged as a useful tool to address environmental security issues. Nevertheless, the question of harmonization of risk-based approaches and decision tradeoffs has not been addressed, especially as it is applied to non-chemical stressors. The 2007 NATO workshop in Portugal started with building foundation to apply chemical risk assessment approaches and tools to a broad collection of non-chemical stressors including physical (unexploded ordnance, noise, temperature, pH), novel technologies and emerging materials (nanomaterials, pharmaceuticals and pathogens), biological (invasive species, microbial agents) for environmental decisions at different scales (from real time emergency response to long-term deliberative stakeholder process). The workshop evaluated the potential application of current risk analysis approaches to non-chemical stressors and provided a comprehensive analysis of management alternatives. The need to facilitate the transfer and use of quantitative information from risk and uncertainty analyses within decision-making processes was discussed. Tools developed in the field of operations research and management science, such as multi-criteria decision analysis could be instrumental in such linkages.

72 Measuring up to LEED: A Life-Cycle Analysis of LEED Building Design. A. Paleshi, Systems Design Engineering, University of Waterloo, Waterloo, Ontario, Canada. As the Leadership for Energy and Environmental Design (LEED) program grows in popularity, so too does the academic critique of LEED as a process for evaluating the impact of buildings. Many critics suggest that Life-Cycle Assessment (LCA) should replace the LEED point system as a more sophisticated method of evaluating trade-offs and setting targets, but the scope of such efforts conflicts sharply with the shortness of typical building development timelines. There is, however, a fundamental question that LCA can help to answer now: How does pursuing LEED during the design of a building transform the desires of the owner from "building a green building" to "building a LEED building"? A case study to pursue this question, undertaken with consultants Enermodal Engineering Ltd. of Kitchener Ontario, will be discussed. The building owners are guided through a visioning session to independently quantify their goals in the areas of function, cost, aesthetic and environmental impact. Then, the design team develops a concept of the building following the LEED process. During the concept development, key decisions and motivations for design choices are tracked. After the design is complete, three Life-Cycle Assessments of the proposed building are prepared: one of a least-cost or "standard practice" design, one of the LEED concept design, and one of a design which attempts to meet the original targets without specifically following any LEED requirements. A comparison of these three assessments will be reviewed and a survey of the successes and short-comings of the LEED concept design process will be discussed.

73 The Use of LCA in the Building Assessment System of the GeSBC - Towards the Complete Picture. A. Braune, K. Sedlbauer, LBP-GaBi, University of Stuttgart, Stuttgart, Germany; J. Kreissig, PE INTERNATIONAL, Stuttgart, Germany; A. Rudolphi, GFOEB, Berlin, Germany. The environmental impacts of buildings occur throughout all life cycle phases: Starting with the production of the building materials, followed by the construction and operation and renovations, until the final demolition and disposal of wastes. To overcome the shifting of burdens between life cycle phases, the life cycle perspective needs to be regarded by the design and planning teams. Hence, the overall environmental performance of a building can significantly be enhanced when it is designed regarding the life cycle

perspective and the impacts of all building aspects. Eco-design of buildings provide uncountable numbers of options for the planners. But unlike to industrial products, each building design has its very specific requirements by the user, the owner, the building's local conditions and the design team. Therefore, an environmental assessment of a building needs to be tailored to the unique building and carried out according to the specific design and surrounding conditions. At the same time, a building assessment has to be applicable in practice and needs to fit to the workflow of the design team. The trade-off between accuracy in the analysis of the building and appropriateness of the involved effort is of crucial importance for efficient application of life cycle based environmental assessment. The currently founded German Sustainable Building Council (GeSBC) will provide a certification system, which is based on life cycle thinking. To fulfill this requirement and to get to the complete picture, LCA-based information and communication tools will be implemented in the overall building assessment system. As foreseen in the upcoming international standards on building assessment, Environmental Product Declarations (EPD) according to ISO 14025 provide comparable and reliable information on the environmental performance of products. They contain verified data of Life Cycle Assessments (LCA) of the product. For the complete picture, a "model-specification LCA" serves identifying the environmental hotspots in the planning phase, detailed LCAs help the design team to better integrate eco-design. The presentation will introduce how to efficiently analyse the environmental life cycle performance of buildings. It will focus on current developments in generating EPDs and the future use of EPDs in building assessment.

74 Life Cycle Assessment as a Decision Tool: Case Studies in Green Building Design and Construction. R.J. Ries, Civil Engineering, University of Pittsburgh, Pittsburgh, PA. Life cycle assessment (LCA) can be a valuable tool for evaluating and improving building design and construction. In many cases, the use of LCA can identify opportunities for reducing the environmental impacts of constructing, operating, maintaining, and decommissioning buildings and infrastructure. Four case studies of LCA in design and construction illustrate approaches used and insights into model development and highlight the challenges of the use of LCA in this domain. A hybrid process-input-output LCA model developed for commercial building construction qualitatively and quantitatively examined environmental impacts due to the construction phase of commercial buildings located in the United States. The results indicate that when compared with the entire building life cycle, construction - including service sectors such as design and construction management - is as important as the other life cycle stages of materials and end-of-life scenarios. Recommendations for hybrid modeling developed from this work are discussed. A case study comparing three residential heating, ventilating, and air conditioning (HVAC) systems in four regions in the United States demonstrates the importance of regional variations in electrical power generation mix, climate, and typical construction on energy use and environmental impact. These results clearly indicate that system selection should not be made without considering the primary energy sources, especially for the regional electric power grid. A case study of a vegetated or green roof in Pittsburgh, PA identifies the key aspects for evaluating the benefits of green roofs from both water pollution and energy reduction perspectives. Green roofs do require more materials, often stronger structural members, and maintenance compared to standard roofs. The study found that, in this case, modeling the cooling energy use reduction resulting from lower roof temperatures on vegetated roofs is significant, and could result in lower overall life cycle environmental impact from green roofs. Finally, a model developed for the analysis of industrial and institutional floor maintenance programs found that building operations during floor maintenance made a noteworthy contribution to overall environmental impact. This model will be used to illustrate incorporation of uncertainty and variability in LCA models in the building and infrastructure sectors.

76 EPDs in building assessment – Requirements on a North American EPD scheme. J. Kreissig, M. Binder, PE INTERNATIONAL, Leinfelden-Echterdingen, Germany; A. Braune, LBP, Department of Life Cycle Engineering, University of Stuttgart, Stuttgart, Germany. The further development of green building assessment schemes like LEED requires a life cycle approach with an assessment on the building level. For this assessment comparable and consistent LCA information is required, otherwise the assessment will compare the inconsistency of data instead of the building. EPD schemes have shown to be able to provide this type of information, driven by the producers and their need to communicate reliable and third

party verified environmental information. Investigating worldwide existing EPD schemes in the building sector it has shown, that some key elements of the systems were responsible for the success of the program: - Development of a general program describing the organisation of the EPD scheme in line with ISO 14025 and product category rules (PCR) for construction products. This PCR is the basis for consistent and comparable EPDs. - Development of product specific annexes in the PCR for the different product groups (e.g. metals, wood, minerals, plastics etc.) describing only the specific requirements for the specific product group. - A third party involvement in two stages, an expert panel with representatives from government, science, test institutes and NGOs and an internet forum open for discussion of all interested parties. - Addressing human health and local environment as well as life cycle documentation according to ISO 14025 as additional information. The presentation will explain the outline of a North American EPD scheme and discuss strength and weak points of the approach.

77 Including Sustainability in Bridge Management Systems. C.A. Gwaltney, Civil Engineering, University of Evansville, Evansville, IN; C.A. Gwaltney, Construction Engineering and Management, Purdue University, West Lafayette, IN. Several recent efforts to improve the environmental profile of civil engineering infrastructure, such as LEED and BEES, have raised awareness and likely improved design and construction practices throughout the United States. However, the application of industrial ecology or green design tools is primarily limited to buildings. There is little research or design guidance related to bridges. Despite the development of sophisticated multi-objective optimization models for management of bridge structures, there remains scant consideration of the potential environmental or socio-political impacts of bridge design and construction. This research presents an approach to life cycle assessment of bridge structures. However, particular emphasis is placed upon socio-political aspects, where conventional LCA tools are insufficiently developed. Therefore, we present a case study in public participation for sustainability as exemplified by the New Harmony Bridge between southern Indiana and Illinois. The eventual result of this work will be development of a sustainability module for incorporation into existing bridge management systems. Sustainable principles are not used effectively for planning, construction and management of bridges in the United States. Sustainable principles are those described by Triple Bottom Line (TBL) sustainability; socio political, environmental and economic. Life-Cycle Cost (LCC), an economic assessment tool, seems to be the only one of the TBL principles utilized in today's Bridge Management System (BMS). The BMS is a method of rating crossing alternatives for the purpose of managing the system for a particular jurisdiction. A tool currently used to address environmental impacts of projects is the Environmental Life Cycle Assessment (ELCA). The ELCA is considered the foundation of sustainable development and construction, but falls short of a full sustainable assessment since it does not assess the impacts of socio-political aspects. Socio-political issues can be broken down into two components; those impacted by the production of a product, and those impacted by the product itself. Relief for the critical state of the US system of bridges may come from the implementation of these sustainable principles.

78 Incorporating Spatial and Temporal Resolution in Impact Assessment of Tropospheric Ozone in the Life Cycle Assessment of Buildings. R.J. Ries, V.P. Shah, Civil Engineering, University of Pittsburgh, Pittsburgh, PA. By aggregating life cycle inventories and impacts, conventional Life Cycle Assessment (LCA) isolates the analysis from its context. In contrast, environmental decision-making is contextual. Decisions regarding the design, use, and retirement of product systems involve spatial and temporal trade-offs. The ability to incorporate spatial and temporal resolution into environmental LCA would enable explicit differentiation between impacts at different locations and points in time. We present a framework that incorporates geographic and meteorological information into life cycle inventory and impact assessment. To illustrate the framework, we evaluate the ozone formation potential of discontinuous emissions from building operations. Incorporating spatial and temporal resolution into LCA requires at a minimum differentiated inventories and differentiated impact characterization. Differentiated inventory includes not only the mass of an emission, but also the time and location of its release. This requires a methodology and to evaluate environmental impact in different locations at different times. One approach is to develop these factors through the use of environmental models. In this study, the differentiated inventory is generated from simulation modeling of building operation. The spatially and

temporally differentiated impact assessment is developed through the use of the Community Modeling and Analysis System (CMAS), a widely accepted tropospheric ozone modeling framework developed through support of the US Environmental Protection Agency. Results of the study show that including spatial and temporal considerations in both life cycle inventory and impact assessment can add valuable insight into the results. The results of the study will be presented and compared to results from conventional LCA practice. Highlights of the challenges and recommendations for possible approaches to large-scale spatially and temporally differentiated LCAs will be discussed as well.

79 UNEP/SETAC Life Cycle Initiative: Recent Developments and Successes. J. Fava, Five Winds, West Chester, PA; G. Sonnemann, S. Valdivia, UNEP, Paris, France; A. Quirós, EcoGlobal, San Jose, COSTA RICA; G. Norris, Harvard, Boston, MA. Phase 2 was launched in early 2007. The first phase of the UNEP/SETAC Life Cycle Initiative concluded with important achievements and the completion of a series of products. In the second phase of the Initiative (2006 – 2010) the work will be structured the activities in five work areas on Life Cycle Approaches as it applies to: Consumption Clusters (structured in housing, mobility, food and consumer products), Resources/Materials, Methodology, LCM (in cooperation with the WBCSD), and Development. The last work area is strongly focused on emerging and developing economies supported by our regional networks. This paper will present a general outline of the planned steps for the next 4 years and will provide examples of projects underway, including establishing a Life Cycle Management roundtable with the World Business Council for Sustainable Development (WBCSD), establishing partnerships with UNEP's Sustainable Building and Construction Initiative (SBCI), Strategic Approach to International Chemicals Management (SAICM) and the Resource Panel, maintenance of the Life Cycle Inventory database registry, supporting the set up of Life Cycle Inventory data format converter, integration of socio-economic aspects into LCA, capacity building for developing countries at various conferences, second phase of Life Cycle Awards for projects using Life Cycle approaches in developing countries, and LCI data pool for developing countries.

80 The environmental impacts of residential buildings – How to efficiently identify life cycle based improvement potentials. B. Wittstock, A. Braune, Dept. Life Cycle Engineering, Universität Stuttgart, Chair of Building Physics, Echterdingen, Germany; J. Kreissig, N. Gallon, PE INTERNATIONAL, Stuttgart, Germany; C. Wetzel, Calcon, München, Germany. The overall environmental performance of buildings can best be improved by considering the life cycle perspective. This holds true for both, planning of new buildings and retrofitting of existing buildings. Applying the method of Life Cycle Assessment efficiently supports to identify environmental improvement options. For this purpose, the research project "Environmental Improvement Potentials for Residential Buildings" (IMPRO-Building) was initiated by the European Commission (IPTs). It is aiming at identifying environmental improvement options by analyzing the environmental impacts from residential dwellings throughout their entire life cycle. Main objectives of the project are to outline the current situation of residential buildings in the EU-25 and to assess and evaluate environmental improvement options for these buildings from a European perspective. To efficiently get to the environmental relevant aspects of the various building types in Europe, a highly sophisticated generic life cycle model of buildings has been developed by the project team. It is used to identify the environmental hot spots and to evaluate proposed improvement options. More than 70 building types are assessed in a consistent way. The life cycle model for 'existing buildings' is used to assess improvement options that are based on retrofit measures. The model for 'new buildings', on the other hand assesses buildings that are planned today, using current construction materials and techniques and therefore considers the entire construction phase, the use phase and the demolition of the building. This reflects the different questions from the decision makers. The presentation will give an overview on the life cycle impacts of different residential building types in the EU-25. It will further present the methodology used, focusing on the generic parameterized life cycle models for the various building types. The environmental hotspots of residential buildings will be presented, based on more than 70 consistent building LCAs.

81 Plant uptake, phytometabolism, and phytotoxicities of fluorinated organic pollutants: Insights from duckweed and duckweed callus cultures. D. Reinhold, Civil and Environmental Engineering,

Georgia Institute of Technology, Atlanta, GA; F. Saunders, Division of Environmental Science and Engineering, National University of Singapore, Singapore, SINGAPORE. Constructed treatment wetlands, designed for nutrient removal and water reclamation, are effective biological systems for treating wastewater effluents containing many emerging pollutants, including pharmaceuticals, pesticides, and industrial chemicals that are fluorinated. However, the role of plants in removal is unknown for most fluorinated organic pollutants. This research advances understanding of the role of plant uptake in treatment of fluorinated organic pollutants by utilizing duckweed as a model plant to assess the relative importance of plant uptake and metabolism in removal of fluorinated organic pollutants from wetlands. *Lemna minor* and *Landoltia punctata*, collected from wastewater treatment wetlands, were exposed to pharmaceuticals and fluorinated organic pollutants in batch reactors and removal was monitored with HPLC-DAD/MS. Subsequent studies utilized control reactors to account for non-uptake processes, plant extractions to identify metabolites, and plant callus culture to compare metabolites and toxicities in vitro and in vivo. Plant uptake was an important removal process for many fluorinated organic pollutants, including fluorinated phenols and Prozac®. *L. minor* and *L. punctata* metabolized 3-trifluoromethylphenol (an intermediate in pharmaceutical production) through conjugation with carbohydrates, and metabolism in both whole plants and callus cultures was compared. The use of duckweed callus cultures was further explored by comparing toxicities of fluorinated organic pollutants to whole plants (i.e., oxygen production assessment) and callus cultures (i.e., growth by area) with the goal of better understanding integration of in vivo and in vitro plant studies. In addition to expanding our understanding of metabolism of emerging pollutants, this research seeks to further the use of plant callus cultures in plant uptake, phytometabolism, and phytotoxicity studies.

82 Relationship of macrophytes and root-associated microorganisms in oil sands naphthenic acids phytotoxicity and phytoremediation. S.A. Armstrong, Toxicology Graduate Program, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; L.A. Phillips, J.J. Germida, Department of Soil Science, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; S.A. Armstrong, J.V. Headley, K.M. Peru, Environment Canada, Saskatoon, Saskatchewan, Canada. Naphthenic acids (NAs) are highly toxic organic acid compounds released during the extraction of crude oil from oil sands in Alberta, Canada. NAs subsequently accumulated in the large volumes of tailings water produced on a daily basis by the oil sands operations. The complex nature of dealing with a mixture of different NA compounds, combined with their acute aquatic toxicity, and large volume of production has made them an emerging pollutant of concern for Western Canada. Recent studies have investigated the potential of using emergent aquatic macrophytes to phytoremediate NAs from tailings pond water. Since root-associated microorganisms are an important component of dry-land phytoremediation systems, here we investigate their relationship with NA phytotoxicity and dissipation with emergent aquatic macrophytes. Total microbial DNA was extracted from bulk water, rhizosphere, and endophytic samples, and analyzed by DGGE. Bands of interest were excised and sequenced. There were observed differences in the prevalence of specific bacteria in the presence and absence of NAs indicating that bacteria may play a role in mitigating the toxic effects of NAs to aquatic macrophytes.

83 Towards a credible model of chemical bioaccumulation in plants. D. Mackay, E. Webster, Canadian Environmental Modelling Centre, Trent University, Peterborough, Ontario, Canada; J.E. Hubbarde, Department of Applied Mathematics, University of Western Ontario, London, Ontario, Canada. A credible mass balance model of chemical uptake by plants is an invaluable component of risk assessments since plants are key points of entry to wildlife and human food webs. A model can also provide a design basis for phytoremediation. Features of the fugacity-based Crop Plant model (CroP4) are described. The aim of the model is to have the capability of application to a variety of annual plant species and chemicals. Aspects discussed include: the need for up to four compartments (root, stem, foliage, and fruit or nut); devising expressions for plant growth from germination to harvest; expressing phase equilibria between compartments, fluids, and soil (Z values); including transport and potential transformation processes (D values); and solution of the set of differential equations for defined chemical exposure levels. The output of the model is illustrated and discussed. It is concluded that achieving credibility requires collaboration between plant physiologists, chemists, experimentalists and modellers.

84 Removal of trichloroethylene from shallow subsurface environments: volatilization from trees and soil surface versus groundwater interception trench. W.J. Doucette, R. Winters, R. Dupont, Utah Water Research Laboratory, Utah State University, Logan, UT; K. Gorder, Environmental Management Division, Hill Air Force Base, Hill Air Force Base, UT. Volatilization of TCE by indigenous trees (phytovolatilization) and directly from the soil surface may play a significant role in the removal of TCE from shallow groundwater plumes at some sites. In this study, we compared TCE removal via volatilization (plants and soil surface) to that removed by a 50-foot (length) groundwater interception trench installed between 22 and 35 feet below ground surface near the location of the trees. Phytovolatilization samples were collected on sorbent traps from leaves and trunks of 8 willow and polar trees, ranging in height from 6 to 12 m, for the analysis of TCE by thermal desorption GC/MS. Soil surface flux measurements were made at approximately the same locations and times. The TCE removed by each mechanism was compared to the TCE collected in the groundwater interception trench. Phytovolatilization from leaves was scaled to the amount of water transpired. Using sap flow estimates of transpiration, yearly removal of TCE at the site was in the same order of magnitude as TCE removed via the interception trench and by volatilization from the soil surface. Loss of TCE via the trunk, scaled to the area of the flux chamber, was minimal for the mature trees at this site.

85 Screening the phytoremediation potential of desert broom (*Baccharis sarothroides* Gray) growing on mine tailings in Arizona, USA. N. Hague, J.L. Gardea-Torresdey, Environmental Science and Engineering, University of Texas at El Paso, El Paso, TX; J.R. Peralta-Videa, J.L. Gardea-Torresdey, Chemistry, University of Texas at El Paso, El Paso, TX; G.L. Jones, Phelps Dodge Miami Inc, Claypool, AZ. This research was conducted at a copper mine tailings reclamation project (CMTRP) located in the Globe-Miami mining district near Claypool, AZ, USA. Desert broom (*Baccharis sarothroides* Gray), an environmentally friendly and available plant that might have phytoremediation potential, grows at the CMTRP. Therefore, in this research metal concentrations both in the tailings and plants (elemental ratio from soil to plant) were investigated. Triplicate samples of soil cover, tailings and plants of desert broom were collected. The metal concentrations in the soil cover and tailings were determined using ICP-OES. Based on the concentration, the elements were classified as major elements: (K > Al > Fe > S > Ca > Mg > Na > Cu > P) and minor elements: (Mn > Pb > Mo > Cr > Vn > Zn > As > Ni > Co). The concentration of Cu, Pb, Mo, Cr, Zn, As, Ni, and Co in tailings was 454.9, 209.7, 89.32, 85.6, 51.2, 49.2, 39.3, and 36.3 mg/kg, respectively. The concentration for major and minor elements in the soil cover was 10~15% higher than that of the tailings except for Cu and Mo. The concentration of Cu, Pb, Mo, Cr, Zn, As, Ni, and Co in desert broom was 819.3, 152.7, 74.3, 56.7, 39.9, 43.1, 97.3, and 26.3 mg/kg for roots and 1212.7, 102.2, 106.7, 104.4, 56.12, 34.3, 31.2, and 10.1 mg/kg for shoots, respectively. Considering the translocation factor (TF), enrichment coefficient (EC), and the accumulation factor (AF), desert broom could be a potential hyperaccumulator of Cu, Pb, Cr, Zn, As, and Ni for application in phytoremediation of copper mine tailings in Arizona, USA.

86 Phytoextraction of persistent organic pollutants (POPs): Results from greenhouse and in situ field studies in PCB- and DDT-contaminated soils. M.L. Whitfield Åslund, B.A. Zeeb, Chemistry, Royal Military College of Canada, Kingston, Ontario, Canada; A. Rutter, Environmental Sciences, Queen's University, Kingston, Ontario, Canada. The category "persistent organic pollutants" (POPs) includes both well known environmental contaminants (e.g. PCBs, DDT, dioxins and furans) and emerging pollutants (e.g. PBDEs). As a group, these contaminants are known to be persistent, hydrophobic, and bioaccumulative. Due to their hydrophobic nature (log Kow > 3.5), these contaminants are expected to be too strongly sorbed to soil particles to be taken up by roots or translocated within plants to any significant extent. However, recent work has identified plants such as pumpkin and zucchini, in the species '*Cucurbita pepo* ssp. *pepo*', that are capable of accumulating levels of POPs from soils that greatly exceed the modeled expectations. This indicates a potential to develop a type of phytoremediation, known as phytoextraction, as a remediation technique for POP-contaminated soils. The objective of phytoextraction is for plants to accumulate significant amounts of a target contaminant from soil and store it in the plant shoot, which can then be harvested and treated as contaminated waste. Although this process still relies on traditional treatment methods such as incineration to deal with the harvested plant biomass, it leaves the soil on site intact, and

reduces the volume of contaminated solids for transport and treatment. We have had the opportunity to research the potential of this technology both in the greenhouse (with soil [DDT] ~1.5 µg/g) and at two separate PCB-contaminated field sites (one contaminated with ~25 µg/g Aroclor 1254/1260 and one contaminated with ~4.0 µg/g Aroclor 1248). Initial results confirmed the ability of *C. pepo* species to take up higher than expected levels of organochlorines, even under realistic field conditions, and provided valuable information about the mechanisms of organochlorine uptake and transfer in *C. pepo*. Further work investigated potential methods for optimizing the uptake process and has identified a few promising techniques. We have also looked into the uptake potential of other plant species, including that of native colonizer species at the two PCB-contaminated field sites. The results of these studies will be discussed. Both contaminant and site specific results will be highlighted.

87 Uptake and transformation of atrazine and metolachlor in prairie grasses for phytoremediation. J.R. Coats, K.L. Henderson, Y. Khrunyk, Entomology, Iowa State University, Ames, IA; S. Schiewer, Civil and Environmental Engineering, University of Alaska-Fairbanks, Fairbanks, AK. Earlier studies in our laboratory have demonstrated the efficacy of several species of prairie grass - switch grass, big bluestem, yellow indian grass - in phytoremediation of herbicide residues in soil. Numerous questions arise, however, with regard to how much herbicide residue is in the grasses and for what purposes the grasses may be used. We have demonstrated that the rhizosphere effect, based on microorganisms living in the plant root-zone, is responsible for at least part of the detoxification of herbicides in contaminated soil. The capabilities of the grasses to biotransform atrazine or metolachlor are being examined, to provide detailed information on the quantity of the parent herbicides and specific metabolites found in the grass tissues. The experiments utilized ¹⁴C-atrazine and ¹⁴C-metolachlor to determine how significantly the transformational capabilities of the grasses contribute to the overall phytoremediation advantage. Uptake and metabolism of atrazine and metolachlor clearly contribute to the net transformation effect of prairie grasses in herbicide-contaminated soil or water.

88 Quantification of glutathione levels in plants exposed to chlortetracycline and characterization of plant response after antibiotic uptake. M.H. Farkas, J.O. Berry, Biological Sciences, State University of New York at Buffalo, Buffalo, NY; M.H. Farkas, D.S. Aga, Chemistry, SUNY at Buffalo, Buffalo, NY. Glutathione (GSH) is a multifunctional and abundant tripeptide (γ-glutamylcysteinyl glycine) that plays a major role in xenobiotic detoxification. Glutathione S-transferases (GSTs) are enzymes that mediate the covalent attachment of GSH to an electrophilic xenobiotic, which renders the xenobiotic inactive and tags it for further processing within the cell. The concentration of GSH within a cell is thought to be of great importance for the plant's defense system to properly function. Certain xenobiotics such as herbicide safeners act to the activity of many enzymes in the glutathione pathway. Some of these enzymes are GSTs, however others function to increase GSH biosynthesis and effectively protect the plant from herbicide stress. We have previously demonstrated that GSTs play a major role in the detoxification of the widely used antibiotic, chlortetracycline, in maize (*Zea mays*), but not in pinto beans (*Phaseolus vulgaris*). In a manner analogous to herbicide safeners, our early research has shown that chlortetracycline induces GST activity in maize and increases its ability to detoxify the antibiotic. In the present study, we will further characterize chlortetracycline uptake by these two plants and the effects this has on GSH levels. Traditionally, GSH quantification requires extensive sample preparation and is quite time-consuming. So, we will present a simple method for rapid sample preparation and quantification using liquid chromatography with mass spectrometry detection.

89 Arsenate-induced expression of chitinase in the Dwarf Sunflower *Helianthus annuus*. I. Atkinson, R. Wei, Chemistry, Cleveland State University, Cleveland, OH; H. Van Keulen, Biological, Geological & Environmental Sciences, Cleveland State University, Cleveland, OH; T.J. Cutright, Environmental Engineering, University of Akron, Akron, OH. Arsenic (As) compounds are widespread as the results of various anthropogenic activities and present severe health problem in many parts of the world. Remediation of arsenic contaminated soils and water therefore is a major environmental issue, and phytoremediation is regarded as a promising approach for cleanup of soil and water contaminated with arsenic. While over 400 plants are known to accumulate one or more toxic metals, only a few plants have been reported to accumulate arsenic. Here we report the results of a study designed to better understand the mechanism of uptake

and accumulation of As in *Helianthus annuus*, a hyperaccumulator plant. A total uptake of four metals (Cd, Ni, Hg, and As) at the end of a 4-week cycle showed variable uptake of the metals in roots, leaves, and stems. Metal uptake was highest in roots and lowest in leaves. The presence of other metals appeared to have little effect on the uptake of As. Proteins were extracted from leaves of plants exposed to arsenic alone or in combination with other metals. Protein patterns were analyzed by one-dimensional SDS-polyacrylamide gel electrophoresis. Several polypeptides, with molecular weights ranging from less than 10 to over 45 kDa appeared to be unique in extracts made from leaves of plants in response to arsenic stress. One polypeptide was induced strongly. It had an approximate molecular mass of 32 kDa and was recovered from gels and submitted to LC-MS/MS immunoblot analysis. It was identified as a chitinase, which gene was induced at the transcription level when As was present.

90 Cities as Sources of POPs: Birmingham, UK as a Case Study. S. Harrad, University of Birmingham, Birmingham, United Kingdom. Concentrations of PCBs and PBDEs in both outdoor air and soil at 10 locations along a 79km rural:urban transect following the prevailing wind direction across the UK's 2nd largest city (Birmingham, population 2.5 million), display a well-defined peak in the city centre and decline with distance from the centre. This demonstrates the important role of the city as a source of these contaminants to the wider environment. Comparison of chiral signatures of PCB 95 in both air and soil suggest strongly that volatilisation from soil is not a significant source of PCBs to air. Instead, the racemic signatures found in outdoor air match those observed in both the commercial formulations and samples of indoor air from buildings within the city. This – combined with the fact that concentrations of PCBs and PBDEs in indoor air exceed substantially those outdoors – implies that ventilation of indoor air is a substantial source of POPs to outdoors. The presence of PCBs in indoor air 30 years after the cessation of their UK manufacture and new use, at concentrations that have not declined significantly since the late 1990s, is evidence that the application of similar policies to minimise future exposure to PBDEs are unlikely to be sufficient.

91 PBDEs' Behavior in Indoor Environment- A Mass Balance Fugacity Model Approach. X. Zhang, M. Diamond, Department of Geography, University of Toronto, Toronto, Ontario, Canada; S. Harrad, School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham, United Kingdom. A mass balance fugacity model was developed and applied to investigate indoor sources/sinks of polybrominated diphenyl ethers (PBDEs), possible human exposure pathways in indoor environment, and the contribution of indoor PBDEs to the outdoor environment. Considering the indoor facilities that can affect PBDEs' fate, the model, based on that developed by Bennett (2004), includes five compartments: air, polyurethane foam (PUF) made furniture, carpet and organic film on floor and wall surface. Steady state (SS) is assumed for one scenario to represent average long term conditions. Because PUF furniture and carpet contains a large amount of PBDEs added during production and has a high absorption capacity for the chemicals, it may act as a source for PBDEs when the PUF concentration is higher than the SS concentration and as a sink when other indoor sources (e.g. electronic devices) dominate and the PUF concentration is lower than the SS concentration. To describe its source/sink characteristics, another scenario considers PUF and carpet as pseudo-steady state components whose concentrations were used as input for the model calculations. Particles present in all compartments and may affect the fate of the chemicals especially for the heavy congeners. Based on the different dynamic behaviors and exposure risks, particles were divided into different size fractions and calculated individually by assuming constant particle air concentrations in the model. Air exchange, dust removal and chemical reaction were considered as loss pathways. The emission and loss rates for the chemicals were assumed constant. Sensitivity analysis was conducted to identify the key parameters and processes governing the chemicals' indoor behavior. Finally, in order to calibrate and evaluate the model, it is applied to specific indoor environments, where PBDEs' concentrations in different indoor media were measured.

92 Influence of Asian and Western U.S. Urban Areas on the Atmospheric Transport of PAHs, PCBs, and FtOHs in the Western U.S. T. Primbs, S. Simonich, A. Piekarz, Chemistry, Oregon State University, Corvallis, OR; S. Simonich, J. Field, Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR; D. Jaffe, University of Washington-Bothell, Bothell, WA; C. Higginbotham, Science, Central

Oregon Community College, Corvallis, OR. Anthropogenic semivolatile organic compounds (SOCs) undergo long-range atmospheric transport to the western U. S. from global and Eurasian sources as well as regional atmospheric transport from North American sources. High elevation sites in the western U.S. may be in the free troposphere more often than lower elevation sites, and allow for more conclusive identification of trans-Pacific transport events to the western U.S. Atmospheric measurements of anthropogenic SOCs were made at Mt. Bachelor Observatory (MBO) located in Oregon's Cascade Range (43.98°N, 121.69°W, 2.7 km a.s.l.) to further understand the trans-Pacific transport of SOCs from urban areas. High volume air sampling (~644 m³ for 24 hour periods) of both the gas and particulate phases was conducted from April 2004 to May 2006 at MBO (n=69). Air trajectories were calculated using data from NOAA's HYSPLIT model and then were used to calculate source region impact factors (percentage of time spent in designated source region). Particulate phase PAH concentrations increased with increased air mass time in Asia. Gas phase PAH concentrations increased with increased air mass time in California's urban areas and in the states of Oregon and Washington. The latter two source regions also had increased concentrations of levoglucosan and retene which may indicate the impact of fires. FtOH and PCB concentrations were significantly (p-value < 0.05) correlated with gas phase PAH concentrations, suggesting that gas phase PAHs, PCBs, and FtOHs are coming from urban areas in the western U.S.

93 Over-water and urban contaminants measurements as part of the Integrated Atmospheric Deposition Network (IADN). R. Wu, P. Blanchard, L. Jantunen, F. Froude, A. Sheppard, Science and Technology Branch, Environment Canada, Toronto, Ontario, Canada. In the summers of 2002, 2004-2006, a 12-m diameter buoy platform outfitted to measure atmospheric PCBs, PAHs, organo-chlorine pesticides, mercury and ozone was positioned at the western end of Lake Ontario, midway between Toronto and Niagara-on-the-Lake. The data gathered via this platform were compared to those from the regionally representative IADN monitoring site of Point Petre on the north-eastern shore of Lake Ontario. While the Point Petre data are the basis of the loadings calculations for all of Lake Ontario, the Lake Michigan calculations incorporate data from the urban sampling site of Chicago. This has shown to make a significant difference for several chemicals, thus, in summer 2005, an air sampling site was established in downtown Toronto, taking simultaneous measurements with the over-lake buoy. The urban sampling site data can be compared to over-lake buoy measurements to verify whether current assumptions made as to the extent of urban influence on overall lake loadings are appropriate, as the buoy is more representative of actual lake conditions. The integration of the urban data would provide a more complete picture of the deposition values into the lake, and especially the gas absorption term of the loadings calculation. The comparison, coupled with using Geographic Information Systems (GIS) tools can lead to refinement of the current IADN loadings calculations. Results from the buoy measurements as a comparison with the Point Petre data will be presented. There will be a focus on the data from the summer of 2005, which includes the integration of the urban data into the deposition model, and how the inclusion of urban data influences the lake contaminant flux values.

94 Trace Metal Dry Deposition Rates Along an Urban Coastal Transect in Southern California. K. Schiff, L. Sabin, So Cal Coastal Water Research Project, Costa Mesa, CA. While recent studies indicate atmospheric deposition is a significant source of metals to the Santa Monica Bay and coastal river systems of the Los Angeles area, the spatial extent of the atmospheric source along the entire southern California coast has not been measured in thirty years. This study provides measurements of dry atmospheric deposition of chromium, copper, lead, nickel and zinc at eight sites located along the coast between Santa Barbara and San Diego, and compares these data to historic measurements from the 1970's. Median dry deposition fluxes across sites ranged between 0.23 to 3.6 (chromium), 0.21 to 5.4 (nickel), 0.52 to 14 (lead), 0.89 to 29 (copper), and 4.8 to 160 (zinc) µg/m²/day. Differences in metal dry deposition flux rates observed between sites were dominated by proximity to urban areas and/or other nearby sources, with the highest metal fluxes observed near the Los Angeles Harbor and San Diego Bay sites. Compared with data from the 1970's, lead fluxes were typically one to two orders of magnitude lower in the present study (2006), indicating atmospheric sources of these metals have decreased over the past three decades. Chromium fluxes were also lower in 2006 compared with the 1970's, although to a lesser extent than for lead. In contrast, copper and zinc fluxes were typically within the same order of magnitude between the two time periods, with many

higher measurements observed in 2006 compared with the 1970's. This result indicates atmospheric sources of copper and zinc have not decreased, and likely increased over the past three decades in southern California. Differences in sampling conditions (e.g., Santa Ana winds) and measurement techniques help to further reinforce the conclusions observed in metal flux rates for these time periods.

95 PCB sources and fate in New Jersey. L.A. Rodenburg, Environmental Sciences, Rutgers University, New Brunswick, NJ. New Jersey (NJ) is the most densely populated of the United States. Polychlorinated biphenyls (PCBs) are a significant concern in NJ due to their widespread use in urban areas in closed applications such as transformers and capacitors, as well as open applications such as paint and joint compounds. Two of the state's major waterways, the Delaware River and the New York/New Jersey Harbor, are on the 303(d) list for PCB contamination, resulting in fish consumption advisories. PCB concentrations in both systems exceed water quality standards by 2 to 4 orders of magnitude. In addition to the widespread use of Aroclors, inadvertent production of PCBs in current manufacturing processes has led to widespread contamination in both of these systems. This research has taken a holistic approach to assessing the sources and fate of PCBs in these systems by combining monitoring, mass balance approaches, source apportionment, statistical data analysis, trackdown studies, and examination of intermedia transfer, with focus on air/water and air/land interactions of PCBs. Atmospheric deposition of PCBs to these systems has been evaluated via the New Jersey Atmospheric Deposition Network (NJADN) which includes monitoring sites in urban, suburban, and rural areas. As in other studies, atmospheric PCB concentrations in NJ display a strong urban gradient. Elevated urban PCB concentrations lead to atmospheric deposition loads to both waterways that exceed the expected TMDLs (Total Maximum Daily Loads). The NJADN data has been used to investigate atmospheric PCB sources and to examine the fate of atmospherically deposited PCBs in sub-watersheds of the Delaware River. A combination of active and passive air sampling the Philadelphia metro area has increased our understanding of urban gradients and facilitated source trackdown. In addition, statistical analysis of data on water column concentrations of PCBs in these systems has enabled source apportionment that is sometimes at odds with loading profiles conducted via sampling of suspected sources.

96 Investigations of Atmospheric PCB Sources in the Chicago Area. W.J. Mills, mills consulting inc., Oak Park, IL; T. Holsen, civil and environmental engineering, Clarkson University, Pottstown, NY. Research has indicated that there are significant sources of PCBs in urban areas near the Great Lakes and that these areas should be considered as major sources of PCBs to the Great Lakes. In Chicago, urban concentrations 5X higher than non-urban areas have been observed. In addition, the PCB flux measured in Chicago is up to 3 orders of magnitude higher than in the non-urban areas. A series of research projects were undertaken in recent years to investigate possible sources of PCBs to ambient air in Chicago. In one study, hybrid receptor modeling indicated 3 PCB source directions for the Chicago area. In another study, air samples were obtained in the vicinity of the sludge drying beds to measure the contribution of PCBs to the atmosphere in Chicago from this potential source. These ambient air results, combined with flux chamber, and sludge PCB measurements indicated that sludge beds were responsible for PCB emissions were insignificant when compared to estimated (using simple box model) total PCB inputs to Chicago air shed. Analysis of the air monitoring data also indicated that there were other sources northeast of the sampling site which were more significant. In another study air samples collected at UIC and IIT, separated by a distance of approximately 6 km, showed seasonal PCB concentration fluctuations, indicative of evaporative sources but levels of PCBs observed at UIC were consistently elevated by a factor of approximately 2X. These results indicate that the using a single air monitoring site as representative of an urban air shed could be underestimating actual air concentrations. PCB fluxes from soils were measured on-site, and in a laboratory setting using flux chambers to generate empirical data for comparison with estimated emissions from modeling. The results were found to agree reasonably well and the principal source of any difference was found to be in the physical constants used in modeling. Most recently work has been carried out investigating possible emissions of PCBs from operating PCB transformers. The results from these investigations indicate that well-maintained, sealed, operating PCB transformers emit quantifiable levels of PCB, but are not major contributors to the observed emissions inventory.

97 Concentrations and fluxes of persistent organic pollutants to Lake Ontario via the Greater Toronto Area watersheds. L.E. Melymuk, M. Robson, M. Diamond, Geography, University of Toronto, Toronto, Ontario, Canada; P. Helm, B. Gilbert, Ontario Ministry of Environment, Toronto, Ontario, Canada. Its is now widely acknowledged that large urban areas such as the Greater Toronto Area (GTA) act as considerable point sources of a range of persistent organic pollutants (POPs) to the wider environment. One of the primary ways in which this occurs is via their movement into and through the waterways that run through them. To investigate this area a range of samples, including air, soil, deposition and bulk water samples were collected from ten riverside sites in the GTA. These samples were then analyzed for a variety of persistent organic pollutants, including polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), polycyclic aromatic hydrocarbons (PAHs) and selected organochlorine pesticides (OCPs). Alongside of this a variety of geographical data was collated and used to compile a GIS database for the surrounding areas. These combined data sets were then used to calculate loading estimates to the lake for this pathway and to assess the relationship between land usage and pollutant sources.

98 Sources and Fate of Hydrophobic Organic Contaminants in the New York/New Jersey Harbor Estuary. R. Landeck Miller, K.J. Farley, J.R. Wands, HydroQual, Inc., Mahwah, NJ. Mechanistic numerical models have been developed and applied for addressing the causal link between external sources of contaminants, such as tributary headwaters, sewage treatment plants, urban runoff, combined sewer overflow, atmospheric deposition, and landfill leachate, to ambient concentrations of contaminants in water, sediment, and biota of the NY/NJ Harbor. The contaminant classes considered include PCBs, dioxin/furans, organochlorine pesticides, and PAHs. Developing estimates of the contaminant loading sources was an important aspect of the work. Numerical models developed and applied include hydrodynamic, sediment transport, organic carbon production, contaminant fate and transport, and bioaccumulation models. After several years of development and calibration, these models now diagnose how much of observed Harbor contamination results from current loadings versus legacy contamination still remaining in the system. Legacy contamination is a consequence of the industrial heritage of Newark, New York, and other large cities. Further, the models have been used to forecast expected future reduced contamination levels achievable through natural attenuation and a combination of natural attenuation and various reductions of current loadings and/or removal and remediation of in-place sediments. The driving force for the development of the models was the problem of sediment contamination in the NY/NJ Harbor estuary adversely impacting both the disposal costs and the disposal options for material dredged from the Harbor. Moving forward with scientific and policy agendas in the NY/NJ Harbor region, particularly as they relate to PCBs and dioxin/furans, will likely be guided by the insights gained from model results (e.g., loading component evaluations). Additional data collection, remediation of in-place contamination, and reduction of on-going diffuse sources (e.g., runoff, tributary inputs, etc.), as suggested by model results, may be involved in future agendas. Current application of the CARP models is supporting the development of Total Maximum Daily Loads (TMDLs) for attainment of water quality standards. The CARP modeling approach and application serves as an excellent case study for other urban estuaries and ports. Although developed specifically for the NY/NJ Harbor, the CARP model kinetic formulations are easily transferable to other urban systems and can be adapted for considering other contaminants.

99 Atrazine and Amphibians: Reproductive Effects and Risks from Agricultural Uses. K.R. Solomon, Centre for Toxicology, University of Guelph, Guelph, Ontario, Canada; J. Carr, Biological Sciences, Texas Tech University, Lubbock, TX; L. Du Preez, Zoology Department, University of the North West, Potchefstroom, NW Province, South Africa; J. Giesy, Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; R. Kendall, E. Smith, TIEHH, Texas Tech University, Lubbock, TX; G. Van Der Kraak, Saskatoon, University of Guelph, Guelph, Ontario, Canada. The herbicide, atrazine is widely-used in agriculture for the production of corn. Some studies have reported adverse effects on sexual development of atrazine in frogs and other amphibians. To assess whether atrazine causes adverse effects in frogs through mechanisms mediated by endocrine and other pathways, several hypotheses were tested in laboratory and field studies, using guidelines for the identification of causative agents of disease and ecotoxicology derived from Koch's postulates and the Hill guidelines. The hypotheses were: Atrazine used in crop protection causes

adverse effects in amphibians through; 1) estrogen-mediated mechanisms, 2) androgen-mediated mechanisms, 3) thyroid-mediated mechanisms, 4) adverse effects on gonadal development in amphibians, or 5) adverse effects at the population level in exposed amphibians. The biological plausibility of the proposed mechanisms of endocrine disruption will be critically discussed in relation to laboratory, microcosm, and field observations. This will include new data on the oocyte response, transgenerational effects, and the influence of genetic factors. An overall assessment of the effects atrazine on reproduction in amphibians will be presented.

100 Clade-specific occurrence of testicular oocytes in *Xenopus laevis* from South Africa. G. Van Der Kraak, R.H. Hanner, Integrative Biology, University of Guelph, Guelph, Ontario, Canada; L.H. du Preez, N. Kunene, School of Environmental Sciences and Development, North-West University, Potchefstroom, South Africa; J.P. Giesy, Toxicology Centre, University of Saskatchewan, Saskatoon, Ontario, Canada; A.J. Hosmer, Syngenta Crop Protection Inc, Greensboro, NC; K.R. Solomon, Centre for Toxicology, University of Guelph, Guelph, Ontario, Canada. There has been considerable controversy over the possible effects of the herbicide atrazine on gonadal development in amphibians, including the potential relationship between exposures to atrazine and the incidence of testicular oocytes (TOs) in *Xenopus laevis*. A study was conducted to investigate the occurrence of TOs in adult frogs collected from north-east South Africa (SA) including sites that were upwind and hundreds of km from the major atrazine use-area. As well, the occurrence of TOs was determined in frogs from the Western Cape region of SA which is separated by a geographical barrier (the Cape fold Mountains) from areas where atrazine is used. The incidence of TOs was then compared to evolutionary relationships among mitochondrial DNA haplotypes to test whether there were differing phylogenetic predispositions to the incidence of TOs. Both mature and regressed TOs were observed in *X. laevis* collected at the north east sites whereas none were observed at the Western Cape sites. Sequencing of a 650 bp region of the mitochondrial gene cytochrome c oxidase 1 in frogs from the two locations revealed a high divergence in genotype. This suggests that there are phylogenetic differences underlying the different patterns of testicular development in these frogs. Overall, these results suggest that the occurrence of TOs is a natural phenomenon which varies among species or subspecies and does not support an association between atrazine exposures and the incidence of TOs. These results also provide a possible explanation for why conflicting results have been reported concerning the effects of atrazine on amphibian sexual differentiation and point to the need for proper phylogenetic characterization of test species before they are used in assays for endocrine disruption. Keywords: atrazine, endocrine disruption, speciation, DNA bar codes

101 Response of larval African clawed frog, *Xenopus laevis*, to atrazine exposure: Assessment of growth, metamorphosis, gonadal development and sexual differentiation. W. Kloas, I. Lutz, Leibniz-Institute of Freshwater Ecology & Inland Fisheries, Berlin, Germany; A.J. Hosmer, Syngenta Crop Protection, Inc., Greensboro, NC; T.A. Springer, H.O. Krueger, Wildlife International Ltd, Easton, MD; J.C. Wolf, Experimental Pathology Laboratories, Inc., Sterling, VA; L.R. Holden, Sielken & Associates Consulting, Inc., Bryan, TX. In 2003, a U.S. EPA Scientific Advisory Panel (SAP) reviewed the available data concerning the potential effects of atrazine on amphibian development and sexual differentiation. Specifically, the SAP addressed the issue of potential feminization of male frogs during larval development. The EPA and SAP concluded that a high degree of uncertainty was associated with the existing laboratory and field data, including issues of animal husbandry, the unknown biological variability of normal gonadal development, and lack of standardized procedures and terminology. EPA required that studies be conducted which addressed the deficiencies and uncertainties of the existing database. Preliminary positive control studies (17 β -estradiol) were conducted to refine rearing and data collection methods and develop standardized gross morphological and histopathological terminology. Definitive atrazine studies were conducted in parallel at two independent laboratories. *Xenopus laevis* were exposed to five concentrations of atrazine (0.01, 0.1, 1, 25 and 100 μ g/L) and 17 β -estradiol at 0.2 μ g/L from NF stage 47-48 through stage 66 to determine any potential impact on development and sexual differentiation. Growth, mortality, and development metrics indicate good biological performance of the animals. Results of gross morphological and histopathological assessments of the primary endpoints: age at completion of metamorphosis, frequencies of males (sex ratio), occurrence of mixed sex, intersex and testicular oocytes, were consistent

between laboratories. Findings will be presented. Keywords: atrazine, *Xenopus laevis*, metamorphosis, sexual differentiation

102 Modeling the Potential for Atrazine-Induced Changes in Midwestern Stream Ecosystems using the Comprehensive Aquatic Systems Model (CASM). D. Volz, P. Hendley, Environmental Safety - Americas, Syngenta Crop Protection, Inc., Greensboro, NC; S. Bartell, S. Nair, E2 Consulting, Maryville, TN. The "Comprehensive Aquatic Systems Model for Atrazine" (CASM_Atrazine) was developed to simulate ecological production dynamics of a generic 2nd-to-3rd-order Midwestern stream with or without atrazine exposure. CASM_Atrazine predicts daily biomass production of modeled aquatic plant (phytoplankton, periphyton, and macrophytes) and animal (zooplankton, benthic invertebrates, and fish) populations as nonlinear functions of fluctuating environmental conditions, food-web-related interactions, and producer- and consumer-specific sensitivities to atrazine exposure. The primary purpose of this model is to simulate the potential for realistic, time-varying atrazine concentrations to influence producer and consumer biomass and community structure over a one-year period. First, a baseline (no atrazine) stream simulation was developed to model seasonal patterns and magnitudes of producer and consumer community biomass production reflective of Midwestern streams. Second, producer community responses modeled by CASM_Atrazine were compared to measured effects within freshwater micro- and mesocosms exposed to similar atrazine exposure profiles. Importantly, based on these comparisons with experimental data, a no-effect threshold for CASM_Atrazine modeling was established when simulating potential effects of time-variable atrazine exposure on producer communities. Extensive sensitivity analyses were also performed to address the impact of model uncertainties on model performance and robustness. These efforts demonstrated that model parameter variations within the hypothetical parameter space of CASM_Atrazine did not significantly affect modeled assessments of atrazine chemographs derived from the Atrazine Ecological Exposure Monitoring Program. Therefore, CASM_Atrazine is a robust and reliable tool for predicting community-level effects from atrazine chemographs derived from Midwestern lotic ecosystems.

103 Estimating Water Quality Guidelines For Atrazine and Diquat Using Multi-Modal Species Sensitivity Distributions. B. Zajdlik, G. Dixon, University of Waterloo, Waterloo, Ontario, Canada; G. Stephenson, Stantec Consulting Ltd, Guelph, Ontario, Canada. Species sensitivity distributions (SSDs) are being used to generate water quality guidelines globally. In Canada, a suite of potential models has been endorsed as suitable for describing SSDs. However these models might not be suitable for substances with multiple modes of action such as pesticides, herbicides, etc. This is particularly true for those substances with a very narrow biological target. These substances produce multi-modal SSDs where sensitive target organisms comprise one mode of the SSD and non-target organisms comprise the remaining modes. Various options to estimate guidelines from this type of SSD have been discussed. We compare two such options using the estimation of water quality guidelines for atrazine and diquat as examples.

104 Environmentally Relevant Levels of Atrazine in Outdoor Microcosms disrupt Metamorphosis and Sexual Development in *Rana pipiens*. V.S. Langlois, A.C. Carew, V.L. Trudeau, Centre for Advanced Research in Environmental Genomics, University of Ottawa, Ottawa, Ontario, Canada; B.D. Pauli, National Wildlife Research Centre, Environment Canada, Ottawa, Ontario, Canada; M. Wade, Environmental Health Science Bureau, Health Canada, Ottawa, Ontario, Canada; G. Cooke, Toxicology Research Division, Health Canada, Ottawa, Ontario, Canada. We assessed whether concentrations of atrazine within the Canadian guidelines for the protection of freshwater aquatic life are affecting sexual development and metamorphosis in a native North American species, the Northern Leopard frog, *Rana pipiens*. Tadpoles were exposed in outdoor microcosms to nominal concentrations of 0 μ g/L, 0.1 μ g/L and 1.8 μ g/L of formulated atrazine from Gosner stage 25 until stage 42 (at forelimb emergence). HPLC-MS/MS analysis (detection limit = 0.003 μ g/L) indicated that average levels for each treatment were 0.006 μ g/L, 0.13 μ g/L and 2.26 μ g/L atrazine, respectively. These concentrations are comparable to those in water in corn producing areas of Eastern Ontario (0.01–1.55 μ g/L atrazine). Exposure to 17 α -ethinylestradiol (EE2) was used as a positive control. Both atrazine treatments significantly reduced metamorphic success ($p < 0.001$), but this was not accompanied by changes in body weight or snout-vent length. EE2 also delayed metamorphosis. Gene expression analyses of thyroid hormone receptors TR α and TR β and deiodinases type 2 and 3 were performed in tails of tadpoles at Gosner stage 34 and 42. Only deiodinase

type 3 was significantly reduced in Gosner stage 34 tadpoles exposed to 1.8 µg/L atrazine. Gonadal gross morphology showed a significantly higher proportion of females in the 1.8 µg/L atrazine group ($p < 0.05$) compared to controls. However, histological analysis indicated no presence of testicular oocytes (intersex gonads) in males in the control or atrazine treatments at Gosner stage 42. In contrast, 22.2% of males treated with EE2 exhibited an intersex condition. Our study suggests that low environmental levels of atrazine may have important physiological consequences to developing R. pipiens. Supported by Environment Canada, Canadian Water Network, Health Canada, and the NSERC-PG program.

105 Susceptibility of amphibians to estrogenic contaminants: somatic vs. ovarian development. S. Storrs, R.D. Semlitsch, Division of Biological Sciences, University of Missouri, Columbia, MO. Estrogenic contamination is present in amphibian habitats worldwide through surface water runoff, aerial drift, and even rainfall, yet not all amphibian species are equally affected by these estrogens. We examined three species with varying somatic and ovarian developmental rates to assess their susceptibility to estrogenic contaminants. American toads (*Bufo americanus*), gray treefrogs (*Hyla versicolor*), and Southern leopard frogs (*Rana sphenoccephala*) were exposed to 17-β-estradiol (10-7M), three concentrations of a widespread estrogenic herbicide (1, 3, 30 ppb atrazine), or a solvent control (ethanol). All larvae were raised individually in 800 ml of treatment water. Somatic and ovarian developmental stages as well as time to metamorphosis were recorded in subsets of each species. Toads and treefrogs were examined at three weeks and metamorphosis, while leopard frogs were examined at three, six, and nine weeks as well as at metamorphosis. Our results demonstrate that each species displays heterochronic somatic and ovarian development. Further, the more rapid of the two rates determines the susceptibility to estrogenic contaminants. These results suggest that amphibians with shorter larval periods, and therefore quicker somatic developmental rates (i.e. American toads, gray treefrogs), are more susceptible to somatic treatment effects (i.e. prolonged time to metamorphosis) due to estrogenic contaminants. Moreover, the results suggest that amphibians with relatively rapid ovarian development (i.e. Southern leopard frogs) are more susceptible to gonadal treatment effects caused by estrogenic contaminants.

106 America's Next Top Model: Evaluating Species, Population and Experimental Conditions for Studying Endocrine Disruption in Amphibians. T.B. Hayes, V. Khoury, A. Naryan, Integrative Biology, UC Berkeley, Berkeley, CA. The herbicide, atrazine, is a potent endocrine disruptor that chemically castrates and feminizes male amphibians at low ecologically relevant doses (≥ 0.1 ppb). Though effects have been demonstrated in the laboratory and the field, in multiple species, some studies suggest that atrazine is only effective at higher doses or not at all. Though most negative studies suffer from poor design or misinterpretation of data, we considered that the response to atrazine may vary between species, between populations within a species, and with experimental conditions. We examined effects of atrazine on larval growth, development and sex differentiation. We compared effects on leopard frogs (*Rana pipiens*) and African clawed frogs (*Xenopus laevis*). Further, we compared effects using five populations of *R. pipiens*. For *Xenopus laevis*, we compared effects on populations from Capetown and Potchefstroom, South Africa with animals purchased from Nasco Co. (origin unknown), from my UC Berkeley colony, and feral animals collected from San Diego, Irvine, and San Francisco. We observed extreme variation between species and populations. Whereas atrazine induces hermaphroditic development in *X. laevis*, male *R. pipiens* do not develop ovaries, but rather develop testicular oocytes. Further, there was variation between populations within species. Atrazine had no effects on sex differentiation in *R. pipiens* from Utah and *X. laevis* from Capetown. For *X. laevis*, we also compared larval development at 16, 22, and 28°C. Temperature had a profound effect on developmental time. Animals metamorphosed within one month at 28°C, but in excess of three months at 16°C. There were also temperature $\times$ population effects. Potchefstroom animals metamorphosed one month earlier than other populations at 16°C. Populations also differed in the timing of gonadal development, with some populations (San Francisco) metamorphosing with small underdeveloped gonads. The variation between populations may determine sensitivity to atrazine. Populations that develop slower are exposed for a longer period of time and may show greater "sensitivity" to atrazine for this reason, whereas populations with delayed gonadal development may appear less sensitive because their gonads are not differentiated at metamorphosis.

107 Effect of BDE-47 on Drug Metabolizing Enzyme Activities in Rainbow Trout and Human Liver Fractions. K. Johanning, L. Easterwood, J. Hill, J. Sahi, CellzDirect, Inc., Austin, TX. Polybrominated diphenyl ethers and its congeners such as BDE-47 (2,2',4,4'-tetrabromodiphenyl ether) are used extensively as flame retardants in commercial products. BDE-47 is highly lipophilic and has been found at concerning levels in humans and wildlife including aquatic species. BDE-47 exposure has neurobehavioral, endocrinological and developmental effects and there are increasing concerns about the effects of bioaccumulation in fish and fish-eating animals, including humans. BDE-47 alters gene expression in *Oncorhynchus mykiss* (rainbow trout) and is a concentration dependent inhibitor and inducer of cytochrome P450 1A (CYP1A). We have earlier examined the transgenerational effects of BDE-47 on xenobiotic metabolism pathways in rainbow trout livers and found up-regulation of CYP1A (EROD) and CYP3A, no change in UDP-glucuronosyltransferases (UGT) and a decrease in sulfotransferase (SULT) activity. Changes in metabolism of a chemical can significantly affect metabolic activities and thereby bioaccumulation potential. An increase in enzyme activity can decrease bioaccumulation whereas a decrease in enzymatic activity can inhibit metabolism, potentially increasing bioaccumulation. To further characterize the effects of BDE-47 on rainbow trout hepatic drug metabolizing enzymes, we have now conducted inhibition assays using S9 fractions prepared from pooled male trout livers. To evaluate species-specific differences and the effect of BDE-47 on rainbow trout livers, we also conducted studies with pooled human hepatic S9 fractions in parallel, using the same concentrations and probe substrates. Varied patterns of inhibition were found. Our results will aid in predictions of bioaccumulation and also demonstrate inter-species differences in the effect of BDE-47 on drug metabolizing enzymes in rainbow trout and human.

108 A review of bioaccumulation modeling approaches for persistent organic pollutants. C. Barber, B. Rashleigh, US EPA, Athens, GA; W. Munns, US EPA, Narragansett, RI. Persistent organic pollutants and mercury are likely to bioaccumulate in biological components of the environment, including fish and wildlife. The complex and long-term dynamics involved with bioaccumulation are often represented with models. Current scientific developments in this area include how to adequately represent diet, dermal, and gill exchanges, represent food web structure and dynamics, link bioaccumulation models to chemical fate and transport models, incorporate residue-based effects models, and integrate to ecological and human health dietary risk assessment models. The accurate representation of bioaccumulation in models is critical because such models are often used in decision-support. Here, we review and discuss bioaccumulation representations that are needed to support decisions about environmental protection, restoration, and enhancement. Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

109 Lipid-normalized Critical Body Residue Determinations for PBTs Relative to Reproduction and Population Dynamics of Meiobenthic Copepods. T. Chandler, W. Klauber, L. Ferguson, Environmental Health Sciences, University of South Carolina, Columbia, SC; L. Ferguson, Chemistry and Biochemistry, University of South Carolina, Columbia, SC. CBRs linked to population level effects are rare but of ultimate value to risk assessment. Lifecycle-based CBRs of persistent bioaccumulative toxicants (PBTs) were determined via microscale analysis of lipids, copepod bioaccumulation, reproductive effects, and population impacts -- using microplate exposures of meiobenthic copepods and Leslie-matrix population modeling. PBTs were compared for reproductive and population growth effects across copepod test populations as a function of lipid-normalized male and female body burdens (AFs). Bioassays (from hatching through two broods) were done with the PBTs lindane, DDD and fipronil sulfide. Lipid-normalized body burdens were measured as a basis for CBRs of PBTs causing developmental or reproductive toxicity. Life-stage transition probabilities, fecundities and mortalities were used to construct empirical Leslie-matrix population growth models and produce population-growth CBRs. Significant toxic responses were observed for lindane (LD) for delayed total development from nauplius to adult (60.0 and 44.5 pg-LD/µg lipid for gravid females and males), decreased mean viable offspring production (122 pg-LD/µg lipid for gravid females), and decreased fertilization success. The EC50 for decreased reproductive output was 28.2 µg-LD/L. Lipid-normalized CBRs of 354 pg-LD/µg lipid and 253 pg-LD/µg lipid were predicted for males and gravid females respectively, linked to 50% decreased reproduction, at log BCF

values of 4.06 and 3.92. Leslie-matrix modeling predicted a lipid normalized population growth CBR (linked to 50% projected population reduction after three generations) of 60 or 58 pg-LD/ μ g lipid for males or gravid females. For fipronil sulfide (FS) -- concentrations of 0.18, 0.36, and 0.72 μ g/L yielded significant FS toxic effects that spanned delayed naupliar development (at 0.18, 0.36, and 0.72 μ g/L), delayed copepodite development (at 0.72 μ g/L), delayed total development (at 0.18, 0.36, and 0.72 μ g/L), decreased reproductive success (at 0.36, and 0.72 μ g/L), and depressed fecundity (at 0.72 μ g/L). A reproductive output EC50 of 0.16 μ g-FS/L corresponded to CBRs of 0.38 pg-FS/ μ g dry weight or 2.8 pg-FS/ μ g-lipid. A Leslie matrix-based CBR of 1.6 pg-FS/ μ g-lipid would predict a 50% 3-generation population growth suppression relative to empirical controls.

110 Synthesis of Recent Global Efforts to Advance Bioaccumulation Assessment. A.V. Weisbrod, Procter & Gamble, Cincinnati, OH; M. Bonnell, Environment Canada, Gatineau, Quebec, Canada. Bioaccumulation assessments have traditionally relied on a variety of methods, including computer models, fish bioconcentration factor (BCF) tests, biota-sediment measurements, and field monitoring of known persistent organic pollutants (POPs) and other 'priority pollutants'. With ratification of the Stockholm Convention, countries have begun to change their laws and/or procedures to identify previously unrecognized persistent, bioaccumulative, toxic substances (PBTs) in commerce. Through these initial efforts, it became clear that the traditional methods to assess bioaccumulation were insufficient to meet legislated timings, mandatory reductions in animal use, and deliver accurate assessments for the broad diversity of chemicals in commerce at a reasonable cost. To address these needs, a strategic collaborative effort was initiated in 2004 by government, industry, and academia to improve the state of bioaccumulation science and to communicate new approaches for chemical management programs in North America and Europe. This presentation gives an overview of the initial problem areas, the models, and in vitro and in vivo tests that are proposed in weight of evidence or tiered approaches to bioaccumulation assessment. Through several consortia, collaborators are developing more than 15 new methods, databases, and concepts. These advances will be explained in the context of addressing urgent regulatory needs worldwide and how they are being integrated into processes in Canada, the EU REACH implementation projects (RIPs), at the OECD level, and the 2008 Pellston Workshop developing guidance to assess POPs at the global level. Although the collaborative efforts to date have largely focused on fish and estimating BCF, work is expanding to explore bioaccumulation in other biota and methods with greater field relevance. A forecast of activities by the consortia, including the Bioaccumulation SETAC Advisory Group, will be presented.

111 The role of stable isotopes analysis in modelling trophic transfer of persistent organic pollutants in Irish marine species. B. McHugh, E. McGovern, Environmental Chemistry, Marine Institute, Galway, Galway, Ireland; B. Foley, School Of Pharmaceutical Sciences, Dublin Institute of Technology, Dublin, -, Ireland. The utilisation of stable isotope fractionation techniques to describe diverse environmental and biological processes is well documented. One of the most significant applications of the technique lies in the measurement of the degree of fractionation of nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$) in marine species to assess relative trophic level status in biotic systems and to assess dietary carbon sources in aquatic biota where trophic level status can be expressed as the relative position of constituent organisms within an ecosystem to each other. Stable isotope techniques have also been shown to provide a quantitative, continuous variable to study biomagnification of contaminants and to demonstrate trophic interactions within complex food webs. While the biomagnification of POPs in lower trophic level species and top of food web predators in Arctic and other regions has been completed few such assessments are available in marine species from Irish waters. A detailed study of biomagnification/bioaccumulation of POPs and the potential role stable isotope derived trophic position plays in describing contaminant levels/profiles in Irish marine species has not been previously been reported. This current work describes the completion of an isotopic ratio based evaluation of the structure of the Irish marine web for a number of selected species, derivation of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ baseline information for the primary consumer blue mussels (*Mytilus edulis*) from Irish waters, assignment of relative trophic status to constituent members of the web and investigates the potential application of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ isotope ratios in modelling lipid and persistent organic pollutant bioaccumulation in marine organisms from Irish waters.

112 Accumulation of trifluralin in two aquatic invertebrates: Formation and persistence of unextractable biotransformation products. M.B. Dudley, J.B. Belden, Environmental Studies, Baylor University, Waco, TX. Trifluralin is one of the top ten most heavily used active ingredients in pesticides in the United States. It is also listed as a persistent, bioaccumulative, and toxic chemical by the US EPA. Although trifluralin itself has previously been demonstrated to accumulate in biota, the extent of adduct, or unextractable residue, formation is not known. Other nitroarene compounds such as trinitrotoluene and musk xylene have been frequently reported to form unextractable residues. In this study, two aquatic invertebrates, *Lumbriculus variegatus* and *Hyalella azteca*, were exposed in aqueous media to ^{14}C -labeled trifluralin. Following exposure, the accumulation of ^{14}C -trifluralin was determined in the organisms (both extractable and unextractable portions). Extracts were analyzed using chromatography and scintillation counting to separate parent compound and biotransformation products. In *L. variegatus*, almost all radioactivity was recovered as extractable parent trifluralin indicating limited biotransformation. In *H. azteca*, unextractable residues accounted for a significant amount of total body residue. After 72 hours of continuous uptake, unextractable residues accounted for ~50% of total radioactivity recovered from the organisms. Biological half lives for extractable and unextractable trifluralin were 38.5 hours and 91.18, respectively. Thus, after 96 hours of depuration, unextractable residues accounted for ~65% of total trifluralin residues. Due to the extent of unextractable residues, further research investigating the ecotoxicology and trophic transfer of unextractable residues is needed.

113 The Case of the Mysteriously Declining PAH Bioaccumulation Factors in the Estuarine Oligochaete, *Monopylephorus rubroniveus*. T.R. Garner, J.E. Weinstein, Department of Biology, The Citadel, Charleston, SC; D.M. Sanger, South Carolina Sea Grant Consortium, Charleston, SC. *Monopylephorus rubroniveus* is a cosmopolitan tubificid oligochaete worm that is associated with fine sediments in estuaries, both intertidally and shallow subtidally. In southeastern U.S. tidal creek-salt marsh environments, it is the numerically dominant macrobenthic organism during certain seasons, having population densities as high as 90,000 individuals/ m^2 . Previous laboratory toxicological studies involving *M. rubroniveus* have demonstrated that this species is highly tolerant of sediment-associated fluoranthene, a common PAH congener found in these systems. These laboratory studies have also demonstrated that fluoranthene bioaccumulation in these oligochaetes is not concentration-dependent, with bioaccumulation factors (BAFs) significantly decreasing as a function of increasing sediment PAH concentration ($r^2=0.93$, $p=0.0001$). Subsequent field studies examining total PAH tissue residues in *M. rubroniveus* collected from tidal creeks with different land use classifications found a similar pattern. Oligochaetes from urbanized tidal creeks, with relatively high sediment concentrations of PAH, had significantly lower BAFs compared to oligochaetes from reference creeks ($p=0.014$). The fact that PAH bioaccumulation becomes less efficient with increased contamination may be related to stress-related physiological changes in these oligochaetes and probably contributes to their extreme tolerance of PAH.

114 Forecasts and sensitivity of PCB bioaccumulation in fish of Lake Hartwell, South Carolina, USA. B. Rashleigh, C. Barber, US EPA, Athens, GA; D. Walters, US EPA, Cincinnati, OH. The EPA aquatic ecosystem model AQUATOX was applied to the Twelvemile Creek arm of Lake Hartwell, which received 400,000 lbs of PCBs from the Sangamon-Weston Superfund Site near Clemson, South Carolina, USA, from 1955 until the early 1990s. AQUATOX was used to characterize food web dynamics, simulate bioaccumulation, and identify important pathways of contaminants to higher trophic levels. The model was also used to estimate the time needed for PCB concentrations in all fish to be reduced to target recovery levels. Under the scenario of constant tributary flows, no new external loadings, and a linear decline of existing loadings, the model calculated that target recovery levels should occur in approximately 6 years. We used new capabilities in AQUATOX Release 3 for comprehensive sensitivity analysis of the model results. A sensitivity analysis of fish PCB concentrations to a 10% decrease in individual parameter values revealed the strongest responses to fish consumption rate (+200 for bass%), input nutrient concentrations (+179% for catfish), and optimum temperatures for fish (+140 for bass%). Largemouth bass and channel catfish were more generally sensitive to parameters changes than shad and bluegill. High sensitivities of certain parameters indicate uncertainty in forecasts for bioaccumulation in this system. Although

this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

115 Variation in Soot Carbon-Water Partition Coefficients: Native versus Added PAHs. W.A. Thorsen, Exponent, Bellevue, WA; D. Shea, Environmental and Molecular Toxicology, North Carolina State University, Raleigh, NC. Recent evidence demonstrates strong sorption of polycyclic aromatic hydrocarbons (PAHs) and other hydrophobic organic contaminants (HOCs) to the soot carbon sorptive phase in soils and sediments. Empirically derived soot carbon-water partition coefficients (K_{sc}) are, in many cases, orders of magnitude greater than organic carbon water partition coefficients for the same individual analytes, but are not readily available in the literature. Much of the recent work demonstrates decreased chemical and biological availability of PAHs as a result of adsorption to soot carbon. However, the modeling of this increased sorption is complicated by effects of PAH sources on chemical and biological availability, independent of soot carbon content. Limited research has evaluated differences in soot carbon sorption between native and added PAHs. In this work, we demonstrate increased K_{sc} values for multiple native PAHs compared to PAHs added exogenously. Although K_{sc} values for native and added PAHs are linearly associated with contaminant hydrophobicity (K_{ow}), the type (or source) of soot carbon (e.g., traffic soot versus oil soot) further affects the degree of soot carbon partitioning. This work provides additional information to elucidate possible sorption mechanisms between PAHs and soot carbon, and has application for manufactured gas plants and similar industrial sites where PAH contaminants formed in tandem with soot may have substantially decreased bioavailability.

116 Which PAHs and Sediment Characteristics Are Most Important for Causing Toxicity to *Hyalella azteca*? S.B. Hawthorne, D. Miller, C. Grabanski, Energy and Environmental Research Center, University of North Dakota, Grand Forks, ND; J. Kreitinger, N. Azzonlina, RETEC, Inc., Ithaca, NY. The EPA's hydrocarbon narcosis model lists 18 parent and 16 groups of alkyl PAHs (PAH-34) that should be measured in sediment and/or sediment pore water in order to estimate potential toxicity to benthic organisms. Ideally, methods would focus on those PAHs that are most responsible for toxicity, however, there is very little information available about the relative importance of the two- to 6-ring PAHs and parent vs. alkyl PAHs in the PAH-34 list. We have performed these measurement and determined 28-day toxicity to *Hyalella azteca* on 100 sediments collected from 8 manufactured gas plant (MGP) and aluminum industry sites. The initial data analysis shows several significant trends including (1) Sediment PAH concentrations have little or no relationship to toxicity, (2) toxicity predicted based on equilibrium partitioning (K_{oc}) also shows a weak relationship to toxicity, and (3) measured pore water concentrations are good predictors of toxicity. Most importantly, the majority of toxicity (ca. 80%) was caused by alkyl PAHs, and not the parent PAHs which are the focus of most studies. In addition, since the majority of toxicity is associated with lower molecular weight PAHs, there is little difference in the toxicity predicted whether 'freely-dissolved' or 'total-dissolved' pore water concentrations are measured. Additional sediment characteristics including TOC, black carbon (BC), texture, dissolved organic matter (DOM), and the presence of NAPL are currently being investigated, and their relationships to *Hyalella* toxicity will be reported.

117 A SPME-based passive sampler for dissolved organic contaminants in sediment porewater. K. Maruya, D. Tsukada, D. Greenstein, S. Bay, SCCWRP, Costa Mesa, CA; Z. Yang, E. Zeng, Chinese Academy of Sciences, Guangzhou, China. Because elevated concentrations of sediment-associated persistent organic pollutants (POPs) (e.g. PCBs, DDT, chlordanes and PAH) pose a risk to the health of aquatic systems, they are subject to an emerging category of environmental regulation – sediment quality objectives (SQOs). Although bulk sediment concentrations are typically used to generate chemical specific SQOs, these data are not universally predictive of bioavailability (and thus effects) due to heterogeneity of sediment-POP interactions. The dissolved fraction of POPs in sediment porewater offers a perhaps more relevant measure of what is bioavailable to sediment dwelling organisms. To that end, we recently developed a passive sampler using commercially available solid phase microextraction (SPME) fibers capable of determining dissolved phase POPs at ng/L or lower concentrations in sediment porewater. Equilibrium fiber calibration experiments using ^{14}C -labeled analogs resulted in quantitative mass balances and confirmed equilibrium values of fiber-water partition coefficients (K_{fs}). Static time-series experiments with sediments spiked with 12 model POPs revealed that chemical-specific equilibration times ranged from several days to several weeks.

A sediment concentration series 60 d equilibrium experiment indicated that dissolved POP concentrations in porewater correlated well with both sediment and total porewater concentrations, the latter determined independently. Preliminary results from a direct comparison of invertebrate body burdens and SPME porewater concentrations using laboratory microcosms should be available at the time of presentation. Although not yet designed for rapid assessment, this approach may supplement or eventually replace bulk sediment chemistry as an essential line of evidence for assessing sediment quality.

118 Applying Flocculation and Isotope Dilution-Solid Phase Microextraction for Determining Freely Dissolved Nonionic Organic Contaminants in Pore Waters. D. Thal, Sediments and Tissues, TestAmerica Severn Trent Laboratories, Knoxville, TN. The EPA has developed equilibrium sediment benchmarks and risk assessment guidance based on a traditional strategy for determining exposures of benthic receptors (i.e., estimating pore water concentrations from sediment organic carbon concentrations) as predicted by equilibrium partitioning theory. In this strategy, estimates of freely dissolved pore water concentrations of nonionic organics are derived from organic carbon concentrations, via equilibrium partition coefficients (K_{OCs}). This indirect approach has emerged due to difficulties in generating enough pore water for analysis, and the absence of a way to selectively extract freely dissolved analytes. The approach works on the assumption that organic carbon controls the equilibrium. A growing body of literature indicates that where black carbon is present, the equilibrium is not well predicted by this approach. Indeed, literature K_{OCs} produce thousand-fold overestimates of dissolved PAH concentrations. Black carbon exists in varied mixtures of heterogeneous forms. As a result reliable generic black carbon partitioning coefficients will be elusive. Fortunately, new techniques and methods are emerging that provide more direct measures of freely dissolved concentrations. Hong & Ghosh et al. have demonstrated a straightforward flocculation method for removing particles and colloids, leaving the dissolved concentrations essentially unaltered and available for analysis. Hawthorne et al. have applied this technique to generate pore waters that are amenable to analysis by isotope dilution-solid phase microextraction (ID-SPME). They developed and reported a method which provides freely dissolved concentrations at sub ug/L to low ng/L (depending on analyte solubility). It is significant that these sensitivities, which rival those from a 1 L liquid-liquid extraction, are achieved using a few mL of pore water. An interlaboratory validation study was completed this year. This presentation provides more specific information on the difficulties with the traditional approach, and reports on our experience as a commercial laboratory in setting up for the analysis, learning the analytical techniques and participating in interlaboratory validations. It provides an evaluation of the performance capabilities of the method and recommended quality assurance elements and discusses broader applications of the approach.

119 Bioavailability of particle-associated cadmium and fluoranthene to the nematode *Caenorhabditis elegans* measured with biomarker of exposure and effects on reproduction. W. Ahlf, A. Matthäi, K. Offermann, Institute of Environmental Technology and Energy Economics, TUHH, Hamburg, Germany. The uptake routes and bioavailability of cadmium are investigated by quantitative determination of mRNA expression of the cadmium responsive gene *cdr-1* in *Caenorhabditis elegans*. At first water and bacteria were tested as exposure routes of cadmium. Results showed that dietary cadmium uptake is the major pathway for metal effects and accumulation in the nematode. Body burden and gene expression rate indicate a negligibly less cadmium uptake by water, but less *cdr-1* expression was observed after exposure via particles with different surface functional groups also. In all cases the effects are reversible and no inhibition of reproduction could be observed. The polycyclic aromatic hydrocarbon (PAH) fluoranthene (Flu) was exposed in the same way to the nematode. After the incubation a whole life cycle test (96h) was performed. The worms were able to recover completely from short time exposure in high concentrated Flu media, but not from long time exposure in low concentrations. Second the induction of the gene expression of a Cytochrome P450 Monooxygenase (CYP35C1) was examined via Real-Time PCR after the exposure time. Gene expression and effects on the chronic parameters were compared to find a relationship between the gene induction and the capacity of the whole organism to recover from the toxic stress.

120 A Decision Process to prioritize the Need for Bioavailability Testing at Contaminated Sediment Sites. E.S. Dillon, CH2M HILL, Okemos, MI. The bioavailability of contaminants in sediment is known to

be controlled by various partitioning dynamics and geochemical processes. However, the chemical form that the contaminant entered the aquatic environment can also play a significant role, affecting the utility of the commonly applied bioavailability models and measurements. In many cases the application of standard bioavailability models and measures may overestimate risk or may not adequately explain observed effects at sediment sites. A decision process was developed to help prioritize the need for and the selection of standard and/or non-standard approaches for addressing bioavailability at contaminated sediment sites. The process addresses the contaminant source and subsequent fate as it enters the aquatic environment. The application of the decision process will be illustrated using a variety of site examples covering a range of potential sediment contaminants and source conditions.

121 The speciation and distribution of selenium in a contaminated lake ecosystem in Northern Canada. C.I. Wiramanaden, E.K. Forster, K. Liber, Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; C.I. Wiramanaden, I.J. Pickering, Department of Geological Sciences, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Selenium bioaccumulates in sediments and lower trophic level organisms. Therefore, seemingly innocuous water-borne concentrations can result in high selenium concentrations in sediments, macroinvertebrates and fish. The route and magnitude of exposure cannot be predicted using water-borne concentrations, instead the transfer of selenium among all environmental compartments must be understood. This transfer is controlled by selenium speciation. The Key Lake system in Northern Saskatchewan has experienced decades of exposure from uranium milling. However, the spatial distribution of selenium and its partitioning among environmental compartments are not well understood. The work presented here will focus on the relationship between selenium speciation and concentrations in abiotic and biotic components. We describe the Se distribution throughout several lakes impacted by selenium in milling effluent. Using total Se concentrations (analysed using ICP-MS) and analysis of chemical speciation (using X-ray absorption near edge spectroscopy), we present site-specific relationships between Se in benthos and their environment. We sampled twenty-four sites over five lakes; four with increasing distance from the effluent discharge point and one upstream reference lake. Sediment cores, water, pore water and benthos were analysed for total Se, while select samples were also analysed for Se speciation analysis. Lake and pore water Se concentrations show a gradient from 18 to 1ppb with distance from the discharge point. However, there was no obvious relationship between Se concentrations in benthos and those in water or pore water. Sediment Se concentration and speciation will also be presented in an effort to relate levels in benthic macroinvertebrates to Se speciation and bioavailability in sediment.

122 Assessment of the Ecological Effects of Arsenic on a Southern Ohio (USA) Stream. G.M. Huddleston, ENTRIX, Inc., Pendleton, SC; B. Gillespie, ENTRIX, Inc., Houston, TX; P.B. Dorn, D.C. Wong, Shell Health, Houston, TX. Davis Creek is a southern Ohio (USA) stream that receives a permitted discharge from the Belpre Elastomers Plant. Concentrations of arsenic in sediments of Davis Creek exceed ecological screening benchmarks. To address this concern, a sediment quality triad investigation was conducted over a two-year period that included sediment and surface water chemistry measurements, toxicity tests of whole sediment, interstitial water, and surface water, and benthic and artificial substrate community assessments. The concentration of arsenic in surface and interstitial water was below U.S. Environmental Protection Agency ambient water quality criteria and was not toxic in laboratory tests (*Ceriodaphnia dubia*, *Pimephales promelas*). Similarly, sediments did not significantly affect survival of *Hyalella azteca* and *Chironomus tentans*. Further, only a single sediment sample adversely affected growth of *H. azteca*. Differences in benthic community structure, determined by rapid bioassessment and Hester-Dendy sampling, were primarily related by variations in sediment moisture, particle size, and ammonia, and not to variation in arsenic concentrations. The Invertebrate Community Index (ICI) for Davis Creek was lower than values established for other warm water ecoregional reference streams in Ohio. However, this ICI comparison may have been invalid because, unlike the reference streams, the Davis Creek watershed is small with intermittent headwater flow that severely limits recruitment and nutrient input. Results of the sediment quality triad investigation did not indicate that Davis Creek was biologically impaired as a result of sedimentary arsenic originating from the NPDES discharge.

123 Wetland Sediment Treatment Using Lead Stabilization Amendments. D.R. Lavoie, CH2M HILL WDC, Chantilly, VA; M. Niemet, CH2M HILL CVO, Corvallis, OR; J. Blount, CH2M HILL, Otis ANG, MA; J.L. Staszak, CH2M HILL VBO, Virginia Beach, VA; S.A. Hurff, NAVFAC-Washington, Washington, DC. A former rifle range at Naval Air Station Patuxent River (St. Mary's County, Maryland) has contributed to elevated lead levels in downgradient wetland sediments. The detected lead concentrations in wetland surface water exceeded federal Ambient Water Quality Criteria. Apatite IITM was identified as a candidate sediment amendment material to reduce the bioavailability and concentrations of lead in wetland surface water. While Apatite II™, a phosphate-based material, has been successfully used to reduce lead solubility and bioavailability in groundwater, surface water, and riverine sediments (Wright et. al., 2004, Kaplan and Knox 2004), no field applications or laboratory studies have demonstrated its effectiveness in organic acid-rich environments common to wetlands. In addition, the phosphate present in the Apatite II™ could contribute phosphorus loading in the presence of such organic-acid rich wetland environments. These important uncertainties were assessed via bench- and field-scale testing to determine feasibility for full-scale field application. These tests simulated interactions between amended and un-amended wetland sediments to determine its effectiveness as an amendment to reduce the bioavailability of lead in the wetland environment under varying remedial conditions (e.g., excavated vs. unexcavated) and potential nutrient loading and subsequent ecological impacts. Based on the test results, Apatite II™ was not recommended for application primarily because: 1) excavation alone resulted in lead reductions in surface water; and 2) potential long-term, phosphorus-driven changes to the ecology and geochemistry of the wetland system might cause increases in lead mobility. This presentation summarizes the findings of both the bench- and field-scale tests and pilot studies.

124 In Vitro Debromination of PBDEs in Carp Liver. S.M. Kelly, H.M. Stapleton, Nicholas School of the Environment, Duke University, Durham, NC; C.L. Mitchelmore, Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomons, MD. Polybrominated diphenyl ethers (PBDEs), a class of flame retardants that have been found in increasing levels in biota in recent years, have been shown to undergo reductive debromination in several animal models. The cellular mechanism responsible for the biotransformation of PBDEs has not been elucidated, however, we hypothesize that either deiodinases (DI) or glutathione S-transferases (GSTs) are involved. The current study was designed to determine which enzyme(s) catalyze the debromination of PBDE congeners in common carp (*Cyprinus carpio*). Carp was utilized for this study because our previous work has demonstrated that carp have an increased ability, relative to other fish species, to debrominate BDE congener 99 to BDE 47 in vivo and in vitro. Hepatocyte microsomal and cytosolic fractions were prepared from the livers of three individual adult carp. The cell fractions were incubated with BDE 99 or BDE 153 at 25°C for 90 minutes. While BDE 153 was not debrominated in either cellular fraction, BDE 99 was debrominated to BDE 47 at similar rates in both microsomal and cytosolic fractions in each fish. Inter-individual variation was high, with percent conversion of BDE 99 to BDE 47 ranging from 6.5–13 % in microsomes and 0.05–11% in cytosol. The addition of iodoacetate, a known inhibitor of DIs and a possible inhibitor of GSTs, completely inhibited the debromination of BDE 99 in both cellular fractions. N-ethylmaleimide, a reported activator of microsomal GSTs, did not affect debromination in the microsomal fraction. Examination of the mass balance in these experiments indicates that not all of the BDE 99 that is lost during incubation is debrominated to BDE 47 and we were unable to detect OH-BDEs metabolites in any of the incubations. These results suggest that a portion of BDE 99 (up to 29% in the microsomes and up to 25% in the cytosol) may be covalently binding to biomolecules in the cellular fraction, rendering it unextractable. Additional investigations are currently underway to further explore which enzyme systems are mediating debromination of BDE 99 in this species and to determine the fate of the portion of BDE 99 not accounted for in the mass balance.

125 Investigating the Role of Deiodinases in the Debromination of BDE Congeners in Common Carp (*Cyprinus carpio*) Liver and Intestinal Microsomes. C.L. Mitchelmore, R.T. Benedict, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, Solomons, MD; S.B. Brown, National Water Research Institute, Environment Canada, PO Box 5050, Burlington, Ontario, Canada. The debromination of polybrominated diphenyl ether (BDEs) congeners has been demonstrated

in whale, rat, rainbow trout and carp microsomes. This research investigated deiodinases (DIs) as the potential mechanism for BDE debromination. Juvenile carp (*Cyprinus carpio*) intestinal and hepatic microsomes were incubated with radioactive thyroid hormones, 2,4,4',6-tetrabromodiphenyl ether (BDE-75), BDE-99 (2,2',4,4',5-pentabromodiphenyl ether), a DI inhibitor (iodoacetic acid), and/or competitor (reverse thyronine). Radioactive deiodination assays were analyzed for iodothyronine products by high performance liquid chromatography (HPLC). BDEs were analyzed by gas chromatograph, mass spectrometer operated in electron capture, negative chemical ionization mode (GC/ECNI-MS). BDE-75 was not debrominated by carp liver and intestinal microsomes yet BDE-75 significantly inhibited ($p < 0.05$) thyroxine outer-ring deiodination (T4ORD) by $26 \pm 11\%$ and $19 \pm 19\%$ respectively. In liver and intestinal microsomes $85 \pm 51\%$ of BDE-99 debrominated to BDE-47 (2,2',4,4'-tetrabromodiphenyl ether) but did not modify DI activity. T3 inner ring deiodination (T3IRD) was not apparent in liver microsomes and not consistent in intestinal samples. These in vitro BDE studies suggest that: 1) BDE-99 debromination is not likely occurring by deiodinase enzymes and 2) BDE-75 can inhibit T4ORD which may affect T3 concentrations within tissues.

126 Evidence of metabolic debromination of decabromodiphenyl ether (BDE-209) occurring in the aquatic environment. M. La Guardia, R.C. Hale, T. Mainor, E. Harvey, Virginia Institute of Marine Science, Gloucester Point, VA. Polybrominated diphenyl ethers (PBDEs) are commonly used brominated flame-retardants (BFRs). They are environmentally persistent and have become widely distributed. PBDEs can bioaccumulate and disrupt biological processes, e.g. the endocrine system. However, identification of their major routes of release into the environment is lacking. To date, the majority of PBDEs detected in biota contain six or fewer bromines, presumably from the recently discontinued commercial penta-PBDE product. However, the dominant PBDE product in commerce, the deca-formulation (decabromodiphenyl ether (BDE-209) >97% by weight) remains in commerce, as it is believed to pose comparatively minimal risk. Nonetheless, concerns exist over the possible debromination of deca- into more bioaccumulative congeners. However, this has only been shown under laboratory conditions. To evaluate the potential for debromination under realistic environmental conditions the distribution of PBDE congeners were tracked in a variety of matrices from a wastewater treatment plant (WWTP) sludge to receiving stream sediments and associated aquatic biota. BDE-209 was the major congener detected in sludge (58.8 mg/kg, d.w.), sediments (6.2 to 3150 mg/kg, %TOC) and some biota (non-detect to 21,650 $\mu\text{g/kg}$, l.w.). Also detected in these matrices were 22 additional PBDEs. Sludge congener profiles were similar to the penta- and deca- formulations, suggesting minimal -209 debromination during wastewater treatment. Similar profiles were also observed in surficial sediments collected at the outfall and several km downstream, again indicating minimal debromination. However, sunfish (*Lepomis gibbosus*), creek chub (*Semotilus atromaculatus*) and crayfish (*Cambarus puncticaudatus* sp. c) collected near the outfall contained tri- through deca-PBDEs, including congeners not detected in the commercial deca- mixture, sludges or sediments (BDE-179, -184, -188, -201 and -202). A previous laboratory study identified these PBDEs as BDE-209 debromination products in fish. This suggests that metabolic debromination of -209 does occur in the aquatic environment under realistic conditions. Hence risk assessments that assume no BDE-209 debromination may underestimate associated bioaccumulation and toxicity attributable to the less brominated congeners produced.

127 Water column partitioning of BDEs in the New York/New Jersey Harbor. L.A. Rodenburg, A. Zarnadze, Environmental Sciences, Rutgers University, New Brunswick, NJ. Despite their emerging concern, few measurements of polybrominated diphenyl ether (BDE) concentrations in ambient water have been published. In this study, BDEs were measured in water samples from the New York/New Jersey Harbor. Samples were taken in Raritan Bay during 4 intensive sampling campaigns in 2000-2001. BDEs 17, 47, 100, 99, 154, 153, 183, and 209 were detected. The average sum of BDE concentrations in the particle and apparent dissolved phases were 175 ng/g solids and 110 pg/L, respectively. These levels are as much as 100 times higher than levels measured in other aquatic systems. BDE 209 constituted ~85% and ~9% of the sum of BDEs in the particle and apparent dissolved phases, respectively. Three pieces of evidence suggest that a significant fraction of BDEs in the water column are sorbed to DOC. First, the detection of BDE 209 in the apparent dissolved phase is an indicator of sorption because this

extremely hydrophobic molecule should strongly prefer the particle phase. Second, the plots of log K_{oc} (organic carbon-water partition coefficient) vs. log K_{ow} (the octanol-water partition coefficient) display slopes significantly less than 1. Third, log K_{oc} displays a significant decline with increasing total suspended matter (TSM), i.e. the so called "solids concentration effect". Three models were used to attempt to quantify the extent of colloid sorption, but the three gave very different results, suggesting that further research is needed to understand the water column partitioning of BDEs.

128 Polybrominated Diphenyl Ethers (PBDEs) in the San Francisco Estuary. S. Klosterhaus, D. Oros, J. Oram, D. Yee, C. Grosso, San Francisco Estuary Institute, Oakland, CA; F. Rodigari, East Bay Municipal Utility District, Oakland, CA; D. Crane, Water Pollution Control Laboratory, California Department of Fish and Game, Rancho Cordova, CA; R. Grace, Axy's Analytical Services Ltd., Sidney, British Columbia, Canada. California has the most stringent fire safety regulations in the United States and subsequently PBDE concentrations in people and wildlife from the San Francisco Bay are among the highest reported to date. Since 2002, the Regional Monitoring Program for Trace Substances (RMP) has been monitoring PBDE concentrations in water, surface sediment, and bivalves from the San Francisco Estuary. In addition to these annual data collections, PBDE concentrations have also been determined in sport fish, eggs from double-crested cormorants, and harbor seals. The discussion will focus on the variation in congener patterns among biotic and abiotic matrices, as well as concentration time trends and comparisons to other locations. Despite only recently effective bans of the Penta- and Octa-BDE commercial mixtures in California, RMP monitoring data suggest that declines of PBDEs in cormorant eggs and bivalves may already be occurring. A mass budget of PBDEs in the San Francisco Estuary was recently completed which also investigated concentrations of PBDEs in wastewater effluent and surface water entering the Estuary from local watersheds and the Sacramento - San Joaquin River Delta. Relationships between potential source congener patterns and accumulation in biota will also be discussed.

129 A Mass Budget of Polybrominated Diphenyl Ethers in San Francisco Bay, CA. J.L. Oram, L.J. McKee, M.S. Connor, D.R. Oros, SFEI, Oakland, CA; C.E. Werme, Consultant, Berkeley, CA. A mass budget of polybrominated diphenyl ethers (PBDEs) in San Francisco Bay was developed as a first step towards understanding the local sources and transport processes controlling PBDE fate in a highly urbanized estuary. Extensive monitoring of PBDEs in estuarine water and sediment, local watersheds, air, and wastewater effluents and sludges was integrated with a mass budget model to establish a plausible range of PBDE loads to San Francisco Bay. Estimates of BDE 47 loads ranged from 11 to 28 kg/yr with wastewater effluents as the largest contributor. Estimates of BDE 209 loads ranged from 22 to 24 kg/yr with runoff from local watersheds being the largest contributor. The mass budget model was additionally used to provide an informative assessment of the future trajectory of the Bay under likely environmental conditions. Results indicate that San Francisco Bay is at a critical juncture in terms of its future trajectory; it is plausible that Bay inventories will decline with only a slight reduction in external PBDE loads.

130 Comprehensive mass balance evaluation of PBDEs in landfill leachate and potential for transfer from E-waste. M.N. Danon-Schaffer, A. Mahecha-Botero, J.R. Grace, Chemical & Biological Engineering, University of British Columbia, Vancouver, British Columbia, Canada. A comprehensive mechanistic mass balance model is under development to predict the environmental fate of polybrominated diphenyl ethers (PBDEs) in landfills, with possible extension to other systems. The mass balances, applied to different homologue groups and to different sub-systems - field e-waste, soil, air and water - include input streams, degradation, transfer between compartments and accumulation. The model uses as input upstream sources of PBDEs in the electronic waste (e-waste) stream (personal computers, printers, hard drives, circuit boards, keyboards, mice). The model predicts time-dependant variation of group concentrations in the different subsystems. Landfill conditions are obtained from experimental field measurements. Key mass transfer parameters are obtained from experiments conducted in a solid-liquid contacting chamber with crushed electronic equipment exposed to landfill leachate. Several scenarios are simulated depending on the source of PBDEs. The modeling predictions indicate that higher-molecular-weight PBDE congeners degrade more quickly than lower molecular weight congeners. The transient model predicts that the time of decay of PBDEs from e-waste added to the landfills is of the order of ~13 years. Even if there

were to be a total ban on PBDEs so that no further additions were made to manufactured products, the accumulated active products would, given their life expectancy, continue to result in PBDEs entering landfills for a much longer period of time.

131 Current-Use Flame Retardants in Sediments of the Lower Great Lakes. C. Marvin, E. Sverko, D. Zaruk, K. Pleskach, Environment Canada, Burlington, Ontario, Canada; G.T. Tomy, Department of Fisheries and Oceans, Winnipeg, Manitoba, Canada; P. Helm, Ministry of the Ontario Environment, Toronto, Ontario, Canada. Little information exists on the distribution of certain current-use flame retardants, beyond polybrominated diphenyl ethers (PBDE), in the environment. It is important to gain further knowledge in this respect as these chemicals become alternates to the PBDE formulation. For example, 1,2-bis(2,4,6-tribromophenoxy)ethane (BTBPE) and decabromodiphenyl ethane (DBDPE) have been reported to replace the octa-BDE and deca-BDE mixtures, respectively. Concentrations of BTBPE, DBDPE, 2,3,4,5,6-pentabromomethylbenzene, pentabromotoluene, 2,3,5,6-tetrabromotoluene and tetrabromo and 1,2-dibromo-4-(1,2-dibromoethyl)cyclohexane (TBECH) were determined for surficial sediment in Lakes Ontario and Erie and cores from the central and western basins of Lake Erie. Measured levels were in the pg/g to ng/g range.

132 Atmospheric Deposition as a Source of Hexabromocyclododecanes and Polybrominated Diphenyl Ethers to Coastal Water. A.M. Peck, Skidaway Institute of Oceanography, Savannah, GA. The ubiquitous occurrence of the polybrominated diphenyl ethers (PBDE) and hexabromocyclododecanes (HBCD) in aquatic environments is well documented. The sources and fate of these contaminants in these systems is relatively understudied, especially for HBCD. The objective of this study is to quantify the atmospheric inputs of these compounds to coastal water in the southeastern United States. Precipitation samples are currently being collected to determine the wet deposition of these flame retardants. Periodic high-volume air samples are also being collected and will be used to determine gas-phase and particulate-phase air concentrations of three HBCD isomers (α -HBCD, β -HBCD, and γ -HBCD) and a suite of PBDE congeners including BDE 47, BDE 99, BDE 100, BDE 153, BDE 154, and BDE 209. Concentrations of these compounds associated with atmospheric particulates will be used to estimate dry deposition. Paired dissolved-phase and gas-phase concentrations will be used to calculate net and gross gaseous deposition and volatilization.

133 Biomonitoring of Fourche Creek to Assess Stream Conditions and Manage an Urbanized Arkansas Watershed. T.C. Hudson, J. Farris, Environmental Sciences, Arkansas State University, Jonesboro, AR. Increased demand on ecosystem services is currently a driving force for cities worldwide to assess and/or maintain their watersheds; this includes the metropolitan area of Little Rock, Arkansas. These demands in the Fourche Creek watershed have directed a need for assessment of ecological values, conditions, and costs for sustainable and low-impact development. Eight sites along Fourche Creek were sampled following three rain events and during two periods of stream base flow from 2005-2006. Stream reach habitat, water quality, and laboratory biomonitoring was used to characterize ambient site water and sediment conditions. Water quality variables tended to differentiate by the influence of contributing runoff of each sampled event, with no significant differences among the sites for any sampling period, but significant differences among events ($p \leq 0.05$). Nitrate, for example, was significantly different for each sample event ($p < 0.001$). Pimephales promelas survival was significantly reduced in water sampled from three sites during periods of reduced stream flow and after rain events. Ceriodaphnia dubia survival and reproduction and P. promelas growth were not significantly reduced in waters from Fourche Creek. Chironomus dilutus survival was significantly reduced (mean survival $\leq 38\%$) in sediments collected from three sites during both periods of reduced stream flow. Measured organism impairment was attributable to reach-specific habitat variables that supported less conducive media for sediment tests (i.e. reduced organic content). These findings indicated that water quality issues along the watershed fluctuated with the contribution of overland flow. These fluctuations reemphasized the need for more robust and diverse monitoring tools and assessments capable of accounting for the influence of multiple factors on the Fourche Creek watershed.

134 The Water Research Strategy: Research Needed for Aquatic Ecosystem Protection Programs in the Office of Water-US EPA. M. Reiley, Office of Science and Technology, US Environmental Protection Agency,

Washington, DC. The talk will present the Water Research Strategy for the Office of Water-US EPA. The US EPA Office of Water implements aquatic life and ecosystem protection legislation which promote the Office's goal to protect and improve the chemical, physical, and biological integrity of the nation's waters. By doing so, ambient waters in the United States are of sufficient quality to achieve their designated uses be they human uses such as recreational, commercial, or subsistence fishing or aquatic life and wildlife uses such as spawning and eating. The US water environment has improved significantly under the technology and water quality based toxics point source control programs. And though these aquatic ecosystem pressures remain, the chemicals of concern, the sources that contribute them to the environment, and the impacts are changing. Questions of science are emerging as fast, or faster, than we can put them to rest. There are questions about: pollutant bioavailability, mixtures, mode of action, cause and effect, relevant assessment and measurement endpoints, reducing uncertainties, interspecies extrapolation. OW is also working to determine the state of the Nation's waters and impacts of urbanization. Approaches are needed to evaluate alternative remedial and protective actions, to determine recovery potential, to understand aquatic system interconnectedness and essential habitat, to sufficiently understand aquatic systems to enable watershed approaches to water quality management, as well as to determine the effectiveness of the management practices that have been put in place. The scientific objective of this session is to raise awareness of the research needs of the Office of Water's water quality regulatory programs so that investigators can develop more informed proposals, research, academic, and outreach programs. The goal: increase the number of collaborative research activities, leverage the research resources and expertise of a broader universe of investigators, and diversify the perspectives that are brought to water regulatory science. The outcome will be broader interests, participation, and perspectives brought to water quality and ecosystem decision making. We will establish more accurate levels of aquatic life, human health, and aquatic ecosystem protection. The science will gain faster acceptance application by all stakeholders.

135 A Reevaluation of the Water Quality Criterion for Hydrogen Sulfide in Marine Waters. W. Gardiner, J.Q. Word, B.W. Hester, B.A. Williams, NewFields Northwest LLC, Port Gamble, WA; D. Coats, Marine Research Specialists, Ventura, CA. Hydrogen sulfide (undissociated H₂S) is a soluble, toxic compound that occurs naturally in anaerobic marine sediments. It can also be introduced directly into the aquatic environment through the domestic and industrial waste-water discharges. The availability and toxicity of H₂S is closely associated with pH, with toxicity increasing with decreasing pH. The current water quality criterion for hydrogen sulfide in marine waters (2 $\mu\text{g/L}$) is based largely on toxicity data generated with freshwater species, as well as one marine species. Because pH is typically lower in freshwater, it is likely that the existing criterion may not be appropriate for marine species. The objective of this investigation was to evaluate the H₂S sensitivity to marine water-column and benthic organisms, identify critical data gaps, conduct acute and chronic bioassays to fill those data gaps, and to develop a Probabilistic Risk Assessment model to determine a protective H₂S level. A critical challenge in conducting toxicity tests with H₂S in aerobic marine systems is that the half life of the H₂S is extremely short, typically < 1 hour. A continuous-flow dosing system was developed specifically for this program in order to maintain continuous levels of H₂S within the test treatments. The results of this program indicate that an H₂S is acutely toxic to marine organisms at concentrations ranging from 7 $\mu\text{g/L}$ (larval mussels) to 6000 $\mu\text{g/L}$ (adult clams). Larval echinoderms and bivalves used in many regulatory tests appear to be the most sensitive; however, this sensitivity appears to be limited to the first 6 hours of the test period. Results also confirm observations that H₂S toxicity is primarily associated with acute toxicity, with little chronic effects observed, indicating an acute to chronic ratio of 1:1. The PRA model was developed with over 100 data points from the literature and current study and suggests a H₂S concentration that is protective for marine species.

136 Stream Quality in the Tennessee Drainage of North Alabama; Potential impact on an aquatic salamander. J.R. Rayburn, G.R. Cline, Biology, Jacksonville State University, Jacksonville, AL. In Alabama, Hellbenders (Cryptobranchus alleganiensis) are restricted to the Tennessee River drainage system where they are listed as a Priority 1 species (highest conservation concern). In October 2005, we began a survey of historic sites in three Alabama Counties north of the Tennessee River. Physical and chemical characteristics of these streams were measured. The pH, temperature, dissolved oxygen, conductivity and turbidity were measured using a Turo T-611 water

quality multiprobe. Water Flow was measured using a flow meter. Width and depth of the streams were estimated with meter sticks and measuring tape. Percent bed rock, boulder, cobble, gravel and siltation were noted as observations. During hellbender surveys, observed species were identified and crayfish densities were estimated. The results indicated flow rates ranged from 3.6 – 129.1 cm/s. These waters ranged from neutral to slightly alkaline (pH 7.00-8.12). Conductivity was relatively low at these sites (29-177 us/cm) indicating low dissolved ion concentrations. Dissolved oxygen and temperature were in the good range for these waters (49-100% DO; 4.5- 8.9 mg O₂/l; 15.32-29.9 oC). These streams are fairly clear (turbidity 3-59 NTUs), but there was considerable siltation at most sites. Water quality is high enough to support pollution in-tolerant species such as crayfish (a major component of hellbender diets) and queen snakes (*Regina septemvittata*).

137 Toxistoichiometry: Integrating Ecological Stoichiometry and Ecotoxicology. J.H. Larson, Biological Station, University of Oklahoma, Kingston, OK; P.C. Frost, L. Hansen, Department of Biology, Trent University, Peterborough, Ontario, Canada; J.H. Larson, D.M. Costello, K.J. Kulacki, G.A. Lamberti, Department of Biological Sciences, University of Notre Dame, Notre Dame, IN; C. Metcalfe, Department of Environmental and Resource Studies, Trent University, Peterborough, Ontario, Canada. Evaluation of toxicity is most often done by the use of standard bioassays on commonly used test organisms. Relating the results of these short-term, laboratory tests to real-world scenarios is not only difficult, it may be impossible. For example, frequently used protocols often provide organisms with an abundance of high-quality resources, while in nature organisms are often faced with either low quantity or low-quality resources. Indeed, numerous studies have shown that the effect of toxins varies with the quantity of food an animal receives. Less well studied is how the quality of available resources influences the effect of a toxin. Imbalances between the nutritional quality and a consumer's dietary needs are common in nature and appear to play a role in individual physiology, population dynamics, community interactions, and ecosystem processes. Organisms may respond to variations in food quality with corresponding variations in growth, reproduction, assimilation, and excretion. We conducted a series of experiments using aquatic organisms to assess the role of food quality in determining an organism's response to toxins. We found that some toxins (iodine, cobalt, fluoxetine) have effects on *Daphnia* spp. that differ based on the available food quality. Other toxins (bendiocarb, triclosan, methanol) do not appear to be influenced by differences in food quality. This work demonstrates that the implicit assumption of many bioassays (that food quality does not matter) must be discarded in favor of context specific understanding of the relationship between an individual's physiological state and the effect of a toxin.

140 Fish responses in field and laboratory conditions to oil refinery effluent. J.R. Adams, D. MacLachy, K. Munkittrick, Biology, University of New Brunswick Saint John, Saint John, New Brunswick, Canada. Since 2003, we have been investigating effects on fish health downstream of Canada's largest refinery, situated in Saint John, New Brunswick. The refinery produces 270 000 barrels of oil per day and discharges effluent at a rate of 24 274 m³/day. In early work, low dissolved oxygen from ballast water added to the final effluent had an impact on fish in the receiving environment. The current study was initiated to: (1) assess recovery of the receiving environment after the removal of ballast water from the final discharge, and (2) determine if the effluent affects caged or laboratory-exposed fish. Liver size was increased in mummichog (*Fundulus heteroclitus*) caged downstream of the discharge and detoxification activity was decreased. Female plasma testosterone and liver detoxification activity (as assessed by ethoxyresorufin-O-deethylase) were increased downstream. Lab exposures of mummichog and northern redbelly dace (*Chrosomus eos*) to effluent, and effluent combined with sediment, have not to date confirmed the caged mummichog results. Along with caging fish and conducting bioassays, monthly fish community surveys and water quality surveys are conducted on the river. Together, the laboratory and field experiments, fish community and water quality surveys suggest effects in the receiving environment not yet explained by laboratory efforts.

141 Development of standardized procedures to detect impact of endocrine disruptors on development and sexual differentiation of the amphibian *Xenopus laevis*. I. Lutz, W. Kloas, Inland Fisheries, Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany; T.A. Springer, H.O. Krueger, Wildlife International Ltd., Easton, MD; L.R. Holden, Sielken & Associates Consulting, Inc., Bryan, TX; J.C. Wolf, Experimentel Pathology Laboratories, Inc., Sterling, VA; A.J. Hosmer,

Syngenta Crop Protection, Inc., Greensboro, NC. Amphibians are the classical models for demonstrating endocrine disruption affecting sexual differentiation and metamorphosis. However, there is a need for standardized procedures that meet recommended ASTM criteria for ecotoxicological testing. To address this need, a protocol, meeting ASTM and Good Laboratory Practice requirements, has been developed using the amphibian *Xenopus laevis* as a model for testing the response to the estrogen estradiol(E₂). Studies were conducted in two laboratories according to the protocol, using the same experimental procedures, to obtain inter-laboratory comparisons. *Xenopus* larvae were exposed to E₂ in flow-through test chambers at concentrations ranging from 0.2µg/L to 6µg/L and from 0.015µg/L to 1.5µg/L, respectively. Study endpoints included age at completion of metamorphosis, gonadal development based on gross morphology, and a variety of other morphological features potentially related to endocrine disruption. Results from the two studies indicate a high degree of reproducibility of the biological effects observed, including the concentration-response curves. In addition, a dramatic increase of sensitivity towards feminization that was related to maintenance of the E₂ exposure, was observed when responses of frogs in the flow-through exposure chambers were compared to responses of frogs in semi-static exposure scenarios. Based on the biological performance observed, and the inter-laboratory consistencies, we suggest that the methods and procedures that were developed be considered as a basis for standardization of studies designed to identify chemicals that are endocrine disruptors affecting development and sexual differentiation in amphibians. Keywords: *Xenopus laevis*, endocrine disruption, flow-through exposure system, development, sexual differentiation

142 Preliminary PCDF and PCDD tissue-based assessment of great blue heron (*Ardea herodias*) residing in the Tittabawassee River floodplain, MI, USA. R.M. Seston, M.J. Zwiernik, T.B. Fredricks, S.J. Coefield, D.L. Tazelaar, M.W. Nadeau, P.W. Bradley, J.P. Giesy, Zoology Department, Center for Integrative Toxicology, Michigan State University, East Lansing, MI; M.S. Shotwell, D.P. Kay, ENTRIX, Inc., East Lansing, MI; J.P. Giesy, Department of Veterinary Biomedical Sciences and Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. The great blue heron (*Ardea herodias*) (GBH) was selected as a species of interest in an ecological risk assessment being performed on the Tittabawassee River, Michigan, USA. The trophic status of the GBH, along with its strong site fidelity and territoriality, make it an ideal species to investigate bioaccumulative contaminants. The target study area, which includes 38 km of the river from the upstream boundary at the city of Midland, MI to the confluence of the Tittabawassee and Shiawassee Rivers, has previously been shown to contain elevated concentrations of polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-*p*-dioxins (PCDDs) in soils, sediments, and biota. GBH tissues, including eggs, nestling tissues (liver, adipose, and muscle), and blood plasma of nestling and adult GBH, were collected from both reference and target areas. Concentrations of the seventeen 2,3,7,8 substituted PCDD/Fs were quantified in each tissue type and normalized to 2,3,7,8 dibenzo-*p*-dioxin using WHO avian TEFs. Total TEQs in blood plasma of adult GBHs trapped in the reference area ranged from 1.2-3.0 pg/mL, ww (n=5) and ranged from 2.2-20 pg/mL, ww (n=15) in the target area. On a TEQ basis, 2,3,7,8-TCDF and 2,3,4,7,8-TCDF were the predominant congeners contributing to approximately 80% of the total TEQ attributable to dioxins and furans. TEQs will also be reported for eggs (n=6), nestling tissues (n=9), nestling blood plasma (n=13), and adult blood plasma (n=19) collected during the 2006 field season.

143 Comparison of lethality after in ovo exposure to PCB 126 and a PCB mixture in chicken, quail, tree swallow and American kestrel. E.T. Lavoie, M.E. Barton, K. Whitehouse, N. Thompson, M. Ottinger, Animal Sciences, University of Maryland, College Park, MD. There is a wide difference in sensitivity to polychlorinated biphenyl (PCB) toxicity between different bird species. Evaluations of the variation in sensitivity to environmental contaminants between different bird species is of great use to risk assessors and researchers alike. In a series of egg injection studies we compared the lethality of either PCB 126 or an environmentally relevant mixture of PCB congeners in Japanese quail, chickens, tree swallows and American kestrels. Responses to PCB 126 were studied in Japanese quail and tree swallows. Responses to a PCB mixture of a profile similar to that found in avian eggs collected at sites on the Upper Hudson River, NY were studied in Japanese quail, chicken and American kestrel. Egg injections were made into the air cell and eggs incubated in the laboratory by standard methods. The dose range of PCB 126 used was 0 - 4000 ng/g egg. The dose range of PCB mixture used was 0 - 100 µg/g egg.

Doses in both ranges varied depending on species studied. Median lethal dose (LD50) estimates expressed in pg/g of toxic equivalents were as follows: PCB 126 in Japanese quail = 5,600 pg/g; tree swallows = 4,100 & 8,900 pg/g (two experiments). PCB mixture in Japanese quail = 7,280 pg/g; chicken = 89 pg/g. Sample sizes in American kestrels were not large enough to calculate an LD50. These data demonstrate that Japanese quail are an appropriate model for dioxin-like toxicity for certain species of wild birds such as tree swallows (similar median lethal doses in the same experimental paradigm). The LD50 for the PCB mixture in chickens is similar to that previously reported.

144 Influence of Diet and Migration on POP Concentrations in Antarctic Seabirds. H. Geisz, R.M. Dickhut, M.A. Cochran, Biological Sciences, Virginia Institute of Marine Science, Gloucester Point, VA; H.W. Ducklow, Ecosystems Center, Marine Biological Laboratories, Woods Hole, MA; W.R. Fraser, Polar Oceans Research Group, Sheridan, MT. Antarctic seabirds, including Adélie penguins *Pygoscelis adeliae*, south polar skuas *Catharacta macormicki* and southern giant petrels *Macronectes giganteus*, are high trophic level predators that accumulate persistent organic pollutants (POPs) present in the marine food webs in which they forage. Diet and migration patterns influence the level of POP residues per species. The objective of this study was to compare POP levels within the three bird species based on migratory patterns and trophic level using stable isotope analysis of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$. Southern giant petrel and south polar skua tissues are expected to contain POP concentrations several orders of magnitude higher than Adélie penguins due to higher trophic level foraging in the petrels and skuas and winter migratory patterns that include industrialized areas. Necropsies were performed on all three seabird species collected post mortem throughout the austral summer breeding seasons of 2000-2005 on the Western Antarctic Peninsula and Ross Island, Antarctica. Livers of all three species were analyzed for POPs including organochlorine pesticides, polychlorinated biphenyls (PCBs), and brominated diphenyl ethers (BDEs) via gas chromatography/mass spectrometry. Results indicate that both $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ increase with the trophic level of Antarctic seabirds. $\delta^{13}\text{C}$ increases more than 1-2‰ with trophic level in migratory seabirds, possibly due to latitudinal fractionation of $\delta^{13}\text{C}$ in the southern hemisphere. Multiple regression analysis of POP concentrations with $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ indicate that both diet and migration influence POP concentrations in Antarctic seabirds. For example, compounds such as hexachlorobenzene (HCB) and heptachlor epoxide, demonstrate significantly higher concentrations in bird tissues with an increase in $\delta^{15}\text{N}$, but show no relationship with $\delta^{13}\text{C}$. Conversely, alpha-chlordane shows no relationship with nitrogen stable isotopes, but demonstrates significantly higher concentrations with enrichment in $\delta^{13}\text{C}$. This information can be used to assess global use and emission of various pesticides, PCB and BDE chemical species as related to the migratory patterns of Antarctic seabirds.

145 Comparative Effects of Embryonic Exposure to EDCs on the Gonadotropin Releasing Hormone System in Japanese quail. M. Ottinger, N. Thompson, M. Barton, K. Whitehouse, E. Lavoie, Animal and Avian Sciences, University of Maryland, College Park, MD; M.J. Quinn, U.S. Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, Aberdeen, MD. The specific impact of endocrine disrupting chemicals (EDCs) on hypothalamic systems that regulate reproduction has not been compared across a variety of EDCs. In birds, the gonadotropin releasing hormone-I (GnRH-I) system is a key element in reproductive function. The GnRH-I system is sexually dimorphic in adults, presumably due to sexual differentiation of this system during embryonic development. As such, the GnRH-I system becomes a potential target for EDC impact, with possible short and long term effects on reproductive function at hatch and in adults. We have had the opportunity to evaluate a range of EDCs in the Japanese quail. The purpose of this study is to compare the relative effects of embryonic exposure to these EDCs in order to evaluate if the GnRH-I system is vulnerable to particular classes of EDCs. Multiple egg injection studies were conducted in developing Japanese quail, with administration of selected doses of each EDCs between 0 and embryonic day 4, depending on the specific experiment. Hypothalamic GnRH-I content was measured in hatchlings and in young adults by an EIA specific for GnRH-I. Results showed that embryonic exposure to some concentrations of atrazine or trenbolone acetate increased hypothalamic GnRH-I content in adults. Methoxychlor exposure altered GnRH-I in hatchlings; while vinclozolin or PCB 126 exposure decreased GnRH-I at hatch. The structure and known mechanism of action of these compounds is variable but all are considered EDCs. We hypothesize

that there is a sensitive period for exposure to EDCs with the potential of impacting the GnRH-I system and possibly also associated neuroregulatory systems. As such, direct actions of EDCs on the GnRH-I system during embryonic development should be considered as an additional mode of action for some classes of EDCs, with the potential to alter life-long reproductive function.

146 Hormonal and Neurochemical Regulation of Parental Hyperphagia in Doves. J.D. Buntin, Biological Sciences, UW-Milwaukee, Milwaukee, WI; S. Ramakrishnan, Biological Sciences, UW-Milwaukee, Milwaukee, WI; A.D. Strader, Physiology, Southern Illinois University School of Medicine, Carbondale, IL. Parent birds with altricial nestlings must provide food for their young if the reproductive effort is to be successful. Ring dove parents of both sexes provision their young with regurgitated crop "milk" and later with regurgitated seeds that are obtained through increased foraging. Although parental food intake doubles during this period, body weight declines as most of the food is transferred to the young. Prolactin and corticosterone are implicated in parental hyperphagia because they increase food intake in non-breeding doves and are elevated in the blood of parent doves. These hormones may directly influence neural circuits underlying feeding, since intracranial injections of prolactin or dexamethasone strongly elevate food intake. Possible targets of these effects are neurons that express neuropeptide Y (NPY) and the endogenous melanocortin receptor antagonist agouti related peptide (AgRP) in the tuberal hypothalamus. Intracranial injections of these neuropeptides increase food consumption in non-breeding doves. In addition, breeding birds sampled during the post-hatching period when food intake is elevated show increased numbers of AgRP-immunoreactive (ir) cells and NPY-ir cells in the tuberal hypothalamus. These same changes in AgRP-ir and NPY-ir are also seen in non-breeding doves after prolactin or corticosterone administration and following food deprivation, which increases corticosterone secretion in many species. Changes in NPY-ir reflect increased synthesis, since NPY mRNA is also increased in mediobasal hypothalamus of parents that are feeding young, and in non-breeding doves after food deprivation or prolactin treatment. We conclude that changes in prolactin and corticosterone may stimulate parental provisioning by increasing the expression of appetite-stimulating neuropeptides in the hypothalamus. However, these effects may be complex. Studies in other species suggest an inverted U-shaped relationship between corticosterone levels in blood and parental provisioning. Accordingly, metabolic stressors associated with the provisioning effort and environmental toxicants that influence the stress axis could potentially exert profound effects on this behavior and, in turn, on reproductive success (supported by NIMH MH41447)

147 Is Exposure to Cholinesterase-Inhibiting Pesticides Related to Shorebird Habitat Use on the Non-Breeding Grounds? K.M. Strum, B.K. Sandercock, Biology, Kansas State University, Manhattan, KS; M.J. Hooper, TIEHH, Texas Tech University, Lubbock, TX; K.A. Johnson, Chemistry, Southern Illinois University, Edwardsville, IL; M. Zaccagnini, Instituto de Recursos Biológicos, INTA-CIRN, Castelar, Buenos Aires, Argentina; R.B. Lanctot, Migratory Bird Management, USFWS, Anchorage, AK; J. Torres-Dowdall, Biology, Colorado State University, Fort Collins, CO; M. Alfaro, Facultad de Ciencias, Universidad de la República, Montevideo, Montevideo, Uruguay. Monitoring programs indicate that shorebird populations are declining globally. In the Western Hemisphere, twenty-seven shorebird species are species of high concern and seven are highly imperiled. One factor that may be contributing to population declines is exposure to cholinesterase-inhibiting chemicals on the non-breeding grounds. Organophosphate (OP) and carbamate (CB) pesticides are commonly used chemicals in the Americas. These pesticides have caused mortalities in migratory birds and negative physiological effects in laboratory trials of captive birds. Shorebirds wintering in temperate South America and migrating through the Great Plains of the United States use rice fields and sod farms where agrochemicals are used and risk of exposure is high. Consequently, habitat use may contribute to differential exposure among shorebird species. Cholinesterase (ChE) is a specific bio-indicator for OP and CB exposure and can be measured using standard laboratory procedures. Lower levels of absolute cholinesterase activity and recovery to higher levels after 2-PAM (for OPs) or spontaneous (for CBs) reactivation, indicative of poisoning, are expected in shorebirds using agricultural habitats. In 2006, we sampled shorebirds using natural and agricultural habitats in three states in North America during spring and fall migration and three countries in South America during boreal winter, characterizing and measuring ChEs in all species. Preliminary results

indicated an inverse relationship between body size and plasma ChE activity. Acetylcholinesterase (AChE), the enzyme whose inhibition leads to poisoning symptoms, showed less inter-species variation than butyrylcholinesterase (BChE). Plasma ChE activities varied with date of capture in three of five species and sex differences were significant in one of two species tested. We will synthesize data from non-breeding samples, discuss our estimates of exposure, and make recommendations for conservation of neotropical migrants.

148 Wintering Bobolink Populations and Their Vulnerability to Rice Pesticides. R. Renfrew, Vermont Inst of Natural Sciences, Quechee, VT; D. Fry, American Bird Conservancy, Washington, DC; P. Mineau, Science and Technology Branch, Environment Canada, Ottawa, Ontario, Canada; A. Saavedra, Museo de Historia Natural Noel Kempff Mercado, UAGRM, Santa Cruz, Santa Cruz, BOLIVIA; K.A. Johnson, Chemistry and Env't Sci, Southern Illinois University, Edwardsville, IL; M.J. Hooper, Env't Toxicol, Texas Tech Univ, Lubbock, TX. Recent evidence from South America indicates that the Bobolink (*Dolichonyx oryzivorus*) continues to earn its reputation as the "rice bird" on its wintering grounds. However, there have been no studies to characterize its use of rice and how this affects its conservation. In 2005 and 2006 (Jan. - Mar.) we surveyed and captured Bobolinks in rice production regions in Dpto. Santa Cruz, Bolivia, to locate flocks and assess pesticide exposure. We collected blood from 30 and 229 Bobolinks in 2005 and 2006, respectively, in 6 of 9 locations where we found night roosts. Roosts varied in size (range = 200 to 90,000 Bobolinks); two adjacent roosts contained > 130,000 Bobolinks. We measured cholinesterase (ChE) activity in blood to assess exposure to organophosphates and carbamates. ChE activity displayed temporal and spatial patterns of depression, suggesting site-specific occurrence of anti-cholinesterase pesticide exposure. Samples from both years originated from birds potentially exposed to monocrotophos, an organophosphate that previously impacted Swainson's Hawks, Dickcissels and other Nearctic-Neotropical migrant and local species. Bobolink populations face conservation threats in winter because of the degree to which they concentrate in rice production regions, their status as a pest, and the pesticides currently used on rice. Discussions with farmers, regional pesticide industry and regulators are being pursued to develop alternatives to protect Bobolinks and other rice birds.

149 Investigating a mitigation strategy and developing an in vitro assay for Avian Vacuolar Myelinopathy (AVM). W.W. Bowerman, F.E. Wiley, R.S. Haynie, Forestry and Natural Resources, Clemson University, Clemson, SC; S.B. Wilde, S.K. Williams, Belle Baruch Institute, University of South Carolina/SC DNR, Charleston, SC; C.P. Hope, T.M. Murphy, South Carolina DNR, Green Pond, SC; J.J. Hains, Biological Sciences, Clemson University, Clemson, SC; R.L. McCord, J.R. Morrison, Analytical & Biological Services, Santee Cooper Power, Monks Corner, SC; J. Grizzle, Fisheries & Applied Aquaculture, Auburn University, Auburn, AL. Avian vacuolar myelinopathy (AVM) is an often-fatal neurologic disease of unknown etiology affecting waterbirds and their avian predators in several southeastern reservoirs. The suspected causative agent is a neurotoxin produced by a novel epiphytic cyanobacterium in the order Stigonematales. Aquatic plants, especially hydrilla (*Hydrilla verticillata*), elodea (*Egeria densa*), and *Myriophyllum spicatum*, provide substrate for this epiphyte. Research has illustrated disease transfer between aquatic vegetation and associated epibionts, herbivorous waterfowl, and avian predators. Biological control efficacy, susceptibility, and vector potential of triploid Chinese grass carp (*Ctenopharyngodon idella*) to Avian vacuolar myelinopathy (AVM) was investigated during this experiment to explore a viable, ecologically sound management option. Control of aquatic plants would truncate food-chain based transfer. Grass carp were fed hydrilla with and without the associated cyanobacterium in a laboratory setting. Grass carp were also examined after feeding on hydrilla and the associated cyanobacterium in a field setting. Toxin production was validated using sentinel mallards in both field and laboratory trials. Grass carp developed lesions similar in appearance and region to AVM affected birds but did not exhibit signs of neurologic impairment. Chickens (*Gallus domesticus*) fed grass carp tissues did not develop AVM. Development of an in vitro assay began in 2005. Putative toxin extraction techniques were modified and developed for the hydrilla and associated epibionts. The hydrilla complex was extracted using a series of non-polar to polar solvents: hexane, acetone, and methanol. AVM was induced in mallard ducks by administering the methanol fraction via oral gavage. This methanol extract also induced cell cycle arrest C6 rat glioma cells.

150 Potential Environmental Contaminant Risks to Avian Species at Important Bird Areas in the Northeastern United States. B.A. Rattner, B.K. Ackerson, Patuxent Wildlife Research Center, USGS, Beltsville, MD. Environmental contaminants, acting at molecular through population levels of biological organization, can have profound effects upon birds. A screening level risk assessment was conducted that examined potential contaminant threats at 52 Important Bird Areas (IBAs) in the northeastern Atlantic coast drainage. Using geographic information system methodology, data layers describing or integrating pollutant hazards (impaired waters, fish or wildlife consumption advisories, toxic release inventory data, estimated pesticide use and hazard) were overlaid on buffered IBA boundaries, and the relative contaminant threat for each site was ranked. The 10 sites identified as having the greatest contaminant threats included Jefferson National Forest, Stewart B. McKinney National Wildlife Refuge, Great Dismal Swamp National Wildlife Refuge, Blue Ridge Parkway, Shenandoah National Park, Adirondack Park, Edwin B. Forsythe National Wildlife Refuge, George Washington National Forest, Green Mountain National Forest, and Long Island Piping Plover Beaches. These sites accounted for over 50% of the entire study area, and in general had moderate to high percentages of impaired waters, fish consumption advisories related to mercury and PCBs, and were located in counties with substantial application rates of pesticides known to be toxic to birds. Avian species at these IBAs include Federally endangered Roseate terns (*Sterna dougallii*), threatened piping plovers (*Charadrius melodus*), neotropical migrants, Bicknell's thrush (*Catharus bicknelli*), Swainson's warbler (*Limothlypis swainsonii*) and wintering brant geese (*Branta bernicla*). Extant data for free-ranging birds from the Contaminant Exposure and Effects-Terrestrial Vertebrates database were examined within the buffered boundaries of each IBA, and for a moderate number of sites there was qualitative concordance between the perceived risk and actual contaminant exposure data. However, several of the IBAs with substantial contaminant hazards (e.g., Blue Ridge Parkway, George Washington National Forest, Shenandoah National Park) had no recent avian ecotoxicological data. Contaminant biomonitoring is warranted at such sites, and data generated from such efforts should foster natural resource management activities.

151 Key components controlling the partitioning, speciation, and bioavailability of inorganic mercury in anoxic sediments. H. Zhong, W. Wang, Atmospheric, Marine and Coastal Environment (AMCE) Program, Hong Kong University of Science and Technology, Hong Kong, China; W. Wang, Department of Biology, Hong Kong University of Science and Technology, Hong Kong, China. The controls of three key anoxic sediment components (FeS, FeS₂, and S²⁻) on the partitioning, speciation (analyzed by sequential chemical extraction method) and bioavailability (quantified by gut juice extraction) of inorganic mercury (Hg) in anoxic sediments were investigated by spiking the radioactive or stable Hg into different artificial sediments. We found that FeS was the most important component in controlling the partitioning, speciation, and bioavailability of Hg in anoxic sediments. In the presence of FeS, most Hg was associated with FeS, indicating a very high binding ability of FeS with Hg, and most Hg was found in the organo-complexed phase (F3). In contrast, nearly all Hg was in the strongly complexed phase (F4) in the presence of FeS₂. Remobilization of FeS under oxic environment did not lead to a release of Hg, possibly because of the incomplete oxidation of FeS and the strong association between Hg and FeS. In contrast, remobilization of FeS₂ led to desorption of Hg due to its weaker association with FeS₂. Hg bound with FeS₂ had higher gut juice extraction than that with FeS, while mercury sulfide (HgS) was not bioavailable. However, the gut juice extraction was relatively constant and low with the presence of FeS. Hg associated with FeS had very low bioavailability at low Hg to sulfide (S) ratio in sediments, but could become more bioavailable with increasing Hg to S ratio until the ratio reached the maximum (approximately 1:10, mol based). This may have been due to the saturation of stronger binding sites or the oxidation of FeS during the extraction and the subsequent release of Hg from the solid phase. The gut juice extraction of Hg bound with FeS₂ was balanced by oxidation and adsorption of agents in gut juices onto particles. This study suggested that the partitioning and bioavailability of Hg in anoxic sediments were dependent on sediment composition and Hg to S ratios in sediment.

152 Release of fixed Zn from soils - estimating potential risks from future acidification of soils. M. McLaughlin, S. Zrma, J. Kirby, CSIRO/Univ. Adelaide, Adelaide, South Australia, Australia. Risk assessment procedures for metals are starting to consider metal bioavailability issues as integral to

the risk assessment process. Progress in introducing the concept of metal bioavailability into terrestrial risk assessments is problematic however, due to the lack of a suitable generic model, but also due to concern by regulators that future changes in environmental conditions in the terrestrial environment can rapidly modify metal bioavailability. This work examined the potential release of Zn from soils using an isotopic dilution procedure, and evaluated the potential risk arising from this mobilisation as related to different forms of Zn contamination. Soils receiving additions of Zn from geogenic sources, from soluble metal salts, sewage biosolids, smelter emissions and industrial wastes were sampled and isotopically exchangeable Zn determined using ^{65}Zn . Release of fixed Zn to the isotopically exchangeable pool was determined after acidification of the soils. The magnitude of Zn release was related to form of Zn contamination and other soil properties.

153 A WHAM based kinetics model for Zn adsorption and desorption reactions with soils. D.M. Di Toro, Z. Shi, H.E. Allen, Department of Civil and Environmental Engineering, University of Delaware, Newark, DE; D.L. Sparks, Department of Plant and Soil Sciences, University of Delaware, Newark, DE. A novel model has been developed to describe the kinetics of Zn adsorption and desorption reactions with soils. The kinetic model is coupled with the mechanistic equilibrium model WHAM (Windermere Humic Aqueous Model), which is able to account for the variation of reaction chemistry (e.g. pH and Zn concentration) and heterogeneity of binding sites of soil organic matter (SOM). There are only three additional parameters in the model: the desorption rate constants for the fast and slow sites and the fraction active organic matter. All other effects are computed using WHAM determined partition coefficients and the distribution of zinc between monodentate and bidentate sites. The distribution of Zn among these sites changes with reaction time, pH and SOM concentration and affects the rate of adsorption and desorption. For example nonlinear binding of Zn to SOM results in a decrease of the adsorption rate with increase of Zn loading in soils. To test the model, kinetic experiments were conducted using a stirred-flow method. Six soils, covering a wide range in SOM concentrations, were selected for the kinetic experiment and various Zn concentrations and pHs were studied. The performance of the model and the implications for modeling Zn fate will be discussed.

154 Development of linear free energy relationships for estimating monodentate and bidentate metal binding to functional groups present in natural organic matter. R.E. Carbonaro, Civil and Environmental Engineering, Manhattan College, Riverdale, NY; D.M. Di Toro, Civil and Environmental Engineering, University of Delaware, Newark, DE; R.E. Carbonaro, D.M. Di Toro, HydroQual, Inc., Mahwah, NJ. We have previously developed methods for estimating formation constants for metal binding to monodentate ligands containing negatively-charged oxygen donor atoms (e.g. substituted-carboxylates and phenolates). These methods employ linear free energy relationships (LFERs) that depend only on the pK_a of the ligand. This current work involves development of estimation methods for metal-ligand formation constants for bidentate ligands containing negatively-charged oxygen donor atoms. Our approach involves LFERs constructed from linear combinations of the monodentate LFERs. The resulting equations contain only one additional fitting parameter which is dependent upon the identity of the metal ion and the ring size of the bidentate ligand. Therefore, formation constants for metal complexes with bidentate ligands can be estimated if the pK_a values of their functional groups are known. The Windermere Humic Aqueous Model (WHAM) versions V and VI both employ monodentate and bidentate sites for metal binding to natural organic matter (NOM). A comparison of our theoretical LFER predictions to the values employed in WHAM V and VI will be presented.

155 Investigating Solid-Solution Metal Partitioning in Surface Waters using Chemical Speciation Software. K.J. Rader, D.M. Di Toro, Civil and Environmental Engineering, University of Delaware, Newark, DE; D.M. Di Toro, HydroQual, Inc., Mahwah, NJ. The major processes that determine the fate, transport, and toxicity of metals in surface waters are solubilization/precipitation, complexation, and partitioning to suspended particles. The adsorption of metals to particulate matter is particularly important because it leads to the transfer of metals out of the water column to the bottom sediments. Therefore, it is crucial that one be able to predict accurately the extent to which metals partition to particles. WHAM6 is a chemical speciation program that combines two sub-models: WHAM VI and SCAMP. It uses the Humic Ion-Binding Model VI also referred to as the Windermere Humic Aqueous Model (WHAM) VI to quantify the binding

of protons and metals by dissolved organic carbon--specifically humic acid (HA) and fulvic acid (FA). WHAM6 calculates the surface complexation of protons and metals to particulate humic and fulvic acids, metal oxides, and clays using the Surface Chemistry Assemblage Model for Particles (SCAMP). While WHAM6 has been extensively calibrated and tested on laboratory data, additional assessment of its performance on field data is required. In this work, WHAM6 partitioning predictions for trace metals (Co, Ni, Cu, Zn, Cd, and Pb) are compared to observations from several different surface water systems ranging from estuaries with minor metal contamination to heavily impacted rivers receiving acid mine drainage. Complicating factors such as precipitation and calcium/magnesium competition for binding sites will be discussed.

156 Estimation of Characterization Factors for Metals in Life Cycle Impact Assessment of Ecotoxicity – Analysis of Metal's Speciation, Fate and Effects Issues. N. Gandhi, M.L. Diamond, Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario, Canada; M.L. Diamond, Dept of Geography, University of Toronto, Toronto, Ontario, Canada; D. van de Meent, M. Huijbregts, Dept. of Environmental Science, Radboud University, Nijmegen, Netherlands; A. de Koning, J. Guinée, Institute of Environmental Sciences, Leiden University, Leiden, Netherlands; D. van de Meent, M. Huijbregts, W. Peijnenburg, National Institute of Public Health and the Environment (RIVM), Bilthoven, Netherlands; B. Koelmans, Wageningen University and Research Centre, Wageningen, Netherlands. The current method of estimating metal hazards based on Persistence (P), Bioaccumulation (B) and Toxicity (T), as applied to organic chemicals, is inappropriate for metals due to their infinite persistence and dependence of toxicity on metal speciation which in turn, is a function of ambient water chemistry. The UNEP-SETAC Life Cycle Initiative has launched a research project with ICMM aiming to improve characterisation factors (CFs) for metals. The goal is to address key issues in life cycle impact assessment as pertains to metals and to develop a robust and general method to assess environmental fate and potential ecotoxicological effects. To address this need, we conducted a three-tiered analysis. To begin, we calculated metal fate factors that considered metal speciation and water chemistry by incorporating the core elements of TRANSPEC, a coupled metal TRANsport and SPECiation model (Bhavsar 2004), in the newly developed LCIA consensus model for organic chemicals. The first and most sophisticated tier used a BLM to calculate the ecotoxicological effect levels, and thus effect factors, for Cu, Ni and Zn (due to data availability) from a toxicity database in which water chemistry in the test conditions was specified. In the second and less sophisticated tier, we compared the BLM-predicted effect factors with those estimated based on the free metal ion activity model (FIAM) by means of WHAM. Third, we compared the BLM and FIAM effect factors with those reported for soluble phase metal. Further, we compared characterisation factors obtained using these three tiers. We also probed the sensitivity of the fate and effect factors to environmental variability (e.g., pH, DOC etc.). We present the preliminary estimates of fate, effect and characterisation factors obtained from this analysis and compare them with previously reported values.

157 Release of metals and arsenic to natural water from sediments of Lake Roosevelt, Washington, USA. A. Paulson, S. Cox, P. Moran, USGS Washington Water Science Center, Tacoma, WA. Reservoir sediments from Lake Roosevelt, Washington State, USA, that were contaminated with smelter waste discharged into the Columbia River, British Columbia, Canada, were examined using three measures of elemental release reflecting varying degrees of physical mixing and time scales. Aqueous concentrations of Cd, Cu, Pb, and Zn in the interstitial water of reservoir sediments, in the gently stirred overlying waters of incubated sediment cores, and in supernatants of aggressively tumbled slurries of reservoir sediments were generally higher than the concentrations from a reference site. When compared to chronic water-quality criteria, all three measures of release suggest that slag-contaminated sediments near the USA-Canada border are potentially toxic as a result of Cu release and of Pb release in two of the three measures. All three measures of Cd release suggest potential toxicity for one site farther down reservoir, probably contaminated as a result of transport and adsorption of Cd from smelter liquid waste. Releases of Zn and As did not appear to be potentially toxic. Carbonate geochemistry indirectly affects the potential toxicity by increasing water hardness.

158 Development of Methods for Studying the Chemical Speciation of Pb(II) in Battlefield Soils by Continuous Flow Analysis. C.M. Breitigam, J.H. Aldstadt, Dept. of Chemistry & Biochemistry, Univ. of Wisconsin-Milwaukee, Milwaukee, WI. We will describe our work to better understand

heavy metal contamination over long periods of time by studying soils for which the spatial and temporal dimensions are relatively well-defined. Our work is based on the ability to pin-point the initial time and place of contamination on an American Civil War (ACW) battlefield. In addition to the "macroscale" objects (debris) of battle that have been identified using traditional archaeological methods of collection, the firearms used left distinctive chemical signatures. We measured the Pb(II) distribution in soil core samples collected at Manassas National Battlefield transecting the line occupied by an infantry regiment that was heavily engaged, as well as background samples in an area where no fighting occurred. The location was chosen because our results could be compared to recent archaeological studies. We developed, optimized, validated, and applied a sequential extraction approach implemented in a flow-injection system to fractions of the core samples to classify: (a) the non-labile Pb(II), (b) organically complexed Pb(II), and (c) free ionic Pb(II). We quantified Pb(II) by potentiometric stripping analysis (PSA) and inductively-coupled plasma mass spectrometry (ICP-MS). We found significant concentrations of Pb(II) (up to 500 parts per billion) in the firing-line samples. From our studies of the Manassas soil cores, we have found that Pb(II) can be reliably quantified, the depth at which Pb(II) was quantified coincides with deposition 145 years ago, and there is a clear correlation between the deposited Pb(II) and historical accounts of unit position. From isotopic analysis by ICP-MS, we found low levels of Pb(II) in the background samples that originated from a different source than the ACW samples (e.g., tetraethyllead). We will also present our results for characterizing the natural organic matter in these samples as well as the counter-ion environment. Our approach may also provide a sensitive, selective, and low-impact method for providing information of possible relevance to historical archaeologists (more precise unit positions, approximate volume of fire). Our long-term goal is to build a model to define the rate of transport of Pb(II) (in its various physico-chemical forms) in these soils.

159 Copper speciation and organic matter characterization in marine samples determined using molecular fluorescence and relationship to toxicity to *Mytilus galloprovincialis*. S. Smith, Chemistry, Wilfrid Laurier University, Waterloo, Ontario, Canada; W. Arnold, Copper Development Association Inc., New York, NY. Copper speciation in marine systems is influenced by organic matter complexation. In turn, copper toxicity to marine organisms is speciation dependent. Metal induced toxicity has been shown to depend on organic matter quality. Natural organic matter (NOM) quality can vary along estuarine gradients where the terrestrial versus autochthonous organic carbon contributions change as well as in urbanized watersheds where wastewater input to the organic carbon can be a significant contribution. Methods are developed here to quantify differences in organic matter quality and relate these to marine copper toxicity studies. Measurements of fluorescence excitation versus emission surfaces, dissolved organic carbon, chromium reducible sulfide and salinity were performed on marine samples from a variety of sites in North America. In addition, copper toxicity to embryos of the mussel, *Mytilus galloprovincialis* was measured in samples from selected sites to determine the effects of NOM quality on copper bioavailability. Fluorescent excitation versus emission matrices contain enormous amounts of information on the molecular nature of NOM in a given sample. Reducing all that information to a manageable quantity, such as a single number representing organic matter quality, can be difficult. A principle component analysis method is developed to determine a single principle component to use as a quality index. This NOM quality index is compared to the toxicity data for the same samples. To further determine molecular level interactions between copper and NOM, selected samples were titrated with copper at fixed pH in a thermo-jacketed reaction vessel. During titration pH, free copper by ion selective electrode and fluorescence using a fiber optic probe were measured. Fluorescence changes during copper additions are then fit to a multiresponse statistical model to quantify copper speciation in the presence of organic matter.

160 Are biofuels LCAs using the right functional units to compare global warming? E. Johnson, Atlantic Consulting, Gattikon, Switzerland. Many LCAs are devoted to assessing the trade-offs between biofuels and fossil fuels. Always the functional unit is some quantity of energy delivered to an end-user. For global warming comparisons, where land-use plays a key role in carbon sequestration, there is a far more meaningful functional unit - arable land usage. This addresses two key questions raised in the conference: 1) attributional vs consequential LCA, and 2) narrowing the gap between models

and reality. To illustrate the argument, the example of biodiesel vs petroleum diesel is presented; shifting function units yields startlingly different results.

161 Making Stuttgart's public transportation more sustainable. M. Binder, PE Americas, Boston, MA; M. Wiedemann, S. Raff, Stuttgarter Strassenbahnen AG, Stuttgart, Germany; M. Faltenbacher, PE International, Leinfelden-Echterdingen, Germany. The Stuttgarter Strassenbahnen AG (SSB AG) is committed to provide sustainable public transport in Stuttgart. As decisions made on fuel and propulsion technologies not only define direct emissions and costs but also have an influence on the up- and downstream processes, the SSB AG has decided to consider the total life cycle for future decisions. As currently the strategy regarding the choice of fuel and propulsion technology for the next 20 years is under review, the environmental and economic life cycle profiles of different fleet scenarios have been quantified via a transparent comparison of resources consumed, emissions released and costs incurred for different combinations of fuels and propulsion technologies. The following fuels : conventional diesel, biomass-to-liquid (BtL), gas-to-liquid (GtL), biodiesel, natural gas, hydrogen (from electrolysis/steam reforming) and propulsion systems: diesel combustion (with various tailpipe emission treatment technologies), natural gas combustion and fuel cell technology have been analyzed. The study also addresses questions of environmental relevance of bus-based public transport in Stuttgart and its contribution to the city's Clean Air Act. The presentation will: 1.) show how Life Cycle assessment and Life cycle costing has been used to support the strategy decisions, 2.) show the relevance of the different phases (fuel/vehicle production, infrastructure production, use phase, maintenance and End of Life) and 3.) discuss the results of different combinations of fuels and propulsion systems analyzed.

162 The Green Fleet program. G.W. Rock, The Green Car Company, Seattle, WA. The Green Fleet Program is a detailed vehicle lifecycle environmental and economic impact analysis tool. The program uses quantitative values derived from Argonne National Labs GREET lifecycle model like grams of pollutant per lb of fuel consumed or gallons of fuel consumed per lbs of li-ion batteries manufactured/recycled as quantitative input values. These values power a detailed vehicle simulation tool capable of modeling vehicle's as complex as a tri-fuel vehicle. An example of a tri-fuel vehicle would be a PHEV running on electricity, gasoline and ethanol. The program produces lifecycle environmental impact reports detailing any specific vehicles impacts on green house gases, regulated emission, and fossil fuel consumption. The Green Fleet program is used to provide lifecycle vehicle analysis and cost benefit comparisons to municipal, educational, and business fleets purchasing eco-friendly vehicles from The Green Car Company. The program gives the GCC the ability to show fleet managers vehicle to vehicle comparisons, establish baselines, simulate future fleets' environmental impacts, as well as perform dynamic analysis tracking things such as cost to own and operate a vehicle over a range of potential fuel prices. This is a complete vehicle lifecycle economic and environmental impact analysis tool.

163 Life-cycle Environmental Evaluation of California Water Supply. J. Stokes, A. Horvath, University of California, Berkeley, Berkeley, CA. Meeting the demand for water is becoming increasingly challenging in California, the American West, and the world for many reasons, including population growth, industrial contamination, and climate changes. When the readily-available sources are tapped out, future sources require additional energy and resources and subsequent environmental toxicity. Life-cycle assessment (LCA) is a methodology which can inform water supply planners, designers, and system operators about the environmental effects of the choices they face. This study uses LCA to compare water supply alternatives which require different energy and resource inputs, treatment processes and complexity, and infrastructure. To capture the effects of water systems from cradle to grave, a model was created to identify the inputs and outputs of the systems. An Excel-based tool, the Water-Energy Sustainability Tool (WEST), was created to facilitate performing LCA of water supply systems for this and future studies. A partial list of the processes considered by WEST includes: constructing dams, treatment plants, and aqueducts (including equipment tailpipe emissions); manufacturing pipes, pumps, chemicals, and membranes; transporting materials to the construction or facility site; processing fuel for equipment and vehicles; mining fossil fuels needed for energy; and generating electricity. The subsequent environmental implications may be significant. Quantifying life-cycle energy and resource consumption and associated emissions informs more effective environmental management. The resulting environmental effects are broken down according to water source alternatives,

life-cycle phases (construction, operation, and maintenance) and water system components (supply, treatment, and distribution). Operating systems using different energy supplies, including the average national mix, the average California mix, solar power, and other “green energy” sources are compared. Results from a typical case study system will be presented.

164 Assessment of the spatial variability and determination of the optimal regional scale for (eco) toxicity impacts linked to Canadian emissions. R. Manneh, M. Margni, L. Deschênes, CIRAIG-École Polytechnique de Montréal, Montreal, Quebec, Canada; S. Humbert, A. Horvath, University of California, Berkeley, CA; C. Wannaz, S. Shaked, O. Jolliet, University of Michigan, Ann Arbor, MI; S. Schwarzer, UNEP, Geneva, Switzerland. In many damage oriented LCIA studies, the contribution of ecotoxicological and toxicological impacts is found to be significant. Few publications already demonstrated variations up to few orders of magnitude in region-specific intake fractions and characterization factors. The main objective of this research is to analyze which regionalization scale is best suited for evaluating the impacts related to life cycle inventories of toxic emissions in Canada. The development of the intake fractions and characterization factors can be used within the North American context. Characterization factors are developed for 3 regionalization schemes: Canadian provinces (13), ecozones (15) and watersheds (164). The model used is the newly developed multimedia/multipathways fate and exposure model for North America. This model is adapted to the 3 respective Canadian regionalization schemes by determining environmental fate and exposure parameters such as population density, production intensity and air and water advection between the different zones using a geographic information system. Preliminary results at the watershed level, the one showing the highest resolution, show significant variations of the intake fractions by ingestion and by inhalation, the former being the dominant exposure pathway. The results also show higher intake fractions by inhalation for regions with high population density, and higher intake fractions by ingestion for regions with high agricultural and animal production. Spatial variability of fate factors, intake fractions and characterization factors is analyzed within and across each type of regionalization and sensitivity analyses allow validating the choice of the most appropriate regionalization scale. Residual error is calculated and discussed for results obtained by province and by ecozone regionalization scales and plotted against the watershed resolution.

165 What really matters when spatially differentiating human toxicity in North America. S. Humbert, A. Horvath, CEE, UC Berkeley, Berkeley, CA; S. Shaked, C. Wannaz, O. Jolliet, SPH, University of Michigan, Ann Arbor, MI; R. Manneh, L. Deschênes, M. Margni, CIRAIG, Polytechnique de Montréal, Montreal, Quebec, Canada; S. Schwarzer, GRID, UNEP, Geneva, Switzerland. The newly created spatially differentiated North American multimedia, multipathways fate, exposure and effect model considers several hundreds of watersheds, coastal zones and air cells. This model is used to explore the different questions associated with regionalization within North America: 1) What level of spatial resolution is needed to be environmentally relevant, but still affordable? 2) What really matters from an LCIA point of view? 3) Is spatial differentiation still relevant when combining LCI and LCIA? We explore the influence on inhalation and oral intake fractions of parameters such as population density variation, food production intensities, residence time of water within the different watersheds, wind patterns, pollutant half-lives and overall damage. We also examine how the relationship among these different parameters and the location of emissions influences intake fractions. The model captures the important parameters needed to model the fate and exposure of pollutants when emitted into air and water. Conclusions are drawn on when spatial differentiation is necessary and which parameters are most important to consider in such a case. Case studies, involving organics (mainly PAHs and dioxins) and particles emitted during combustion processes related to electricity production and freight transportation, are used to explore the influence of the different conclusions on final LCA results. These results are intended to help the LCA community when addressing the issue of regionalization in order to keep LCA as simple as possible, but as complex as necessary. **KEY WORDS:** Spatially differentiated fate, exposure and effect model; North America; human toxicity; intake fraction

166 Integration of risk assessment and life cycle assessment within a contaminated site remediation project. M. Ditor, R. Samson, L. Deschênes, J. Ménard, G. Bage, CIRAIG - Centre interuniversitaire de recherche sur le cycle de vie des produits, procédés et services, École Polytechnique de Montréal,

Montreal, Quebec, Canada. A remediation project to manage contaminated sediments next to an aluminum smelter in British Columbia will offer a unique opportunity to see life cycle assessment (LCA) and risk assessment (RA) realized in tandem. An integration of these two studies will be attempted at different levels of analysis. At the decision-making level, stakeholder participation will allow for a weighted comparison of the respective results of RA and LCA. Within the life cycle impact assessment (LCIA) method, site-specific data and risk assessment results will be used to modify fate and effect factors in order to create more representative characterization factors. Project objectives include shedding light on the role of LCA within environmental management decisions as well as exploring the possibilities for integrating LCA and RA.

167 LCA and Decision Making at Interface: Execution, Integration and Transparency. M. Binder, PE Americas, Boston, MA; P. Firth, Interface, Atlanta, GA. Corporations have made a rapid shift towards sustainability in recent years. As the intense transition moves from ‘a decision to do something’ towards ‘full strategic implementation’, businesses are seeking credible ways to measure their impact on the environment, guide their decision making processes and track their progress in the future in a scientifically robust way. At the same time, architects, designers and purchasing agents are seeking transparency from these businesses on how choices that affect the environment are being made and specifically about the impacts of the products being purchased. Interface has incorporated Life Cycle Assessment as one of its core measurements and decision making processes for both product and process decisions. Since beginning LCA as a part of research and development in 1999, it has become a measurement system for gauging materials, processes, products and business. Now, Interface is taking it one step further and making our LCAs available through Environmental Product Declarations (EPDs). Breaking through the analytical boundaries of LCA to get to true implementation requires a concerted effort from all parts of the business. Interface has successfully used LCA to engage everyone from research and development to sales personnel, from marketing to senior management. Life Cycle Assessment has truly become a fundamental guiding tool for Interface as we continue to strive for sustainability. This presentation will show: 1.) how LCA has been integrated in product development and research groups at Interface in an efficient way by using professional LCA software (GaBi4), high degree flexibility in modeling, 2.) how to secure data availability with the support of a commercial data base provider and 3.) how Interface will make LCA information available to interested stakeholders.

168 Coupling Ecosystem And Life Cycle Carbon Cycle Models To Quantify Net Forest System Carbon Balance. S.T. Gower, D.E. Ahl, Forest Ecology & Management, University of Wisconsin, Madison, WI. Traditionally forest carbon modeling has focused on the biological carbon cycle. However, it is important to include the industrial forest carbon cycle when considering the net system carbon balance. The objective of this study was to use an ecosystem process and life cycle inventory (LCI) models to estimate the carbon balance of the combined biological and industrial system (dimensional lumber, magazine paper, oriented strand board, etc.), respectively, for the Chequamegon-Nicolet National Forest in northern Wisconsin. We use the couple model to examine how forest management and product decisions affect the net carbon emissions. The LCI included the harvest, primary mill, secondary mill, transportation, product use, and product disposal processes of the major wood and paper products entering the industrial forest carbon cycle for the CNNE. We used BIOME-BGC, an ecosystem process model, simulate spatial carbon sequestration for 100 years for both present day and anticipated climate change scenarios. The industrial carbon budget for was combined with the biological simulation results for 3 harvest scenarios: no harvest, normal harvest, double harvest. All simulations suggest that the CNNE is a net C sink (biological C uptake > industrial C emissions). The normal harvest with a climate change scenario had the highest carbon sequestered for 100 years (0.179 kg C m⁻² year⁻¹) followed by no harvesting with climate change (0.16 kg C m⁻² year⁻¹). Mean annual industrial carbon emissions over 100 years for the normal harvest scenario comprised 12% and 7% of the biological carbon sequestered for the no climate change and climate change scenario3, respectively. The primary factors governing the magnitude of the combined carbon budget, in the absence of climate change, were forest area considered, harvest amounts, and time frame of analysis. Simulation results suggest that forest management activities could be tailored to minimize long-term carbon emissions from industrial processes, but that all processes and greenhouse gas emissions associated with producing a product need to be considered.

169 Why Does Science Have the Need for Healing? B.D. McGaughey, Compliance Services International, Lakewood, WA. This presentation introduces the discussion of “Science, Heal Thyself” by reviewing the elements of good science and symptoms of bad science and where each may show up in law, regulation, research or public communications. Along with the need to debunk junk science is the need to protect science from an expert’s overzealous efforts to be an advocate rather than fact finder. When science is the basis for regulatory decisions that must be made in a timely manner, there is often a departure between the regulatory community and general public in understanding how a body of scientific evidence is used to support decisions. For the public, it may be difficult to dissect an expert’s testimony and its weaknesses with respect to a departure from fact to personal opinion driven by personal agendas, especially when the scientist may use highly technical language or may not differentiate the special scientific application of a term that may also be used commonly in non-technical communications. For the science student, it may be impossible to separate skilled oratory from the skillful application of scientific principles. Whether we care to examine it or not, there is a “science of science.” This session examines what yardsticks should be applied to examine the departures from scientific theory that can be brought by “bad science” or poor application and interpretation of “good science.” The session also explores different approaches regulatory decision-making based on interpretation of scientific results.

170 Sound, Provable Science – The Key to Assessing Public versus Private Health Risk and to Developing Helpful and Ethical Health Risk Communication. R. Gots, National Medical Advisory Services, Rockville, MD. Concern that low-level chemical exposures might have a negative public health impact is the central paradigm underlying environmental regulation. Individuals who are exposed, or believe that they may be exposed to even low-levels of regulated or unregulated agents, are concerned that the exposure will harm them; and they can suffer from some distress as a result. The purpose of this presentation is to explore methods for putting both regulated agents – such as benzene found in drinking water or arsenic in soil, as well as unregulated ones – such as indoor bioaerosols or chemical and bioterrorism agents, into an effective context to ensure that levels of concern are congruent with true, not just perceived, levels of risk. Regulated agents require one methodology, while unregulated agents require another. Part of this discussion will explain the use of a Health Concerns/Indignation Level Matrix, and its application to effective communication activities. For these communication activities to be credible, scientists need to represent their commitment to the health of all parties by applying sound, provable science to a) determining causation for any reported health effects, and b) resolving the cause and its effects, if any. The session objectives include: 1) Translating both regulated and unregulated risks into an effective Risk Communication message, 2) Examining the Health Concerns/Indignation Level Matrix, and applying its strategies in effective communication activities, 3) Providing valuable, proven tools for effective discussions with lay audiences regarding their fears about various environmental exposures, and 4) Discussing the distinct roles of differential diagnosis and causation assessment

171 The Role of Science in the Research and Development of Aquatic Herbicides. K. Getsinger, A. Poovey, US Army Engineer Research & Development Center, Vicksburg, MS. The goal of applied research is to develop techniques, strategies, and products that directly benefit society. Society relies upon this process for food, shelter, health, and safety; therefore, investigators must apply valid scientific principles when conducting studies that enhance the quality of life. Sound and meaningful conclusions are reached when studies have realistic objectives and proper data interpretation. Experimental design, results, and conclusions should be vetted through a rigorous peer-reviewed publication process. Researchers must be well-trained, capable of anticipating and solving problems, and committed to designing and conducting the required studies that provide solutions. One example of an established applied research process is the development, registration, and use of aquatic herbicides. Experienced scientists from the private sector, academia, and government agencies collaborate on multi-tiered studies in the areas of discovery chemistry, human and environmental toxicology, and weed science. This collaboration culminates in timely methods for controlling invasive plants and restoring aquatic ecosystems that are scientifically sound, environmentally compatible, and cost-effective. Ultimately, the quality of the work impacts decision-making, regulations, policy, and the public trust.

172 Impact of the “Precautionary Principle” when Applied to Science-Based Regulatory Decision-Making. A.T. Hall, Bayer CropScience,

Research Triangle Park, NC; J.L. Shaw, Syngenta, Greensboro, NC. The essence of the Precautionary Principle directs that society does not need to wait until it knows all of the answers to the potential effects on an endpoint before attempting to protect non-target organisms from significant harm. The Principle as stated in the 1989 United Nations Conference on Environment and Development Earth Summit Rio Declaration reads: “Nations shall use the precautionary approach to protect the environment. Where there are threats of serious or irreversible damage, scientific uncertainty shall not be used to postpone cost-effective measures to prevent environmental degradation.” Some interpret this statement to mean that decisions can be made in absence of any research. Others interpret the precautionary principle to mean that no decision can be made until uncertainty is removed by exhaustive research. Neither extreme of this polarized debate is correct. This presentation examines how regulatory decisions can rationally use uncertain or incomplete scientific information without postponing decisions that might be urgent, not just for the environment but also for the health of individuals, the economy and our future. The presentation will also address how risk managers operating under regulatory statutes referring to the precautionary principle can make timely decisions, while still allowing for more refined evaluations. A proposal for possible conditions under which the precautionary principle might be applied will be explored.

173 “Precautionary” Regulation in the Biotech Century: Toxicogenomics, Biosafety and Endless Testing of Hypotheses. T.P. Redick, GEECLAW, St. Louis, MO. Advances in science have pushed the knowledge of toxic effects beyond broad epidemiology findings to the specific toxicogenetic pathways, exposing the genetically susceptible subclasses that previously eluded understanding. At the same time, new technologies from biotech crops to nanotech innovations are entering the marketplace, bringing benefits to consumers but posing hypothetical risks to human health and the environment. Advances in detection of health effects bring the power to generate more hypotheses requiring testing, and raise risks of any pathway for harm that is not tested. This presentation will compare challenges in the high-tech, biotech and nanotech industry sectors, discussing the concept of “precautionary priority” in regulation. This principle serves as a check against the potential over-reaction that occurs in implementing the ‘precautionary principle’ to manage risks of new technologies. Through advanced “sustainability” analysis that looks at various impacts, good and bad, regulators can assess the benefits of proceeding with a new technology despite the possibility of a hypothetical risks materializing over the long term. Technologies that will feed the world, cure disease, fuel our vehicles, control our climate and clean up waste, may still pose long term risks that are knowable through modern technology. Philosophically speaking, are we ready to knowingly injure one to save thousands?

174 We Have Met the Enemy and He Is Us: Do Conceptual and Operational Differences Among Scientists Affect Risk Communication. A.S. Felsot, Entomology, Washington State University, Richland, WA. As technology quickly progresses to more complexity and the feeling of helplessness becomes overwhelming, risk communication becomes ever more important. In some cases, especially concerning communication about chemical technologies, our message needs to highlight a discovered hazard, but in other cases our message might need to downplay an insignificant risk. As professional scientists, perhaps we feel that our message of risk to the public is not being understood, or even ignored. Perhaps we lament the inability of the general public to comprehend scientifically derived concepts, and feel modern culture is awash in scientific illiteracy. Before throwing the blame outward, however, we need to look inward to see how our own perspectives and behavior might make us part of the problem, perhaps even a large part of it. Thus, I propose the idea that we cannot expect the public to know “what to think” or “what decision to make” if we ourselves have differences over basic concepts and operational behavior. Regarding conceptual differences, one study has shown in a comparison of expert and lay perceptions of toxicological concepts, significant differences of opinion occur as much within the group of experts as they do between the experts and public. Another example of a conceptual difference would be to ask yourself how you would define hazard and risk, or to think if you sometimes use these terms synonymously. To illustrate operational differences, ask yourself when you read a research paper, if have you properly classified the objective of an experiment. Is the paper about basic mechanisms, hazard identification, exposure assessment, or risk characterization? In your busy workday, do you read more than just the abstract and its spun conclusions, or do you carefully examine the data tables

and graphs to make up your own mind? As good as most experiments read once published, do you ever engage in “alternate” hypothesis gamesmanship, just to be skeptical. After all, shouldn't scientists operate as skeptics when testing a hypothesis and interpreting the observations? Until we see that we professionals have different conceptions about putatively common principles and behave differently in how we go about interpreting information, we cannot expect the public to respond as we want to our risk communication messages.

175 Is Bad Science Better than No Science at All? Public Perceptions and Government: a Cautionary Tale. C.R. Layne, Aquatic Ecosystem Restoration Foundation, Marietta, GA. This presentation provides commentary on the effects of distorted information, rumor, and innuendo, and its distribution on “the information super highway,” with respect to the resulting impact on the function of government at the level of interaction with the public. Based on 35 years of federal service with USDA and the EPA, the speaker will provide examples of how misinformation and misinterpreted science have affected the regulatory system and how public perception is often more likely to be guided by misinformation than scientific realities. Efforts to react to the public and the misinformation that general society may be relying upon often affect public policy and the procedure applied to regulatory operations in a manner stronger than the underlying sound science supports. This phenomenon is not limited to government. How is the public best served when issues based on misinformation, bad science or no science at all are presented? This presentation will explore some options for consideration.

176 What hath Daubert wrought? Scientific and technical expert evidence in the courtroom. E. Eder, Eder Garg Law Group, LLC, Washington, DC. Science and technical expert testimony often is viewed as the critical centerpiece that a party submits to the factfinder in a trial. As cases present ever more complex scientific and technical matters, it can be essential for science professionals to be familiar with standards and rationales that courts use in deciding whether to admit such expert testimony. This is particularly true since some judges see themselves as the gatekeeper to factfinder exposure to so-called ‘junk science’ and agenda-driven conclusions. The Frye standard of ‘general acceptance in the expert’s field’ has largely given way, even in state courts, to the far more nuanced, multi-factor approach that the U.S. Supreme Court set forth in a triad of decisions, starting with the so-called Daubert ruling. This presentation will explore perspectives for science and technical experts to consider before it’s too late. Both results and rationales for admitting or excluding scientific expert evidence can be surprising and difficult to predict.

177 Communicating Science: Model Approaches and Forums. J. Bonner, Council for Agricultural Science and Technology, Ames, IA. Refereed scientific journals are directed at a specific scientific audience and do not communicate to the public what the core issues are in non technical terms. In part, the fact that journal articles are so technical, when translated for the public by what may be “agenda-driven” science, often results in controversy. To fully inform the public, resolve conflict, and clarify technical issues it is necessary to have a forum that provides sound scientific analysis and communicates it in a way that a non-technical audience can understand. One example is the Council for Agricultural Science and Technology (CAST), a non-profit organization established in 1972 as a result of a 1970 meeting sponsored by the National Academy of Sciences, National Research Council. The primary work of CAST is the publication of task force reports, commentaries and issue papers written by scientists from many disciplines. CAST assembles, interprets, and communicates credible, science-based information regionally, nationally, and internationally to legislators, regulators, policymakers, the media, the private sector, and the public. CAST addresses issues of animal sciences, food sciences and agricultural technology, plant and soil sciences, and plant protection sciences with inputs from economists, social scientists, toxicologists, plant pathologists, entomologists, weed scientists, nematologists, and legal experts. This presentation examines the process used to develop communication materials, the types of materials produced and the success such materials have had in the communication of complex scientific details in a manner that can be understood and relied upon by the non-technical audience.

178 Federal Support for Sustainability Research. C.M. Lee, Environmental Engineering & Science, Clemson University, Anderson, SC. From insight gained as the first program manager for Environmental Sustainability at the National Science Foundation, I will discuss federal

programs that support research in sustainability science and engineering. The Engineering Directorate of NSF debuted two programs in October 2006 to support investigator-initiated research in sustainability. Other programs including some housed in the Biological Sciences and Geosciences Directorates have supported research directly related to sustainability for a number of years. Research in sustainability that features international collaboration is supported by the Office for International Science and Engineering at NSF. Programs of the Environmental Protection Agency and the Department of Agriculture that support sustainability projects will also be highlighted.

179 Forest management sustainability in the context of climate change mitigation. E. Sonne Hall, Sustainable Forests and Products, Weyerhaeuser Company, Federal Way, WA. There has been much debate about the role of forests and forest products in climate change mitigation. Life cycle assessment and life cycle thinking can be used to investigate forest management and forest industry trends in the context of climate change. As with all life cycle assessments, the choice of system boundary and functional unit greatly influence the results of the analysis. This paper will pull together research that examines the role of forests and forest products in a sustainable society with emphasis on climate change mitigation. The second half of the paper will examine how one of the largest forest products manufacturing companies, Weyerhaeuser Company, addresses carbon footprint within various system boundaries; including the forest site, the manufacturing site, and the building industry.

180 Demonstrating Net Positive Impact on Biodiversity. E.J. Dorward-King, A. Stuart, HSE, Rio Tinto, London, United Kingdom. Rio Tinto’s leadership in sustainable development thinking and practical delivery has been recognised in numerous external rankings and assessments in the United Kingdom, Australia and worldwide. One aspect of that commitment is expressed in its Biodiversity Strategy. This strategy, finalised and made public in late 2004, commits Rio Tinto to having a net positive impact on biodiversity where it operates. Many observers in the natural resources industry sector and in environmental NGOs were sceptical regarding such a commitment in large part because of the difficulty in assessing impacts (positive and negative) and controversy over how biodiversity offsets could or should be used. There was little consensus in the academic or NGO community about how progress toward or achievement of the goal of net positive impact might be determined. Rio Tinto scientists in conjunction with external experts have developed a methodology for doing this, and it is now being tested at Rio Tinto operations in Australia and Africa. This presentation will describe the methodology and the results from the early pilot studies.

181 Supply-Side Sustainability. R. McCormick, Risk & Environmental Monitoring, Golder Associates, Ltd., Calgary, Alberta, Canada; T. Allen, Department of Botany, University of Wisconsin, Madison, WI. With a few simple graphs, and some far-ranging examples from business, history and even ecology, we’ll look at the sustainability of ultimate means (that is, resources) in supplying a sufficiency of ultimate ends (that is, human desires) by way of efficient translations of ultimate means to ultimate ends. We’ll address the ‘sustainability definition issue’ and solve it easily. From there we’ll look at the thorny issues related to indicators and scale, and offer approaches to dealing with these in your daily life or while working on half-century long projects. The concept of espoused values in relation to actual operational values deserves highlighting, and we’ll do that with the examples throughout the presentation. The possibility of change lies within each of us, mostly in the grey matter between our ears, so come see how systems thinking can lead you and the world toward supply-side sustainability.

182 Local and long-range health impacts of global trade: a textile case study. S. Shaked, Applied Physics, University of Michigan, Ann Arbor, MI; D. Friot, University of Geneva, Geneva, Switzerland; J. Steinberger, University of Lausanne, Lausanne, Switzerland; M. Margni, Ecole Polytechnique, Montreal, Quebec, Canada; C. Wannaz, O. Joliet, School of Public Health, University of Michigan, Ann Arbor, MI; S. Humbert, University of California Berkeley, Berkeley, CA; S. Schwarzer, United Nations Environmental Program, Geneva, Switzerland. Increasing global trade is separating the location of emissions and health impacts of a given product from the location of the consuming population. We estimate the local and long-range health impacts of textile exports using the case study of a T-shirt and polyester jacket made in India and bought in Europe. The health impacts are estimated based on the fate, exposure and intake of pollutants emitted during the manufacturing, transport

and use phases, which occur respectively in the producing nation, the rest of the world and the consuming nation. In order to determine the health impacts of current consumption patterns, we use a multi-continental multimedia model and life cycle impact assessment techniques to link emissions resulting from production to the subsequent health impacts on both the producing and consuming countries. We find that emissions in India tend to result in 3-6 times the health damage relative to that same emission in the US. We also find that when efficient appliances are used in the consuming country (Europe), 70% of a T-shirt's CO₂ emissions take place in the producing nation (India). Additionally, India experiences 75% of the total health impacts from particulate matter emissions throughout a T-shirt's life cycle. The influence of vertical exchange and jet streams on long-range transport and eventual impact will also be discussed. Different scenarios of the model are run examining the total human health damage in the producing country, the consuming country and the rest of the world, in order to provide guidance to decision-makers on the optimal methods for decreasing human health impacts and increasing sustainability in global trade.

183 Designing Sustainable Consumer Products: Perspectives from a Global Company. A.V. Weisbrod, W. Greggs, R. King, Procter & Gamble, Cincinnati, OH; D. Schowanek, R. Pant, E. Linclau, M. Stalmans, Procter & Gamble, Brussels, Belgium. Environmental sustainability as well as energy and carbon savings are increasingly part of political agendas and viewed as the responsibility of whole societies, requiring new efforts by governments, industries, and individuals. From a technical standpoint, there are several ways to accomplish substantial improvement to the environmental attributes of products that are not obvious to the consumer or in list-based environmental preference programs. For decades, P&G has been selecting ingredients based upon their environmental attributes, designing new chemicals with improved environmental profiles, compacting products to improve distribution efficiency for energy and resource savings, and reducing emissions through eco-efficiency and cost saving programs. Examples will be shared of how these concepts are realized in the products used by billions of consumers globally, and how Environmental Risk Assessment and Life Cycle Analysis (LCA) have been applied over the years in a disciplined manner to shape P&G products in the marketplace today. Practical perspective will be provided on the popular 'cradle to gate' Carbon Footprint schemes that focus on a few parameters, possibly neglecting significant energy savings opportunities related to consumer use or disposal. It will be further described how eco-epidemiological approaches have been used to confirm the success of these strategies and how company-wide metrics can be used to evaluate environmentally-relevant progress over time.

184 Environmental Impacts caused by the Diffusion of Refrigerators in Japan. I. Sayaka, Graduate School of Economics, Waseda University, Kawasaki City, Japan. In last decades we have benefited from quite a few industrial products. In Japan many electric appliances had become widely used in last half a century, for instance the rate of diffusion of refrigerators have raised rapidly in 1960s. The rapid spread of home electric appliances which play an auxiliary role of housework like refrigerators has reduced time spent on housework and raised the value of an hour of our lives. The introduction of new goods have created previously unimaginable lifestyle and saved time, and a wide variety of human wants easier to satisfy. In fact, refrigerators enable consumers to purchase and preserve perishable foods more than they can consume in a day. Refrigerators with freezing compartments additionally enable consumers to purchase and preserve ice creams and any frozen foods. The more sophisticated equipments households possess, the greater variety of consumption goods and services they can reach. A microeconomic model has been introduced to describe how the possession of durable products affects to change consumers' behaviors (Ito(2007)). The model theoretically describes the situation that contents of a potential consumable consumption bundle may change due to the specification of a durable product a consumer possesses. Whether a consumer has a refrigerator or which type of refrigerator a consumer has have technical linkages to know what type of grocery products the consumer can have. According to the changes in grocery purchases along with the rapid diffusion of refrigerators in Japan in 1960s, the industrial structure has changed. The industrial structural changes may have great impacts on the environment. In scenario analyses, Input-Output tables will be used to evaluate environmental (CO₂) impacts based on a scenario that the introduction of a refrigerator (a technological development) can be the only cause to change grocery purchases and be a driver to change industrial structures. Even though the environmental impacts have been caused not only by a technological development of one durable product but by mixtures

of several causes, the result which will be shown can be the threshold level the durable products cause. When a new type of durable product is designed and developed, it should be one aspect producers should concern that the technological progress can be the key cause to change consumer behaviors and environmental impacts.

185 Comparison of Agricultural Run-off between Biological Farming and Conventional Chemical Farming. N. David, San Francisco Estuary Institute, Oakland, CA; F. Thomas, California Certified Organic Farmers, Santa Cruz, CA; M. Gibbs, Community Alliance with Family Farmers, Davis, CA. Sustainable cotton and organic stone fruit are two out of several projects in the Central Valley of California, which examine alternatives that benefit the farmer, the consumer, and the protection of water quality. Grants from the California State Water Resources Control Board (SWRCB) are being used for outreach, education, technical support, and political advocacy for farmers trying alternatives to pesticides. Best Management Practices (BMPs) that are being implemented include organic pesticides and pheromone disruption, cover crops, filter strips, beneficial insects, and monitoring of insects and fertility. The San Francisco Estuary Institute is conducting water and sediment quality monitoring for these SWRCB-funded projects with the goal to evaluate potential differences in pesticide and nutrient concentrations running off from various biological/organic and conventional fields. These projects are ongoing and the results from the first year will quantify load reductions of pesticides draining into streams and rivers listed on the 303d list for impaired water bodies. Limited bioassessment samples are also being evaluated. This work will allow the assessment of effectiveness of BMP implementations in combination with data collected from the County Agricultural Commissioner and pesticide use reports. All monitoring efforts are compatible with a state-wide water quality data collection effort, the Surface Water Ambient Monitoring Program (SWAMP).

186 Release Behavior of Munitions Constituents From Breached Shells in the Marine Environment. P. Wang, R. George, B. Wild, Spawar Systems Center, San Diego, San Diego, CA; W. Choi, Computer Sciences Corporation, San Diego, CA; Q. Liao, University of Wisconsin-Milwaukee, Milwaukee, WI. The release rate of munitions constituents (MC) from a breached shell exposed to currents in the marine environment has been developed as a semi-analytical function. This release rate function is dependent upon six (6) variables, including the ambient current, breach hole size, hydrodynamic diffusivity, MC cavity radius inside the shell, the MC dissolution rate, and the MC saturation concentration. The semi-analytical release rate function has been compared and verified with results from the numerical computational fluid dynamics (CFD) model, FLUENT. We have applied the verified release rate function to TNT, RDX and HMX, three common MCs, under various hydrodynamic and shell integrity conditions. For these MCs, the time for complete depletion from a breached shell under various ambient current speeds was calculated to range from less than one year to over one thousand years, depending on the range of realistic values selected for those six variables. Using both the fine-scale hydrodynamic and transport model, TRIM, and the general water quality box-model, WASP, we also simulated the fate and transport of TNT in inner San Diego Bay, released from a 24 in by 8 in breached shell containing 8 kg of TNT, and with hole of radius 0.5 cm. During this model simulation, the resultant steady state TNT exposure concentrations ranged from 0 to 50 ng/L throughout the Bay. In this presentation, we will demonstrate the utility of the release function and application within the model to simulate the dynamic range of potential MC concentrations used to provide exposure estimates.

187 New Orleans Baseline Soil Maps of Lead, Arsenic and Mercury: an Applied Geochemical Approach for Exposure Prevention. H. Mielke, Center for Bioenvironmental Research, Tulane University, New Orleans, LA; C. Gonzales, Department of Chemistry, Xavier University of Louisiana, New Orleans, LA. This urban soil metal research focuses on lead (Pb), mercury (Hg) and arsenic (As) in residential communities of New Orleans. The soil survey of metropolitan New Orleans (n = 5,467 samples stratified by 286 census tracts) was completed before Hurricane Katrina. Composite soil samples (n ~ 19) for each census tract were analyzed for Pb and As by ICP and for Hg by direct mercury analysis (Milestone DMA-80). The findings were integrated into a GIS system and the resulting maps show the spatial distribution of Pb, Hg and As in the city. The patterns for Pb and Hg are similar (correlation ~ 0.9) while the pattern for As is different from the other two metals (correlation ~ 0.6). The largest amounts of Pb and Hg (Pb ~ 1,000 mg/kg; Hg ~ 1,000 µg/kg) were in residential census tracts within

the inner ring of communities surrounding the central business district. The sources of Pb were commercial products with large quantities of Pb such as paint, and vehicle fuels with Pb additives. Hg is associated with sulfur in fuels. As was associated with lead arsenate insecticides, that were commonly used before the advent of synthetic organic insecticides, and CCA-treated wood (i.e., chromated copper arsenate). The soil metal maps of New Orleans show that the urban environment is a historic sink of metals and their pattern in soil defines the chemical milieu of the city. These maps serve as a foundation for developing a science-based strategy for reducing the high childhood prevalence of chronic Pb exposure (~ 14% in pre-Katrina New Orleans) and health effects associated other toxic metals. They also provided critical information necessary to evaluate the environmental impact of flooding of New Orleans after Hurricane Katrina.

188 Coal-Tar-Sealed Parking Lots Are PAH Hotspots. P. Van Metre, B.J. Mahler, J.T. Wilson, U.S. Geological Survey, Austin, TX. Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous contaminants in urban environments, and concentrations are increasing in urban lake sediments across the United States. In 2005, it was reported that refined coal-tar-based parking lot sealcoat was a major source of PAHs to urban streams in Austin and Fort Worth, Texas. Use of coal-tar-based sealcoat is widespread east of the Continental Divide but use is more limited in the west. The study presented here measured PAHs in particles swept from sealed and unsealed parking lots in five U.S. metropolitan areas (New Haven, Conn., Detroit, Mich., Chicago, Ill., Minneapolis, Minn., and Salt Lake City, Utah) and in sealcoat scraping samples from parking lots in two others (Milwaukee, Wis., and Portland, Ore). Parking lot dust samples were collected by sweeping areas of several square meters using a soft, clean, nylon brush and dust pan. Most samples were composites of sweepings from three or more parking lots. The mean concentration of Σ PAH (12 parent PAH and one alkyl-PAH) in dust from sealed lots from the four cities in the central and eastern United States was 2,300 mg/kg, over 70 times greater than the mean of 31 mg/kg from unsealed lots in the same cities. Concentrations in the one western city where dust samples were collected, Salt Lake City, were 2.1 and 0.83 mg/kg for sealed and unsealed lots, respectively. Other sources of PAHs (e.g., exhaust particles, tire wear, leaking motor oil) occur on both the sealed and unsealed lots, thus the refined coal-tar sealcoat is indicated as the most important factor contributing to the large differences in concentrations, a conclusion supported by the chemical assemblages of PAHs in the samples. Samples of sealcoat scraped from parking lot surfaces in Milwaukee (Σ PAH from 8,000 to 19,000 mg/kg) and Portland (Σ PAH from 2 to 30 mg/kg) also show a striking east-west difference. Dust from urban impervious surfaces is readily washed off during storms and carried into streams and lakes. PAH concentrations and assemblages in sediment cores from lakes or reservoirs in each of the watersheds sampled suggest a correlation to sealcoat use. Top-of-core concentrations in the five eastern cities range from 4.6 to 33.8 mg/kg, whereas top-of-core concentrations in the two western cities range from 0.43 to 0.79 mg/kg.

189 Ditolowdimethylammonium cations (DTDMAC) as tracers of contaminant sources in urban harbor sediments. X. Li, B.J. Brownawell, MSRC Stony Brook University, Stony Brook, NY. DTDMAC remains a major class of cationic surfactant used primarily as fabric softeners in some areas of world, although it has been replaced in many products or countries since the early 1990's by esterquats or other quaternary ammonium esters which are more biodegradable. Superhydrophobic and persistent, DTDMAC sorbs strongly via cation-exchange to natural sediments, properties that should make it a powerful tracer of other particle-reactive sewage derived (organic and metallic) contaminants, organic matter. DTDMAC should also provide a useful tracer of sediment transport processes. Despite levels measured in sewage sludge approaching 1% before their phase-out in parts of Europe, there are no reports of DTDMAC concentrations in estuarine or urban harbor sediments in the U.S. We have developed a sensitive method for extraction and HPLC-time-of-flight-MS analysis for DTDMAC in estuarine sediments (and other quaternary amine surfactants), and applied the method to samples from highly urbanized areas of New York and New Jersey Harbor. DTDMAC concentrations in recent surface sediments are up to 109 ppm in sewage impacted muddy sediments and near 1 ppm for sandier New York Harbor sediments as well as in Long Island Sound sediments approximately 60 miles away from intense sewage sources; undetectable concentrations are measured in deep sediment core samples. Optimized detection limits with the current method remain undetermined, but may be as low as 1-5 ng/g. DTDMAC

levels in surface sediments of the Harbor Complex are proportional to levels of other particle reactive contaminants with suspected sewage sources (more particle reactive polyethoxylated nonylphenol ethoxylates, NPEOs, total organic carbon, and silver), and are less well correlated with less ethoxylated NPEO metabolites that we hypothesize are more biodegradable in some environments, and other metals that presumably have other important sources. The analysis of DTDMAC in sediments will also be compared to other particle reactive endocrine disrupting chemicals (e.g., PBDEs) and measures of chronic and acute sediment toxicity. Initial work on historical variation of DTDMAC in sediment core samples indicates approximately a four-fold decrease in concentrations from the mid-1980's to 2001 (Newtown Creek wastewater treatment plant affected sediment with levels up to 350 ppm in 1987) as well as a site at the mouth of the Passaic River.

191 Effects of urbanization on karst ground-water quality in the Barton Springs segment of the Edwards Aquifer, Austin, Texas. B. Mahler, USGS, Austin, TX. Karst aquifers are characterized by transport through a high-conductivity conduit network and storage in a low-transmissivity matrix, and are extremely vulnerable to contamination. Surface-water/ground-water interaction often results in the direct injection of runoff into the aquifer following storms. Here we investigate the effects of urbanization in the Austin metropolitan area on water quality in the Barton Springs segment of the Edwards aquifer, Texas. Samples collected from four hydrologically connected springs were analyzed for a suite of urban-related contaminants that comprises soluble pesticides, solvents, drinking-water disinfection byproducts, and nutrients. Samples were collected routinely (every 2 to 3 weeks) from all four springs, and at closely spaced intervals (hours to days) from two of the springs following two storms. Results of routine sampling demonstrated persistent low level occurrence of atrazine, tetrachloroethylene, chloroform, and nitrate in the four springs. Recharge rates through creek beds during non-stormflow conditions were positively correlated with atrazine and tetrachloroethylene concentrations and negatively correlated with nitrate concentrations at one or more of the springs, demonstrating the effect of focused recharge on water quality at the springs. Storm-related sampling revealed the rapid response of the ground-water-flow system to infiltration of runoff, with atrazine, simazine, chloroform, and tetrachloroethylene defining breakthrough curves at one or both springs that peaked 1 to 2 days following rainfall. Post-storm concentrations increased as much as a factor of 10, and additional anthropogenic compounds were detected in post-storm samples. In contrast, concentrations of nitrate decreased at both springs following storms, indicating a ground-water source with a low nitrate concentration. Comparison of breakthrough curves for different storms suggests that the relation between the vertical position of the conduit system and the water-table level affects the degree to which contaminants in storm runoff are diluted or stored before they discharge from the springs. The results demonstrate the ways in which urban contaminants can affect karst ground-water quality, which include rapid transport through the conduit system and storage in the aquifer matrix, and highlight the need for a range of monitoring approaches in these vulnerable aquifers.

192 Surficial Sediments as sources of Airborne PCBs in East Chicago, Indiana. A. Martinez, K.C. Hornbuckle, Civil and Environmental Engineering, University of Iowa, Iowa City, IA. East Chicago is a heavily industrialized urban community on the southern shore of Lake Michigan. Penetrating the city center is the Indiana Harbor and Shipping Canal, an Area of Concern designated by the International Joint Commission due to contamination by many environmental pollutants including polychlorinated biphenyls (PCBs). PCBs are known to contaminate the harbor and canal, although there is little published data describing the spatial extent and concentration magnitude. We hypothesize that elevated concentrations of PCBs in the sediments are sufficiently high as to contribute to the background atmospheric concentrations of PCBs in the area. To test this hypothesis we have conducted a sampling expedition designed to allow a multimedia comparison of PCB concentrations and fluxes in the Harbor system. We collected surficial sediment, water, and air samples from the harbor and connected canal. The samples were extracted using accelerated solvent extraction. The extracts were analyzed for all 209 PCB congeners by tandem mass spectrometry. Preliminary results indicate an enrichment of PCBs near bridges and in the canal and dynamic air/water/sediment exchange of PCBs throughout the region. The highest concentrations were in areas of sediment accumulation and lower concentrations were observed in areas of constant resuspension due to barge and other water vessel traffic.

193 Do the airborne PCBs contribute to the PCB contamination found in the blood of people living in Chicago? K.C. Hornbuckle, K. Norström, R. Marek, Civil and Environmental Engineering, University of Iowa, Iowa City, IA; K. Norström, G. Czub, M.S. McLachlan, Applied Environmental Science (ITM), Stockholm University, Stockholm, Sweden; P.S. Thorne, Dept of Occupational and Environmental Health, University of Iowa, Iowa City, IA. Fish consumption is generally considered the major route for PCB accumulation in humans. However, the inhalation route may contribute to human exposures of PCBs in some environments and populations where the airborne concentration is high. To examine this hypothesis, we have conducted a preliminary study of the PCB congener distribution pattern in blood serum of five, middle age, Chicago-area, African American males. We have evaluated the potential for inhalation as a significant source of the accumulated PCBs using the ACC-HUMAN bioaccumulation model adjusted for potential Chicago dietary and air PCB concentrations. Blood plasma and air samples were obtained in the winter of 2006/2007. More than 100 congeners were found in the air samples and the sum of the congeners ranged from 0.3 to 8 ng/m³. More than 20 congeners were found in the serum samples and the sum of the congeners ranged from 80 to 500 ng/g lipids. The model was used to examine scenarios that could produce the observed PCB concentrations and congener distributions. This work will be expanded to a cohort of adolescents and their mothers.

194 Cities: from contaminant emissions to exposure. M.L. Diamond, L. Melymuk, M. Robson, Geography, University of Toronto, Toronto, Ontario, Canada; M.L. Diamond, S. Csiszar, Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario, Canada; S.J. Harrad, Environmental Health and Risk Management, University of Birmingham, Birmingham, United Kingdom. Despite calls for sustainability over the past 3 decades, globally we are consuming ever more resources of which an increasing fraction is non-renewable. Nowhere is this more accentuated than in cities. Urban centres are home to 73-77% of populations in Europe, North America, Latin America and the Caribbean and virtually all population growth worldwide will occur in cities from now until 2030. Urbanization demands the geographic concentration of resources that are stored in cities (for example buildings, infrastructure, durable commodities) and that flow through cities (food, consumable commodities). A very small fraction of these stocks and flows are chemicals which are categorized as persistent, bioaccumulative and toxic (PBT). This presentation explores the interconnections among urban stocks and flows, and human exposure of two "PBTs", the brominated flame retardants polybrominated diphenyl ethers (PBDEs) and banned polychlorinated biphenyls (PCBs). PBDEs are contained in numerous consumer products. PCBs, although banned in the 1970s, still exist in urban areas in old electrical equipment and building sealants. Through measurements and modelling, we trace the release of PBDEs and PCBs from commodities and materials in the urban fabric through to our exposure via the indoor environment and food pathways. The use and release of these persistent chemicals poses important questions regarding their management not just at the time of manufacturing, but throughout the life cycle of the products and material in which they are used.

195 Understanding the Past to Improve the Future: Knowledge Gained from the Diversity of POPs. D.L. Swackhamer, Institute on the Environment, University of Minnesota, Minneapolis, MN. Persistent Organic Pollutants (POPs) have been with us since the mid 20th century, when organic synthetic chemicals became widely manufactured following World War II. Many of the industrial POPs were intended to improve and advance our society and our quality of life, but they also had unintended consequences for human and ecological health. Since the 1960s we have labored to understand these consequences and to find an acceptable regulatory framework with which to manage them, and we have attempted to balance environmental and human health risk with the benefits such chemicals provide. We now have nearly 40 years of research on a wide array of POPs, from industrial chemicals and pesticides to manufacturing and combustion by-products, and in every environmental media possible from air to biota. This talk will set the stage for the talks that follow in this session, by examining the diversity of POPs behavior, chemical properties, and effects, and by exploring this research history for lessons that can guide us in POPs research and policy for the future.

196 Climbing the POPs Mountain. C.M. Lee, Environmental Engineering & Science, Clemson University, Anderson, SC. Why should we continue to study POPs such as PCBs after mountains of existing studies? Because, to paraphrase Sir Edmund Hillary, they are still there. New analytical techniques allow new questions and novel insights. Two examples of innovative approaches to studies of POP fate will be explored. The identity of dechlorinators of PCBs has been a long-standing mystery due to the inability to develop pure cultures. However, the development of molecular biological techniques permits a leg up because researchers can propose identities without the necessity of isolating a pure culture. This development promises the advancement of engineering remediation schemes and of fundamental insights about microbial ecology. The second innovative approach is the improvement of commercial chiral chromatography that allows PCBs to be used as probes that can shed light on bioaccumulation and metabolism in food webs. Chiral analysis will provide a path to understand the transfer of POPs from sediment to macro-invertebrates to fish to higher order consumers. Hypotheses about the export or recycling of POPs in ecosystems can be tested with a new set of tools. The footholds provided by new analytical methods will allow us to scale new heights and scan new horizons of POPs research.

197 Consumer and Industrial Chemicals in Natural Systems. K.C. Hornbuckle, Civil and Environmental Engineering, University of Iowa, Iowa City, IA; K.C. Hornbuckle, IHR-Hydroscience and Engineering, University of Iowa, Iowa City, IA. The presence of consumer, industrial, and agricultural products in natural systems is well known. Our awareness of these compounds in the environment is a result of public concern about their presence and subsequent research to investigate the sources and effects. Unfortunately, determination of sources and effects remains a major challenge. Source determination is a particularly vexing aspect of predicting the fate and transport. Three organic compound groups illustrate this point: perfluorinated surfactants; synthetic musk fragrances; and PCBs. Perfluorinated compounds are related to the production and use of many useful products including surface protectants, fabric treatments, and polytetrafluoroethylene. Synthetic musk fragrances are very common additives that are highly persistent and appear to exhibit low-level toxicity to aquatic organisms. PCBs are a valuable comparison group because we understand their environmental cycling and production history quite well. We are also well aware of their harmful impacts on humans and animals. Unfortunately, control of PCBs still suffers from lack of information about their current sources. Strategies for evaluating the sources, effects, and distribution of three compound groups are compared.

198 Exposure and Fate of a New Class of POPs, PBDEs: A Case-Study for Indoor Exposure to POPs. H.M. Stapleton, S.M. Kelly, Nicholas School of the Environment, Duke University, Durham, NC; J.G. Allen, M.M. McClean, T.F. Webster, Department of Environmental Health, Boston University School of Public Health, Boston, MA. Polybrominated diphenyl ethers (PBDEs) are now considered a new class of persistent organic pollutants (POPs). Because PBDEs are used as flame retardants in products such as TVs, furniture, and carpets, indoor environments are likely a significant source of human exposure to PBDEs, contrary to exposure to classical POPs such as DDT and Dioxins, which typically is a dietary source. This shift in our paradigm of exposure to POPs highlights a need for better tools to accurately determine release and exposure in indoor environments. In a multi-investigator pilot study, human exposure to PBDEs has been examined through measurements of PBDEs in indoor air, house dust, and hand wipe

samples. In addition, an XRF (X-ray fluorescence) analyzer has been used to survey potential sources of PBDEs to the indoor air/dust environment. Σ PBDEs (tri- to heptaBDEs) in indoor air (geometric mean: 289 pg/m³ in main living areas, 325 pg/m³ in bedrooms and 469 pg/m³ in personal air) were significantly higher than previously published values for outdoor air. Concentrations of Σ PBDEs (tri- decaBDE) in house dust were significantly higher in the main living room (geometric mean: 10,200 ng/g dust) relative to the bedroom (geometric mean: 4530 ng/g dust). An XRF analyzer was used to characterize the bromine content of furniture, which was found to be a significant predictor of pentaBDEs in dust in both the main living areas and in the bedrooms. The XRF measurements of bromine in electronic products were strongly correlated to decaBDE levels in bedroom dust. Hand wipe samples were also analyzed for PBDEs as an indicator of exposure from hand to mouth contact. PBDEs were detected in every sample and ranged in concentration from 3.3 pg/cm² to 1970 pg/cm² of hand surface area. Assuming that an adult experiences an average of 5 hand-to-mouth contacts per day with just 10% of their hand surface area would therefore result in an exposure of approximately 76 ng of Σ PBDEs/day. This data suggest that hand to mouth contact alone is comparable to or greater than dietary exposure to PBDEs, and highlights the need for a better understanding of indoor exposure to this new class of POPs.

199 Source Apportionment of Urban PCBs. L.A. Rodenburg, B. Xiao, S. Du, Environmental Sciences, Rutgers University, New Brunswick, NJ. Urban areas typically contain elevated PCB concentrations in all environmental compartments, including air, water, soil, and sediment. In many urban waterways, PCB levels exceed the federal water quality standard, such that efforts to identify PCB sources are needed. This research examines the use of Positive Matrix Factorization (PMF) to apportion PCB sources in several systems. Atmospheric sources are examined using gas-phase PCB data from Camden, NJ. Aquatic PCB sources are examined using data on ambient PCB concentrations in the water column of the Delaware River and the NY/NJ Harbor. Application of PMF to these data sets yields as many as 6 identifiable source patterns in each system. Sources identified include unweathered aroclors, wastewater treatment plant effluents, and resuspended sediment. Examination of both atmospheric and aquatic sources allows a more holistic understanding of PCB sources in urban areas and reveals a surprisingly weak linkage between the water column and the atmosphere.

200 Atmospheric POPs monitoring in Canada. P. Blanchard, H.H. Hung, Environment Canada, Science and Technology Branch, Toronto, Ontario, Canada. The Integrated Atmospheric Deposition Network (IADN) and the Northern Contaminants Program baseline POPs monitoring network (NCP-POP) have been monitoring atmospheric POPs continuously in the Great Lakes basin and the Canadian Arctic respectively since the early 1990s. IADN was initiated as a requirement of Annex 15 of the Great Lakes Water Quality Agreement between the United States and Canada and as a response to growing concerns that toxic chemicals were entering the Great Lakes via the atmosphere. NCP-POP was created in 1992 as a research network following studies on Arctic haze and to try to determine sources of POPs found in Arctic biota. The longevity of these networks is an asset to Canada's global contribution to the assessment of the effectiveness of the Stockholm Convention on POPs. Both networks routinely measure legacy chemical such as PCBs, OC pesticides as well as combustion by-products such as PAHs and mercury according to published sampling and analytical protocols. Since several laboratories are involved in IADN and NCP-POP has recently changed analytical laboratory, strict Quality Assurance programs must be in place to ensure the integrity and continuity of the networks' data. POPs concentrations, temporal and spatial trends will be reviewed highlighting differences and similarities between the temperate and high latitudes of Canada. Both networks have recently introduced new and emerging chemicals such as PBDEs and a comparison of levels will be presented. Based on the foundation of these programs, an International Polar Year (IPY 2007-2008) project named "Intercontinental Atmospheric Transport of Anthropogenic Pollutants to the Arctic (INCATPA)" has been initiated. This project will measure atmospheric POPs and mercury at background stations in Canada, Russia, China and Vietnam to assess pollutant transport to the Arctic and investigate the potential influence of climate change. Finally, future considerations for long-term POPs monitoring networks in times of changing government priorities will be offered.

201 Environmental behavior of brominated POPs in aquatic and terrestrial ecosystems, particularly higher brominated PBDEs. C.A. de Wit, Dept of Applied Environmental Science, Stockholm University,

Stockholm, Sweden. Polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecane (HBCD) are widely used flame retardants, resulting in their release to the environment. Studies in the early 1990s focused on the Te-PeBDE congeners found in the PentaBDE product (BDE47, 99, 100). These were found to be widespread in aquatic ecosystems, and to bioaccumulate and biomagnify to a similar extent as PCBs. BDE47 is the predominant congener in most aquatic biota. Increasing temporal trends of Te-PeBDEs in biota were seen from the 1970s to mid-1980s. Analytical methods for DecaBDE (BDE209) as well as HBCD were developed and these compounds were first found in Swedish river sediments downstream of BFR-using textile industries. Fish from this river bioaccumulated Te-PeBDEs and HBCD but only showed traces of BDE209. In laboratory studies, BDE209 was found to be bioavailable to a small extent in fish, but also sequentially debrominated metabolically to lower brominated BDEs. BDE209 photolytically debrominates sequentially to lower brominated BDEs in solution and in sediments and soils exposed to UV and sunlight, but not to the BDEs commonly found in biota. Other studies showed BDE209 to predominate in air and deposition samples, implicating deposition onto vegetation and soils as a possible accumulation pathway into terrestrial food webs, similar to what has been seen for higher chlorinated PCBs and PCDD/Fs. Eggs from peregrine falcons, a high trophic level terrestrial predator, were found to contain high concentrations of Te-HxBDEs as well as BDE209 and HBCD. The BDE pattern was very different from that seen in aquatic predators, with highest concentrations of HxBDEs. A possible pathway of BDE209 to peregrine falcons could be via predation on terrestrial birds feeding on worms. Studies of worms in background soils as well as sewage-sludge amended soils showed that Te-DecaBDEs were accumulated in worms and that sewage sludge amendment significantly increased soil BDE concentrations. Studies of uptake from vegetation to lactating milk cows showed that higher brominated BDEs including BDE209 accumulated in fat and muscle tissue, but that only the lower brominated BDEs transferred efficiently to milk. BDE accumulation in biota decreases with increasing LogKow of the congener. Higher brominated BDEs seem to be accumulated to a higher extent in the terrestrial than the aquatic environment.

202 Using enantiomer fractions of POPs to characterize contamination, degradation, and sources. E. Ulrich, National Exposure Research Laboratory, US EPA, Research Triangle Park, NC; R.L. Falconer, Department of Chemistry, Chatham College, Pittsburgh, PA. Understanding how POPs change and migrate through the global environment is critical to identifying risks and developing control strategies. Methods which can differentiate sources of contamination and modes of degradation support these efforts. Data collected using enantioselective analytical techniques can be combined with quantitative data and other information to provide a more complete understanding of the fate of chiral chemicals in the environment. In the case of organochlorine pesticides, enantiomer fractions (EFs) have been measured in a variety of environmental media across North America. EFs have helped trace the movement of chlordane applied to agricultural fields into Great Lakes air, lake water and reservoir sediments. These EFs can be distinguished from those in indoor air, showing the relative importance of the different sources. Enantiomer fractions may also be used to study biological degradation pathways. Similar EFs may indicate that biologically mediated degradation in one environmental compartment (such as soil) is driving the EF in other compartments (such as sediments) and are not changed by migration. Alternatively, similar EFs may indicate that all the compartments have similar biologically mediated processes (i.e. metabolism). In addition, EFs have been used to determine if compounds have undergone enantioselective degradation. In some compounds such as heptachlor and heptachlor epoxide (HEPX), enantiomer fractions can be used to distinguish between different degradation routes. An abiotic pathway, such as photolysis, can lead to racemic EFs while another pathway, such as biological degradation, can lead to nonracemic EFs. Enantiomer fractions of HEPX measured to date in a variety of matrices are all nonracemic; suggesting the prevalent degradation of heptachlor to HEPX is by biologically mediated processes. This presentation will examine the diversity and utility of enantiomer fractions in helping to improve techniques for understanding environmental fate and transport of persistent organic pollutants. Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

203 What goes up must come down - atmospheric transport and deposition of POPs to high elevation ecosystems in the Western U.S. S. Simonich, C. Schreck, M. Kent, Oregon State University, Corvallis, OR; D.

Landers, USEPA, Corvallis, OR; D. Campbell, USGS, Denver, CO; T. Blett, USNPS, Denver, CO; D. Jaffe, UW-Bothell, Bothell, WA; L. Geiser, USFS, Corvallis, OR. High elevation and high latitude ecosystems in the Western U.S., including U.S. National Parks, have been historically thought of as some of the most pristine ecosystems in the world. Recent research indicates that both current use and historic use POPs from agricultural, industrial, and urban sources in Asia, the U.S., and Canada undergo long-range atmospheric transport and deposition to these remote ecosystems. Temporal data, obtained through analysis of dated lake sediment cores, suggest that the deposition of current use POPs has increased in recent years, while the deposition of historic use POPs has decreased after North American bans. However, the deposition of historic use POPs to these ecosystems continues due to revolatilization from historically contaminated regional soils. Spatial data, obtained through the analysis of annual snowpack, suggest that high latitude ecosystems in Alaska and high elevation ecosystems in the Pacific Northwestern U.S. are influenced by both Asian and North American POP sources, while high elevation ecosystems in the Sierra Nevada and Rocky Mountains are primarily influenced by North American POP sources. In addition, the concentration of POPs in some fish collected from sites in the Western U.S. exceeded consumption criteria for wildlife as well as USEPA consumption guidelines for subsistence fish eaters. Finally, the vitellogenin concentrations in male trout collected from sites in the Rocky Mountains were significantly correlated with endocrine disrupting POP body-burden concentrations. These data suggest that POP deposition and accumulation in high elevation and high latitude ecosystems in the Western U.S. is significant and has the potential to result in ecosystem effects.

204 Henry's Law Constants for PCBs - Experimental and Theoretical Model Disagreements: A Quantum Chemical Analysis. D.M. Di Toro, Department of Civil and Environmental Engineering, University of Delaware, Newark, DE; K. Phillips, S.I. Sandler, Department of Chemical Engineering, University of Delaware, Newark, DE. Experimental difficulties have led to Henry's Law Constants (HLC) measurements at 25°C that differ by up to 2 orders of magnitude for a single congener. There is also disagreement about the relationships between HLCs and the degree and pattern of chlorine substitution and their temperature dependence. Estimated and predicted HLCs in the literature suffer from similar inconsistencies. These differences have been the cause of controversy (Goss et al. 2004, Environ. Sci. Technol., 38, 1626-1628. Baker et al. 2004, Environ. Sci. Technol., 38, 1629-1632). Two independent quantum-chemical methods, COSMO-SAC and SM6, have each been applied to predict a self-consistent set of HLCs for the PCBs at 25°C, which does not depend on existing data for these compounds. The results reveal good agreement between the two sets of quantum chemical predictions, and lend weight to the 25°C measurements of Bamford et al. (2000) J. Chem. Eng. Data, 45, 1069-1074, which have been criticized in the literature. COSMO-SAC has also been used to predict the temperature dependence of the HLC.

205 A New Method for Simultaneous Determination of Air/Water, Octanol/Water and Octanol/Air Partitioning Coefficients for Volatile Methyl Siloxanes. S. Xu, B. Kropscott, Health and Environmental Sciences, Dow Corning Corporation, Midland, MI. Volatile methyl siloxanes (VMS) may enter the environment through industrial activities and the use of various consumer products. Reliable Air/Water (K_{AW}), Octanol/Water (K_{OW}) and Octanol/Air Partitioning Coefficients (K_{OA}) are critical for accurately predicting the environmental fate and transport of these materials. Tremendous challenges have been encountered in determination of these properties due to the low surface energy and extremely low water solubility of these siloxanes that lead to inconsistent and inaccurate values published in literature. A new method has been developed for the simultaneous determination of K_{AW} , K_{OW} , and K_{OA} of these compounds. The advantages of the new method include the improved accuracy, a shortened measurement time, and the self-consistency among resultant partitioning coefficients.

206 Soil-air exchange: from the laboratory to the field experiments. M. Koblikova, P. Ruzickova, J. Klanova, I. Holoubek, RECETOX Research Centre for Environmental Chemistry and Ecotoxicology, Brno, Czech Republic. Semivolatile organic compounds cycle between the atmosphere and the terrestrial environment over the long time periods as they move towards equilibrium partitioning between the compartments. Soil-air equilibrium partitioning has an important impact on the environmental distribution and fate of many POPs; it has been hypothesized that it is a key process controlling the soil and air levels of POPs. Laboratory simulation of POP volatilization

from the soil surfaces is needed for successful environmental fate modeling. Direct measurements of volatilization fluxes have been carried out in our laboratory for a wide range of organic compounds. Conditions of these experiments were carefully controlled to provide useful information about the range of factors affecting volatilization (soil organic matter content, moisture, temperature, wind speed, vegetation cover, physico-chemical properties of chemicals, their concentrations and aging). Laboratory experiments provided good estimates of the field volatilization fluxes and those values - together with monitoring data about the soil contamination - were applied to assess the inventory of POPs in the atmosphere.

207 Identifying Indicators of Reactivity for Chemical Reductants in Anoxic and Anaerobic Sediments. H. Zhang, E.J. Weber, National Exposure Research Laboratory, US Environmental Protection Agency, Athens, GA. To develop reaction transport models describing the movement of redox-active organic contaminants through contaminated sediments and aquifers, it is imperative to know the identity and reactivity of chemical reductants in natural sediments and to associate their reactivity with physicochemical indicators that can be readily measured. For this purpose the reactivity, as defined by the reduction rate of p-cyanonitrobenzene (pCNB), of twenty-one natural sediments with either 3-d (anoxic conditions) or 5-w (anaerobic conditions) pre-incubation periods was studied. The observed reactivity of 3-d sediments k_{3-d} increased log-linearly with increasing pH; the effect of soluble Fe(II) addition on k_{3-d} and its sorption isotherm towards the sediment can both be fitted by the Langmuir isotherm. Electron balance calculation indicated that for fast reactions (reaction time < 10 min), the amount of soluble Fe(II) consumed is equal to the amount of electrons accepted by pCNB. For slower reactions (reaction time from hours to days), the concentration of soluble Fe(II) is much more variable. This is likely due to (1) regeneration of Fe(II) by microbial reactivity and (2) greater contributions from reduced organic carbon (OC) as a source of electrons for reduction of pCNB. The reactivity of 5-w sediments was correlated with physicochemical properties including BET surface area, cation exchange capacity (CEC), texture, various iron compositions, and different OC contents. For all sediments, reactivity correlates well with % organic carbon (%OC) and soluble Fe(II) concentration whose variations account for 62.1% and 23.4% of the variations in the k_{sed} values. For sediments with low (< 5%) or high (> 5%) %OC, the variations in soluble Fe(II) concentration or dissolved OC (DOC) account for 74.9% or 79.9% of the variations in k_{sed} . These experimental observations suggest that both Fe(II) associated with amorphous iron minerals and reduced OC are the predominant reductants in reducing sediments, and that soluble Fe(II) and %OC/DOC can serve as readily measurable indicators of their reactivity. Disclaimer: Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

208 Dissipation of three Sulfonylurea Herbicides in Fortified Farm Dugouts (Ponds). A.J. Cessna, J. Bailey, M. Waiser, J.V. Headley, National Hydrology Research Centre, Saskatoon, Saskatchewan, Canada; D. Donald, Environment Canada, Saskatoon, Saskatchewan, Canada. Sulfonylurea herbicides are used to control broad-leaved weeds in a variety of crops. With low mammalian toxicity, worldwide use is increasing due to their high herbicidal activity at very low application rates (2 to 75 g ha⁻¹). There is concern that this high phytotoxicity may result in negative environmental impacts on sensitive ecosystems such as prairie wetlands which, in Canada, are widely dispersed within agricultural areas where sulfonylurea and other herbicides are extensively used. There is limited information on the persistence of sulfonylurea herbicides in prairie wetlands or their potential to affect the flora and fauna within these ecosystems. In June 2005, a single farm dugout was fortified with the sulfonylurea herbicide sulfosulfuron and, in June 2006, two farm dugouts were fortified with either rimsulfuron or nicosulfuron. Sulfonylurea herbicide concentrations were 3.3, 5.5 and 6.5 µg L⁻¹, respectively. Target fortification levels in each dugout were equivalent to that resulting in a theoretical wetland containing a half metre of water and oversprayed at the recommended application rate. A fourth unfortified dugout was used to provide control water samples. Water samples (500 mL) were collected on the day prior to application (day 0) and on days 2, 3, 4, 5, 8, 10 and 13; then weekly for 3 weeks; once biweekly and then monthly until mid December. Winter samples were collected through the ice. Following solid-phase extraction, the water sample extracts were analysed by HPLC and the sulfonylurea herbicides quantitated by positive ion electrospray tandem mass spectrometry. Mean recoveries from distilled water fortified at

10 ng L⁻¹ ranged from 78 to 96% with RSDs less than 7% (n = 4). Analytical results indicated that the sulfonylurea herbicides were much more persistent in dugout water than conventional herbicides (eg., 2,4-D, MCPA) and that the order of decreasing persistence was sulfosulfuron > nicosulfuron > rimsulfuron.

209 Interpretation of long-term monitoring data for persistent semivolatile chemicals in air using the Junge variability-lifetime relationship. M. MacLeod, M. Scheringer, K. Hungerbühler, Swiss Federal Institute of Technology, Zürich, Switzerland; S. Becker, C.J. Halsall, K.C. Jones, Lancaster Environment Centre, Lancaster University, Lancaster, United Kingdom. In 1974, Junge derived an empirical relationship between the variability in concentration of a trace volatile organic chemical in the atmosphere at a remote location and the atmospheric lifetime of the chemical. For volatile gases, the Junge relationship can be used to estimate atmospheric lifetime from the relative standard deviation of concentration measured at remote locations. However, semivolatile chemicals are not only degraded in the atmosphere but also cycle between the atmosphere and surface media. Therefore the original Junge relationship must be modified to relate the effective atmospheric lifetime of the chemical - accounting for the possibility of several cycles of deposition and re-volatilization - to variability. Effective atmospheric lifetime for semivolatile organic chemicals can be estimated using a multimedia model that accounts for all removal processes from the atmosphere (degradation and net deposition). Here, we present an interpretation of nearly a decade of monitoring data for polychlorinated biphenyls (PCBs) from the International Atmospheric Deposition Network (IADN) using a modified Junge variability-lifetime relationship. There are at least five factors that may determine the variability in PCB concentrations measured at the IADN sites and, by controlling for three of these factors in our data analysis, we have identified two IADN sites (Eagle Harbor and Sleeping Bear Dunes) where variability consistent with the Junge relationship is regularly observed. This indicates that these two sites are remote from PCB sources and are measuring background concentrations of PCBs in air. In contrast, the Point Petre site shows a pattern of variability that is consistent with a local ongoing temperature-driven volatilization source. The Burnt Island and Sturgeon Point sites show a pattern of variability that is between these two extremes. Continued monitoring at the IADN sites in coming years will increase the statistical power of our analysis and support more quantitative assessment of the relative importance of local and distant sources of persistent organic pollutants to the Great Lakes, and provide key insights for refining and improving multimedia models that estimate effective atmospheric lifetimes of pollutants.

210 Tribal Assessment of PBT Contaminant Concentrations Across Size Ranges of Four Commonly Harvested Lake Superior Fish. M. Hudson, Great Lakes Indian Fish and Wildlife Commission, Odanah, WI. Wisconsin and Michigan Chippewa tribes harvested 862 thousand kg (1.9 million lbs) of whitefish (*Coregonus clupeaformis*), 147 thousand kg (325 thousand lbs) of lake trout (*Salvelinus namaycush namaycush*), 21 thousand kg (47 thousand lbs) of ciscoe (*Coregonus artedii*) and 10 thousand kg (22 thousand lbs) of siscowet trout (*Salvelinus namaycush siscowet*) from Lake Superior in 2006. This fishery constitutes both a source of subsistence food and commercial income. GLIFWC has analyzed composites of Lake Superior whitefish, lake trout, ciscoe and siscowet trout, across the size range of commonly harvested fish (whitefish, 43-61 cm, lake trout, 43-72.5 cm, herring, 33-47 cm, siscowet trout, 43-65 cm) for 37 persistent, bioaccumulative, and toxic (PBT) contaminants. Each species of fish were composited within these size ranges based on length, age, and tissue type (skin, fat, muscle) within four size groups. PBT contaminant concentrations were measured in the muscle tissue and estimated in skin and fatty tissue using percent lipid in those tissues and lipid normalized muscle concentrations. The relationship between concentration and length and/or age, regression analysis, and comparison of fillet data to current health advisory trigger levels are evaluated and discussed.

211 Semi-volatile Fluorinated Organic Compounds in Asian and Western U.S. Air Masses. S. Simonich, A. Piekarz, T. Primbs, J. Field, D. Barofsky, Chemistry and Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR. Semi-volatile fluorinated organic compounds were measured in archived air sample extracts collected from Hedo Station Observatory (HSO) on Okinawa, Japan and Mount Bachelor Observatory (MBO), Oregon USA during the springs of 2004 (MBO and HSO) and 2006 (MBO). Fluorotelomer alcohols (FtOHs) were measured in both Asian and western US air masses, though western US air masses had significantly

higher concentrations. Concentrations of fluorotelomer olefins in Asian air masses and 8:2 fluorotelomer acrylate in U.S. air masses were recorded for the first time. N-ethyl perfluorooctane sulfonamide, N-methyl perfluorooctane sulfonamido ethanol, and N-ethyl perfluorooctane sulfonamido ethanol were also measured in Asian and western US air masses but less frequently than FtOHs. The atmospheric sources and fate of FtOHs were investigated by estimating their atmospheric residence times, calculating FtOH ratios with respect to each other, investigating FtOH correlations with non-fluorinated semi-volatile organic compound concentrations, and determining air mass back trajectories. Estimated atmospheric residence times for 6:2 FtOH, 8:2 FtOH, and 10:2 FtOH were 50, 80, and 70 d, respectively. The average ratio of 6:2 FtOH to 8:2 FtOH to 10:2 FtOH concentrations at MBO in 2006 was 1.0 to 5.0 to 2.5 and is comparable to the ratio from a previous study in Canadian Arctic. FtOH concentrations in western U.S. air masses were positively correlated ($p < 0.05$) with gas-phase polycyclic aromatic hydrocarbon and polychlorinated biphenyl concentrations and negatively correlated ($p < 0.05$) with pesticide concentrations. In addition, trans-Pacific air masses did not contain elevated concentrations of these compounds. This suggests that semi-volatile fluorinated organic compounds are emitted from urban areas in the western U.S.

212 Effect of Cu(II) on the sorption of 2,4,6-TCP on humic acid. X. Shan, S. Zhang, B. Wen, Z. Pei, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China; M. Feng, Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, Nanjing 210008, China; T. Liu, Y. Xie, Beijing Synchrotron Radiation Laboratory, Chinese Academy of Sciences, Beijing 100049, China. Compare to the extensive separate studies on the sorption of metals and organic contaminants on humic acid (HA) there is little information on the interaction between both. The results of this study indicated that copper diminished the sorption of 2,4,6-trichlorophenol (2,4,6-TCP) on Tianjin HA (TJHA) remarkably and German HA (GeHA) slightly, and also rendered the sorption more nonlinear and the desorption hysteretic. However, 2,4,6-TCP had little effect on copper adsorption. FTIR results revealed that 2,4,6-TCP reacted with carboxylic and phenolic groups of HA. XAS results indicated that Cu(II) and HA formed inner-sphere complex via these functional groups. These results provided an evidence that Cu(II) competed with 2,4,6-TCP for these sorption sites, which was responsible for the suppression effect in part. AFM image study suggested that Cu(II) promoted the formation of ring structure aggregates of TJHA with hydrophilic exterior regions shielding hydrophobic interior domain from contact with vicinal water molecules, while GeHA formed larger elliptic aggregates in the presence of Cu(II). Such distinct structures of TJHA and GeHA are responsible for more pronounced desorption hysteresis of 2,4,6-TCP from TJHA, and less pronounced desorption hysteresis from GeHA. Fluorescence quenching of pyrene provided insight into the interior hydrophobic nature of TJHA aggregates.

213 Assessment of the Environmental Risks of Three Antihypertensive Agents based on the new EMEA ERA guideline. A. Hartmann, B. Hoeger, Pharma Global HSE&BC, Novartis Pharma AG, Basel, Switzerland; F. Sacher, Analytical Dept., DGVW Water Technology Center, Karlsruhe, Germany; G. Hiller, W. Suessmuth, STP Steinhäule, Abwasserzweckverband, Neu-Ulm, Germany; M. Lehni, Corporate HSE, Novartis International AG, Basel, Switzerland; S. Metzger, H. Kapp, Civil Engineering Faculty, Biberach University of Applied Sciences, Biberach, Germany. The European Drug Regulatory Agency (EMA) has recently issued a new guidance document on the environmental risk assessment of human pharmaceuticals, triggered by growing concerns over adverse long term effects in aquatic ecosystems caused by human pharmaceuticals in the environment (PIEs). The proposed testing scheme requires significant fate and chronic ecotoxicity testing early on in the assessment. Based on these requirements, exposure and chronic effects data on three antihypertensive agents with three different modes of action were acquired, using established OECD methods: an ACE inhibitor, a Ca²⁺-channel blocker and a renin inhibitor. Environmental risk assessments according to the EMA scheme were performed. The results show that, for the antihypertensive compounds in hand, acute-to-chronic ratios were well below 100 and predicted no-effect concentrations (PNECs) based on chronic no-effect levels (NOELs) were either comparable or significantly higher than PNECs derived from acute ecotoxicity data using standard assessment factors. Despite the low risks identified, the potential to enhance the removal of pharmaceuticals from municipal waste streams was investigated. First pilot-scale results confirm that the removal rate of many

human pharmaceuticals can be increased by up to 80% by using reliable, affordable activated charcoal adsorption technology. This study provides first-time experimental evidence on potential long-term effects of selected state-of-the-art antihypertensive drugs. The results seem to suggest that the general assumption of an exaggerated environmental long-term risk of human pharmaceuticals needs to be refined. In addition, we provide risk managers with a viable option to reduce the load of human PIEs where this is deemed necessary.

214 Predicting the Environmental Fate of Active Pharmaceutical Ingredients in Sediments for Regulatory Environmental Risk Assessments. J. Saxe, S. Thakali, M. Sharma, M. Pollock, T. Ward, Gradient Corp., Cambridge, MA; H. Yekel, Wyeth Pharmaceuticals, Collegeville, PA. The environmental risk assessment guideline of the European Agency for the Evaluation of Medicinal Products (EMA) requires that an assessment of potential effects to sediment organisms be conducted if more than 10% of the Active Pharmaceutical Ingredient (API) mass is expected to partition to sediment. The EMA Guideline requires that a laboratory test be conducted using OECD Guideline 308 (Aerobic and Anaerobic Transformation in Aquatic Sediment Systems) to determine whether the 10% threshold is exceeded. A model was developed to simulate the test conditions presented in OECD Guideline 308 for hydrophobic APIs to define the environmental fate of those compounds in a sediment-water system in lieu of conducting the experiment. The model considers the equilibrium partitioning of the chemical between sediment organic carbon and water, and the overall chemical loss from the system due to processes such as hydrolysis and biodegradation. The input parameters required to run the model are the sediment organic carbon fraction, the organic carbon-water partition coefficient, and the overall loss rate constant. If an overall sediment- (or soil-) water partition coefficient is available, it can be used in lieu of the organic carbon-water partition coefficient to predict partitioning if the API is not highly hydrophobic. The model uses these API characteristics to simulate the loss of the compound from the water column and predict the partitioning of the remaining chemical between the sediment and water. The model was validated using data for 10 chemicals and was found to reliably predict or over-predict concentrations in the sediment phase (i.e., model predictions are conservative, relative to the EMA criterion). Therefore, the model is a valuable tool for cost-effectively conducting regulatory risk assessments, since it eliminates the need for conducting expensive and time-consuming sediment partitioning experiments recommended in the EMA guideline solely to determine if sediment API concentrations will be high enough to trigger sediment toxicity tests.

215 Species Sensitivity Distribution Derived Predicted No Effect Concentrations for Ethinyl Estradiol. D. Heijerick, B. Versnoren, P. Van Sprang, Eurac, Gent, Belgium; D.J. Caldwell, Johnson & Johnson, New Brunswick, NJ; B. Mertens, Janssen Pharmaceutica, Beerse, Belgium. Ecotoxicological data for ethinyl estradiol (EE2) were collected, evaluated on their reliability and relevance, and categorized into three datasets: acute EC50's, long term NOECs and reproductive NOECs. With respect to NOEC values, a distinction was made between reproduction and other endpoints, as the known mode of action of EE2 (i.e., reproductive hormone) most likely resulted in the observed large difference in sensitivity indicated by lower reproduction NOECs. For each of these data sub-sets a species sensitivity distribution (SSD) was developed according to the current EU-risk assessment methodology (i.e., derivation of a HC5,50%). These HC5,50% -values represent a PNEC for the different endpoints and can be considered safe exposure levels below which no effects are expected. Reproductive NOECs were collected for 22 species, including six fish species, three amphibians and various invertebrates, mollusks, and insects, with fish being the most sensitive trophic level. Reproductive NOECs were between 0.3 ng/L and 320 µg/L, resulting in a HC5,50% of 0.33 ng/L (lowest NOEC for each species) or 0.46 ng/L (all reproductive NOECs). Based on NOEC-values for other endpoints a HC5,50% of 7.3 µg/L was derived, i.e., more than 4 orders of magnitude above the PNEC reproductive.

216 Estimating the Potency of Steroid Hormone Compounds Relative to 17 α Ethinyl Estradiol (EE2) Using a Rainbow Trout Estrogen Receptor Binding Assay. S. Thakali, J. Saxe, M. Sharma, T. Ward, Gradient Corp., Cambridge, MA; H. Yekel, Wyeth Pharmaceuticals, Collegeville, PA. Currently, there are no fully validated, standard test methods available specifically for measuring the effects of endocrine disrupting chemicals, information that is important for estimating potential environmental risks associated with aquatic organisms' exposures to some chemicals. An in vitro

estrogen receptor (ER) binding assay, using rainbow trout ER, was used to measure the relative potency of estrogen-like active pharmaceutical ingredients (APIs). Estrogen receptors were isolated from cytosolic preparations of rainbow trout liver and radiolabeled 17 α ethinyl estradiol (EE2), a potent estrogen for which ecological effects levels have been well characterized, was bound to the trout ER. A dilution series of each API was added to the system and the amount of radiolabeled EE2 that was competitively displaced by the API was measured. The relative binding affinity, expressed as an IC50 (50% inhibitory concentration), was used to derive a potency ratio between EE2 and the API. The relative potency was then used to predict no (adverse) effect concentrations (PNECs) for the APIs, proportional to the aquatic life PNEC for EE2. The PNECs derived using this approach presume that the most sensitive aquatic endpoints for all the estrogen-like APIs are similar to those of EE2 – a reasonable assumption given that endocrine activity is the shared mode of action of all hormone APIs. The ER binding assay only measures the ability of an API to bind an ER, and does not consider metabolic transformations that may occur in organism, or effects through other modes of action that must be measured using traditional *in vivo* toxicity tests. However, the assay is simple, economical, and rapid, relative to aquatic toxicity tests with reproductive endpoints, thus readily enabling the inclusion of endocrine activity in the risk assessment of new APIs.

217 Non-traditional Responses to Pharmaceuticals in Aquatic Ecosystems. B. Brooks, R. Brain, Baylor University, Waco, TX; D. Huggett, University of North Texas, Denton, TX; J. Lazorchak, US EPA, Cincinnati, OH; H. Sanderson, Danish National Environmental Research Institute, Roskilde, Denmark; J. Stanley, USA CoE ERDC, Vicksburg, MS; J. Sumpter, Brunel University, Uxbridge, United Kingdom. Quantitation of human and veterinary pharmaceuticals in environmental matrices has resulted in pharmaceuticals in the environment receiving unprecedented attention from the scientific community. Aquatic hazard assessments often use quantitative structure activity relationships and standardized toxicity tests, which assess mortality, growth or reproduction responses following short term exposures. Although these traditional approaches are appropriate for many substances, their application to pharmaceuticals has been questioned. For example, if an aquatic criterion were developed for ethinylestradiol, an estrogen receptor agonist, or trenbolone, a synthetic androgen, following traditional approaches, the criterion for each compound could be estimated at levels several orders of magnitude higher than previously reported effect levels for fish reproduction. We examined recent reports of pharmaceutical effects to aquatic plants, invertebrates and vertebrates with a particular focus on non-standardized response variables. Several examples of these non-traditional responses include molecular and biochemical biomarkers, physiological and behavioral studies, and fish partial or full life cycle responses. If a pharmaceutical exhibits a high acute-to-chronic ratio (ACR; > 1000), it may chronically elicit responses through a specific mechanism of action (MOA), potentially similar to its activity in mammals. In the case of biomarkers and other non-traditional endpoints, the type of chronic response used to generate an ACR can influence whether a biomarker may be useful in the exposure and effect analysis phases of ecological risk assessment; for example, biomarkers have been historically distinguished as either indicators of exposure or effect in retrospective risk assessments. It appears that aquatic responses to pharmaceuticals that are MOA-specific and sensitive can provide indicators of exposure or effect at concentrations below those eliciting adverse responses in standardized bioassays. However, for a biomarker of effect to be useful in ecological risk assessment, its response should be directly linked to a physiologically and ecologically relevant endpoint.

218 Toxic effect and bioaccumulation of carbamazepin evaluated by biomarkers from different trophic level organisms. G. Vernouillet, P. Juneau, Dpt of Biological Sciences - TOXEN - CRC on Ecotoxicology of Aquatic Microorganisms, Université du Québec à Montréal, Montreal, Quebec, Canada; P. Eullaffroy, C. Blaise, F. Gagné, Environnement Canada, Montréal, Quebec, Canada. Among different organic compounds, pharmaceutical and personal care products (PPCP) represent a major concern of contamination for aquatic environment due to growing consumption and poor degradation. Consequently, important effects on the physiological state and homeostasis of aquatic organisms may occur. In addition to the toxicity induced by direct exposure, it is important to study PPCP bioaccumulation effects to predict a potential danger of these compounds for aquatic ecosystems. The goal of this work was to study for the first time the bioaccumulation of an anti-epileptic drug carbamazepin (CBZ) found systematically in St Laurent River, Qc. We

have investigated CBZ toxicity on a trophic chain composed of a primary producer (*Pseudokirchneriella subcapitata*, an unicellular freshwater alga), a primary consumer (*Thamnocephalus platyurus*, a microcrustacean), and a secondary consumer (*Hydra attenuata*, a cnidarian). We have shown that *P. subcapitata* was more affected by a direct exposure to CBZ compared to *T. platyurus* and *H. attenuata* (CL50=80mg/L (96h), CI50=200mg/L (24h) and CI50=150mg/L (96h), respectively). In order to investigate potential CBZ bioaccumulation, different biomarkers (P4503A, LPO, CAT, GST/GR) were evaluated on the three trophic levels. We found that the investigated enzymatic activities and lipid peroxydation were significantly affected by CBZ contamination through food consumption. This report showed clear evidences that there is a CBZ toxicity transfer through food web levels, which may occur in natural environmental conditions.

219 Implications of ionization state on environmental risk assessments of pharmaceuticals using sertraline as a model weak ionizable base. T.W. Valenti, B.W. Brooks, Biology Department, Baylor University, Waco, TX; P.H. Perez, K. Chambliss, Chemistry Department, Baylor University, Waco, TX. Despite the fact that many pharmaceuticals and personal care products act as weak acids and bases in aqueous solutions, ionization state is seldom considered during environmental risk assessments. The physiochemical properties of therapeutics (e.g. pKa), as well as environmental factors (e.g. pH and temperature), determine the fraction of the compound that is ionized or unionized. Although both forms may be absorbed by aquatic organisms, uptake rates are often higher for the unionized form as it has a greater propensity to cross cellular membranes. The selective serotonin reuptake inhibitor sertraline hydrochloride (Zoloft) was used as a model drug to investigate differences in toxicological responses across environmentally relevant surface-water pH ranges (6-9). Sertraline has a pKa of approximately 9.2 and it acts like a weak base in aqueous solutions, thus becoming more unionized at higher pH ranges. Acute (48 h) and sub-chronic (7-10 d) experiments were completed with *Pimephales promelas* and *Daphnia magna* according to slightly modified United States Environmental Protection Agency (U.S. EPA) protocols. The endpoints derived from acute experiments were fit to linear models based on the approach used by the U.S. EPA to develop ambient water quality criteria for other known ionizable compounds (pentachlorophenol, ammonia). Sertraline was more toxic to both test organisms at higher pH ranges as a 5-fold difference in LC50 values was recorded for acute experiments. There was an even greater disparity between endpoints calculated for sub-chronic bioassays conducted at different pH ranges as lowest observable adverse effects concentrations (LOAEC) varied by as much as 10-fold. These findings suggest that ecotoxicological responses in laboratory studies with pharmaceuticals may require modifying factors to account for variation in pH. Implementing such approaches may improve both prospective and retrospective ecological risk assessments of pharmaceuticals by reducing uncertainty associated with the analysis of effects. This research also has implications for establishing allowable loads of pharmaceuticals in receiving systems based on site-specific water quality parameters.

220 Relationship between oxytetracycline concentrations and tetracycline resistance gene diversity and abundance in aquaculture facilities. K.F. Rubert, J.A. Pedersen, Molecular and Environmental Toxicology Center, University of Wisconsin - Madison, Madison, WI; E.E. Seyfried, K.D. McMahon, Civil and Environmental Engineering, University of Wisconsin - Madison, Madison, WI; C.J. Hedman, Wisconsin State Laboratory of Hygiene, Madison, WI; J.A. Pedersen, Soil Science, University of Wisconsin - Madison, Madison, WI. The proliferation and distribution of antibiotic resistant microorganisms is a subject of concern due to the potential threat to public health. Little is known about environmental reservoirs of resistance, and how these are impacted by antibiotic use in agriculture. Aquaculture facilities often use oxytetracycline to treat bacterial infections. The goal of this study was to identify the types of tetracycline resistance genes associated with aquaculture facilities, and to evaluate whether use of oxytetracycline in aquaculture promotes increased incidence of resistant bacteria. We selected four aquaculture facilities in Wisconsin with different antibiotic use histories and collected both water and sediment samples over two years from multiple locations within each hatchery. Oxytetracycline in water and sediment samples was analyzed by high performance liquid chromatography- electrospray ionization-tandem mass spectrometry. Antibiotic resistance genes were detected using polymerase chain reaction to evaluate the diversity of genes present in each sample as well as the concentration of individual gene types. We found that the gene diversity in

aquaculture water was generally higher at facilities with recent oxytetracycline use, regardless of oxytetracycline concentrations in each sample. The opposite was true for sediments. Some sediment samples contained very high concentrations of oxytetracycline. Quantitative PCR revealed widely varying concentrations of resistance genes in water and sediment. The relationship between resistance gene concentration and oxytetracycline concentration was not linear but suggested that resistance gene concentrations were higher above a threshold of oxytetracycline levels.

221 Human and Environmental Health Implications of Antibiotic Use in Live-stock Production. K. Kumar, Environmental Monitoring and Research, Metropolitan Water Reclamation District of Greater Chicago, Chicago, IL; H. Dolliver, C. Yogesh, S. Gupta, Soil, Water, & Climate, University of Minnesota, Saint Paul, MN. Antibiotics are extensively used in animal agriculture as growth promoters and/or to reduce the risk of disease outbreak in large confinement operations. Most of the antibiotics fed to animals in feed are excreted and end up in manure. Animal manure is then land-applied as a means to provide crop nutrients. Until recently, the major concern of live-stock feeding of antibiotic has been the development and spread of antibiotic resistant bacteria in the terrestrial environment when antibiotic laden manure is land-applied. Our preliminary research shows that this practice may also have other implications related to human and environmental health. For example, (i) antibiotics can be taken up by food crops and find their way into food supply, and (ii) soil ecology may change when antibiotics-laden manure is land-applied thus affecting soil processes impacting the environment. In greenhouse studies, we found that vegetables crops have the ability to take up chlortetracycline and sulphamethazine but not tylosin. Furthermore, antibiotic uptake increased with an increase in antibiotic concentration in the soil. Although the antibiotic concentrations were low, these results raise a potential risk of consuming low levels of antibiotics from produce grown on manure-amended soils. With greater emphasis on sustainable farming, there is even higher demand for organic foods and thus increased risk since manure is the primary source of nutrients. In another laboratory microcosm study, we found that the presence of antibiotics in manure shift the microbial populations towards those dominated by fungi and actinomycetes. This raises the potential of greater CO₂ evolution from antibiotic laden manure applied soil and also increased inhibition of the nitrification. Both of these have implications on the environment especially in the context of carbon sequestration and nitrogen leaching.

222 Nanoparticles as modifying factors in ecotoxicity studies. A. Baun, M. Andersen, N. Hartmann, K. Kusk, E.R. Christensen, Institute of Environment & Resources, Technical University of Denmark, building 113, DK-2800, Lyngby, Denmark; E.R. Christensen, Civil Engineering and Mechanics and Great Lakes Water Institute, University of Wisconsin-Milwaukee, Milwaukee, WI. We have previously documented that presence of manufactured nanoparticles may influence the availability and toxicity of xenobiotic compounds. In this work we will present the results of a series of experiments conducted with the freshwater green algae *Pseudokirchneriella subcapitata* to study the influence of suspensions of C60 and TiO₂ on the toxicity of a range of organic compounds and heavy metals, not considered previously. Experiments with nonylamine/decylamine and ethylparaben/methylparaben were carried out as binary mixture studies with suspensions of C60 added. In experiments with cadmium an almost complete sorption to TiO₂ was found and speciation modeling showed a removal of the divalent ion from the water phase. It was found that, the toxicity of TiO₂/Cd mixtures was not significantly different from that of the metal alone. This indicates that sorbed cadmium is available to the algal cells. The possible implications of nanoparticles in risk assessment and regulatory standards for these and related xenobiotic compounds are discussed.

223 Nanomaterials Risk Management. I. Linkov, Inertrox inc, Brookline, MA. Environmental health and safety program has successfully implemented procedures to address traditional exposure concerns for particulate exposure. Potential toxicity of nanomaterials and resulting risks at different stages of product life cycle (e.g., development, production, use and disposal) has recently attracted significant attention of regulatory agencies and stakeholders. Misconceptions regarding nanomaterials and risk, and the potential for regulatory actions, could lead to significant difficulties for industry operations. This paper presents NanoSAFE, a management program aimed at minimizing the potential health and safety risks associated with nanoscale materials. Assessing nanomaterial impacts through the product life cycle is a unique feature of NanoSAFE. Risk associated with nanotechnology

are clustered into five components: 1. Employee Health Assurance, 2. Workplace Safety Technologies, 3. Toxicological Studies, 4. Environmental Impact Assessment, 5. Management of Facility and Products. Adaptive design of the NanoSAFE program allows focusing limited resources on the most crucial data gaps to support remedial actions as well as help in focusing sampling and material characterization. NanoSAFE was developed and tested in industrial settings with close collaboration with NIOSH. This presentation will discuss NanoSAFE as well as its linkages with risk assessment and decision analysis tools for guiding efficient program implementation. It will be specifically focused on ecological risk assessment through the product life cycle.

224 OECD QSAR Application Toolbox: Harmonization of the tools for hazard and risk assessment. O. Mekenyan, S. Dimitrov, T. Pavlov, G. Chankov, A. Chapkanov, S. Temelkov, G. Dimitrova, R. Vasilev, G. Stoyanova, V. Grancharov, University 'Prof. As. Zlatarov' Lab. of Mathematical Chemistry, Bourgas, BULGARIA; G. Veith, R. Diderich, OECD, Environment Directorate / Environment Health and Safety Division, Paris, France. The lack of data is often perceived as a major problem in hazard and risk assessment. Available data are typically fragmented, stored in different format and sometimes inconsistent. Category approach and (Q)SARs are an alternative for animals testing that can be used to save resources and accelerate hazard and risk assessment. In this respect, a compilation of well structured databases of reviewed data, library of (Q)SARs and grouping engines in a single computerized system is of practical value for collecting weights of evidence and chemicals legislation. As part of the QSAR activities in OECD to increase the regulatory acceptance of QSAR methods when data are lacking, the Joint Meeting in November 2004 has endorsed the development of a QSAR Application Toolbox as a means of making QSAR technology readily accessible, transparent, and less demanding in terms of infrastructure costs (ENV/JM/RD(2005)9). Following the OECD guidance on chemical categories, the OECD Toolbox will focus on methods for grouping analogous chemicals expected to have similar toxicological behavior and on a variety of methods for filling the data gaps in SIDS endpoints for each category. The development of the (Q)SAR Application Toolbox is a large collaborative effort of the governments of member state countries, academia and industry toward harmonization of the tools for risk assessment and regulatory evaluation of chemicals. The European Commission, Danish EPA, US EPA, Japan and Canada have already provided software and data for collaborative effort, and other Member Countries are evaluating novel tools that they might donate. Beta testing by all Member Countries is expected to begin in the fall of 2007.

225 The National Research Council Study on Models in Environmental Regulatory Decision-Making: Practice, Pitfalls, and Prospects. T.E. McKone, School of Public Health, University of California, Berkeley, CA; C.G. Whipple, Environ Inc, Emeryville, CA; J. Graham, American Chemistry Council, Arlington, VA. Many regulations issued by state and federal governments in the U.S. are based on results from computer models. Models have a long history of helping to explain scientific phenomena and of predicting outcomes and behavior in settings where empirical observations are limited or not available. However, by their very nature, all models are simplifications and approximations of the real world. In 2004, the US EPA's Council for Regulatory Environmental Modeling (CREM) requested the National Research Council (NRC) to prepare a report on environmental regulatory modeling. The report, which was released in June 2007, was developed by a committee of 15 experts from various related fields and peer-reviewed by additional experts. In this presentation, we summarize this report and consider the implications of its recommendations for modeling in environmental toxicology and chemistry. The report looks specifically at the use of computational models in environmental regulatory activities, particularly at EPA. The report considers the evolving scientific and technical issues related to the selection and use of computational and statistical models in decision making processes at the EPA. The report provides advice concerning the development of guidelines and a vision for the selection and use of models at the agency. Through public workshops and a number of deliberative meetings the report committed considered cross-discipline issues related to model use, performance evaluation, peer review, uncertainty, and quality assurance/quality control.

226 A systematic approach to microarray data analysis for biomarker discovery. D.L. Villeneuve, D. Martinović, G.T. Ankley, US EPA Mid-Continent Ecology Division, Duluth, MN; R. Wang, I. Knoeb, D.C. Bencic, US EPA Ecological Exposure Research Division, Cincinnati, OH; E.J. Perkins,

Environmental Laboratory, US Army Research and Development Center, Vicksburg, MS; N.G. Reyero Vinas, University of Florida, Gainesville, FL. Oligonucleotide DNA microarrays provide a powerful tool for unsupervised analysis of treatment/stressor-induced effects on the expression of hundreds to thousands of genes. Consequently, microarrays have been heralded as an ideal tool for the discovery of new ecotoxicological biomarkers. However, to date, most microarray studies have yielded lengthy lists of differentially expressed genes, but little in the way of novel markers with utility for exposure and/or effects assessment. In this study, adult male and female zebrafish were exposed to the aromatase inhibitor fadrozole (100 µg/L) or Lake Superior water (control) for 48 or 96 h. Differential gene expression in ovary (48 h and 96 h), female brain (48 and 96 h), and male brain (96 h) was examined using a 22,000 gene zebrafish oligonucleotide microarray. Following initial data analysis to generate lists of differentially expressed genes, we employed a systematic, weight-of-evidence based approach to prioritize targets for subsequent validation as biomarkers of exposure or effect, or as endpoints indicative of aromatase inhibition. A graphical systems model of the teleost brain-pituitary-gonadal axis was used to identify targets known to play a role in regulation of reproductive function in fish. Additionally, lists of differentially expressed genes were compared to those from other microarray studies conducted with fish exposed to either fadrozole or a chemical with an opposing mode of action (ethinyl estradiol). Finally, pathway-based analysis was used to identify biological pathways enriched with genes that were differentially expressed by fadrozole. Priority was assigned to targets that could be functionally linked to pathways relevant to fadrozole's mode of action, an ecologically-relevant response (i.e., reproduction), and/or genes consistently differentially-expressed in different species and experiments. Examples of specific targets identified through this analysis included inhibin βA, neuropeptide Y receptor YB, aromatase (A isoform), fibrinogen gamma polypeptide, collagen type I α1, zona pellucida protein 2.3, and NADH dehydrogenase (ubiquinone 1α subcomponent). *The contents of this abstract do not necessarily reflect EPA policy.*

227 Identification of Development-Specific Gene Expression in the Fathead Minnow (*P. promelas*) using Computational cDNA Subtraction and Custom DNA Microarray Validation. M. Kane, Purdue University, West Lafayette, IN; M. Sepulveda, Forestry and Natural Resources, Purdue University, West Lafayette, IN. The fathead minnow (*Pimephales promelas*) serves as a model organism for assessing the effects of environmental contaminants on organism development and viability in aquatic systems. Yet the utilization of genomic tools has been hindered by the lack of genome sequence and genomic information known in this model species. Utilizing published cDNA library sequences, we used sequence similarity to compare 4,105 cDNAs isolated from fathead minnow fry (less than 14 days old) to over 250,000 adult cDNA sequences derived from various samples and tissue types (e.g. brain, testis, renal, ovarian, hepatic, muscle and pituitary). The objectives of the computational subtraction were (1) to assess the extent of sequence similarity between developing and adult cDNA libraries and (2) to predict which cDNA clones are expressed ONLY in developing organisms. The results revealed BLAST bit scores ranging from 34.2 to 1780 indicating varying degrees of sequence similarity. Using a conservative approach, cDNAs with bit scores of less than 100 were hypothesized to be unique to development. Using this criterion, 334 cDNA clones (8.1% from a cDNA pool of 4,105) were identified as expressed only during minnow development and ideally suited as candidate expression biomarkers of contaminant-mediated developmental changes. To experimentally validate the computational cDNA subtraction, oligo-probe DNA microarrays were designed and produced representing all 4,105 cDNAs in the developmental library (approximately 12,500 probes per array). In addition, the DNA microarray was used to identify tissue-specific alterations in gene expression during development in brain, kidney, liver, ovary, and testes. Finally, in addition to demonstrating the validity of using computational approaches to identifying development-specific and/or tissue-specific gene expression, this approach resulted in the first DNA microarray dedicated to studying minnow development, as well as the effects of environmental contaminants on gene expression during development. The application of this overall approach to other non-sequenced organisms relevant to environmental safety will facilitate a better understanding of environmental toxicology at the molecular and developmental level.

228 Testing of five model endocrine disrupting chemicals using medaka hypothalamic-pituitary-gonadal (BHG) axis model and RT-PCR array method. X. Zhang, A. Tompsett, J. Park, Zoology, National Food Safety

and Toxicology Center and Center for Integrative Toxicology, Michigan State University, East Lansing, MI; M. Hecker, J.L. Newsted, Entrix Inc., Okemos, MI; P.D. Jones, J.P. Giesy, Biomedical Veterinary Sciences & Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Previous studies showed that three chemicals, prochloraz, ketoconazole and fadrozole, displayed similar inhibitory patterns on the steroidogenesis pathway based on the H295R cell-based assay. It has been hypothesized that these chemicals induce similar molecular responses along the hypothalamic-pituitary-gonadal (HPG) axes of vertebrates. In the present study, the three chemicals were further evaluated using the small Japanese Medaka (*Oryzias latipes*) HPG axis as a small fish model. In addition, two other model chemicals with different modes of action (17α-ethinylestradiol and 17β-Trenbolone) were also evaluated. Briefly, four-month-old Medaka were exposed to three different concentrations of each chemical for up to 7 d and effects on egg production were recorded daily. Changes in the expression of 40 genes involved in endocrine processes in the brain, liver and gonads were examined using RT-PCR methods. The concentration-dependent gene expression profile at multiple organization levels was visualized using the program GenMAPP for each chemical. Clustering analysis of genes and chemicals was conducted by "ToxClust" using concentration-dependent response data. Prochloraz, ketoconazole, and fadrozole induced similar sex-, tissue-specific gene expression patterns along the Medaka HPG axis, comparing with 17α-ethinylestradiol and 17β-Trenbolone. Further analysis indicated that the compensatory, up-regulated mRNA expression of the gonadal endocrine genes in the medaka model were correlated to the chemicals induced inhibitory effects in the steroidogenic pathway observed in the in vitro H295R cells-based assay. The association among gene expression profiles, brain-somatic indices (BSI), hepato-somatic index (HSI), and fecundity in each treatment was further examined using phenotypic anchoring techniques. The results indicated that the medaka HPG axis model assay together with the H295R steroidogenesis assay represent a powerful tool for the screening of environmental EDCs and for elucidating chemical modes of action.

229 Gene expression and histological structure as biomarkers of chemical exposure in Japanese medaka. A.R. Tompsett, J. Park, X. Zhang, M. Hecker, J.P. Giesy, Department of Zoology, National Food Safety and Toxicology Center and Center for Integrative Toxicology, Michigan State University, East Lansing, MI; M. Hecker, J.L. Newsted, Entrix, Inc., Okemos, MI; P.D. Jones, J.P. Giesy, Department of Biomedical Sciences and Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; D. Au, Department of Biology and Chemistry, City University of Hong Kong, Kowloon, Hong Kong, China. Genomic and proteomic methods, such as RT-PCR and 2D-PAGE gels, are very sensitive to gross changes, but are not able to detect spatial changes in expression or offer cellular resolution. To better understand the subtle effects of chemicals on cells and tissues, methods to quantify tissue-specific expression of genes in whole fish sections have been developed. These methods have promise to determine mechanisms of toxic action and to classify chemicals during screening tests. Specifically, we designed a dual biomarker system that utilizes whole mount in situ hybridization (ISH) to detect spatial changes in gene expression at the cellular level and basic histological techniques to detect changes in tissue morphology. To validate the system, four-month-old Japanese medaka (*Oryzias latipes*) were exposed to 1, 10, or 100 µg fadrozole /L for 7 d. Fadrozole is a potent inhibitor of the aromatase (CYP19) enzyme, which aromatizes testosterone to estradiol. ISH with radio-labeled RNA probes was used to quantify CYP19a mRNA in whole body tissue sections of medaka. Fadrozole tended to increase expression of CYP19a in ovaries, while there were no observable effects on testes. In addition to the increase in CYP19a gene expression, a shift from predominantly mature oocytes to early stage oocytes was observed in fadrozole treated females. Due to the relatively low resolution of this ISH method, it was not possible to definitively evaluate the data, especially in male fish. As a result, new methods using fluorescently labeled probes are being investigated to improve sensitivity. Considering the results of ISH and histological examination together provided a better understanding of the effects of fadrozole than either of the methods alone.

230 The relationship between environmental methylmercury exposure, metallothionein gene expression, and tissue damage in largemouth bass (*Micropterus salmoides*) collected from the Sacramento-San Joaquin Delta. D. Gehring, J. Geller, M. Stephenson, Moss Landing Marine Labs, Moss Landing, CA; M. Finkelstein, University of California, Santa Cruz, Santa Cruz, CA. The San Francisco Bay and Sacramento-San

Joaquin Delta is the largest estuary on the west coast of the United States and provides habitat for many fish and wildlife species. Methylmercury, a potent neurotoxin, contaminates this ecosystem and the food source for Bay-Delta animals. This study examines the relationship between environmental methylmercury exposure, biochemical, and histological markers in juvenile and adult largemouth bass collected from the Sacramento-San Joaquin Delta in 2005 and 2006. Largemouth bass are a high trophic level species that bioaccumulate large amounts of methylmercury in polluted environments. To understand the impact of methylmercury exposure to fish in the natural environment, largemouth bass were collected from locations throughout the Delta and analyzed for methylmercury concentration in muscle tissue. Many individuals collected for this study contained concentrations of methylmercury that exceed the EPA safety limit for human consumption. Regression analyses ($p = 0.10$) were used to examine the relationship between the tissue concentration of methylmercury, gene expression of metallothionein (a detoxifying protein), and tissue damage (e.g. parasite load, immune response) in liver, spleen, and kidney tissue. Analyses suggest that juveniles might be immunocompromised due to elevated methylmercury exposure as a significant negative relationship was observed with kidney inflammation ($p = 0.064$) and macrophage counts ($p = 0.093$), and a significant positive relationship was observed with trematode parasite load in kidney tissue ($p = 0.002$). Adults do not exhibit this trend, however, a significant negative relationship with kidney macrophage densities ($p = 0.056$), and kidney protozoan parasites ($p = 0.060$). Metallothionein gene expression will be used to determine a biochemical response to metal exposure in the natural environment.

231 Comparison of in vitro and in vivo exposures of Fathead minnow (*Pimephales promelas*) ovaries to endocrine disrupting chemicals reveals dynamic and compensatory responses. E. Perkins, S.M. Brasfield, US Army ERDC, Vicksburg, MS; N.G. Reyero Vinas, N.D. Denslow, Center for Environmental and Human Toxicology, University of Florida, Gainesville, FL; X. Guan, SpecPro, Inc, Vicksburg, MS; D.L. Villeneuve, D. Martinovic, L.S. Blake, J.D. Brodin, G.T. Ankley, US EPA Mid-Continent Ecology Division, Duluth, MN. The steroid hormone pathway functions as a complex interplay of different components at several different levels along the hypothalamus-pituitary-gonad (HPG) axis. *In vitro* exposure of Fathead minnow (*Pimephales promelas*) ovary tissues is a model in screening for chemical impacts on steroidogenesis and is intended to be predictive of *in vivo* responses. However, *in vitro* responses may not reflect that of intact fish as the tissue is no longer connected to the HPG axis and associated compensatory mechanisms. In this study, we investigated the relationship of *in vivo* to *in vitro* effects by examining time course exposures to two model steroidogenesis inhibitors, fadrozole and ketoconazole. *In vitro* effects were examined by incubating 12 ± 5 mg ovary slices in tissue culture medium supplemented with IBMX (0.1 mM), 25-hydroxycholesterol (1 μ g/ml), and one of either 50 μ M fadrozole, 0.5 μ M ketoconazole, or solvent controls for intervals of 1 to 12 hrs. *In vivo*-exposed ovaries were obtained from 5 month old minnows exposed to fadrozole, ketoconazole, or Lake Superior water (control) for 6, 12, or 24 hr. Ovary tissues were examined for changes in gene expression using a panel of 23 quantitative PCR assays of genes known to be involved in the steroidogenesis HPG axis for intervals of 1 to 12 hrs. Levels of estradiol and testosterone excreted into media by ovary tissue exposed *in vitro* and by ovary tissue from fish exposed *in vivo* were measured by radioimmuno assay. Finally, global gene expression responses of 12 hr *in vitro* exposed ovary tissue were compared to 24 hr *in vivo* exposed ovaries from fish for using a 22,000 gene microarray. Fadrozole effects on hormone production *in vivo* and *in vitro* were similar, however intact fish were able compensate for ketoconazole effects seen *in vitro*. Gene expression responses were markedly different between *in vivo* and *in vitro* exposures revealing potential feedback control systems within ovaries as well as the HPG axis. The results provide insight into the dynamic transcriptional networks involved in steroidogenesis and how these react and compensate for chemical stressor effects.

232 Forecasting Population Impacts Using Mechanistic Biomarkers: A Case Study with the Fathead Minnow. D.H. Miller, USEPA, ORD, NHEERL, Mid-Continent Ecology Division, Grosse Ile, MI; K.M. Jensen, D.L. Villeneuve, M.D. Kahl, E.A. Makynen, E.J. Durhan, G.T. Ankley, USEPA, ORD, NHEERL, Mid-Continent Ecology Division, Duluth, MN. A need in ecological risk assessment is the ability to create linkages between chemically-induced alterations at molecular and biochemical levels of organization (biomarkers) with adverse outcomes in whole organisms

and populations. In the current study, predictive relationships between plasma concentrations of testosterone, 17β -estradiol and vitellogenin, and fecundity in female fathead minnows (*Pimephales promelas*) were derived from 21-d laboratory toxicity tests with chemicals with differing mechanisms of action within the hypothalamic-pituitary-gonadal axis (fadrozole, 17β - and 17α -trenbolone, prochloraz, fenarimol). Biologically-plausible relationships between decreased testosterone, estradiol and vitellogenin, and fecundity at the organismal level were utilized to model population-level impacts (changes in population growth rate). Application of the population model requires only a life table, a measure of carrying capacity, and estimation (or measurement) of biomarkers within the fish of the study population. Example applications will be provided using different projection scenarios for a population of fathead minnows exposed to chemical stressors that alter plasma steroid and vitellogenin levels in female fish, thereby decreasing fecundity, and subsequent recruitment to a population. This approach could be applied to other species as a population-level analysis tool for use in interpreting the effects of multiple stressors that alter steroidogenesis, and have a common measurable organismal level effect. *This abstract does not necessarily reflect EPA policy.*

233 Shifts in tissue stable nitrogen isotope ratios potentially provide physical-traceable evidence linking biochemical responses to ecological consequences. P.L. Shaw-Allen, National Center for Environmental Assessment, USEPA Office of Research and Development, Cincinnati, OH; C.S. Romanek, C.H. Jagoe, Savannah River Ecology Laboratory, University of Georgia, Aiken, SC. Ecotoxicology and ecological risk assessment are challenged to rigorously link biochemical responses to toxicants with ecologically relevant effects, such as natality, growth and mortality rates. Biochemical responses are presumed to tax resources, such as protein, needed for growth and reproduction. This presentation proposes that stressor-mediated shifts in tissue stable isotopes of nitrogen (standardized $^{15}\text{N}/^{14}\text{N}$ ratio or $\delta^{15}\text{N}$) can provide evidence of that tax on protein resources. Due to the higher protein deamination and transamination rates of ^{14}N amines compared to their ^{15}N -bearing counterparts, protein decomposition increases $\delta^{15}\text{N}$ in biological tissues through an increased rate of ^{14}N excretion. Toxicant-mediated changes in protein metabolism may, therefore, influence the $\delta^{15}\text{N}$ of tissues. Our studies of snowy egret and largemouth bass exposed to dietary mercury in the laboratory, and bluegill, largemouth bass, yellow bullhead and brown bullhead collected from coal ash or mercury contaminated environments support this hypothesis. Snowy egret nestlings consuming environmentally realistic levels of mercury exhibited mercury-associated behavioral abnormalities and elevated relative $\delta^{15}\text{N}$ in the liver and acid-soluble fraction of the liver. However, the metal binding peptides metallothionein (MT) and glutathione (GSH) did not differ between exposure groups. This challenges the expectation that biochemical responses are more sensitive than organism-level measures. Largemouth bass exposed to dietary mercury exhibited reduced relative gonad mass and increased $\delta^{15}\text{N}$ and GSH in liver acid soluble fraction. Bluegill inhabiting a coal ash-contaminated habitat had elevated hepatic MT, GSH, and $\delta^{15}\text{N}$ in the livers and acid-soluble fraction of livers. Similar associations were found between tissue $\delta^{15}\text{N}$ and contaminant levels in largemouth bass, yellow bullhead and brown bullhead collected from mercury-contaminated environments. These results indicate that shifts in $\delta^{15}\text{N}$ could serve as a marker for toxicant mediated shifts in the metabolism of protein nitrogen. Further development of this approach may produce powerful evidence regarding hierarchical linkages in ecotoxicology.

234 Assessing sediments and fish health using a weight-of-evidence approach – in search for the causes of fish decline in the Danube river. H. Hollert, S. Keiter, M. Böttcher, S. Grund, N. Seitz, Dept. of Zoology, University of Heidelberg, Heidelberg, Germany; K. Wurm, Gewässerökologisches Labor, Starzach, Germany; M. Hecker, ENTRIX, Inc, Lansing, MI; M. Hecker, E. Higley, J. Giesy, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; H. Olsaman, B. van Bavel, M. Engwall, MTM University, Örebro, Sweden. Despite intensive and continuous stocking and improvement of water quality since the 1970s, fish populations, especially those of the grayling (*Thymallus thymallus*), have declined over the last two decades in the upper Danube River (Germany). In order to assess (i) possible links between molecular/biochemical responses and ecologically relevant effects, and (ii) if ecotoxicological effects might be related to the decline in fish catches in the upper Danube river, sediment samples and fish were collected at different locations and analyzed using a weight-of-evidence (WOE) approach with several lines of evidence. The objective of the presentation is to introduce the conceptual framework and to review results of the ongoing study. As

previously addressed by Chapman & Hollert (2006, JSS) a variety of lines of evidence can be used in WOE studies. Briefly, (i) a comprehensive battery of acute (neutral red assay, *Arthrobacter* and *Danio rerio* sediment contact assays) and mechanism-specific bioassays (comet assay, micronucleus assay and Ames test, EROD and DR-CALUX assays, YES and H295r-assays) was used to characterize the ecotoxicological hazard potential. (ii) Histopathological investigations and the micronucleus assay with erythrocytes were applied, representing *in situ* parameters. (iii) Diversity and abundance of benthic macroinvertebrate and fish as well as (iv) persistent organic pollutants (PCB, PAH and PCDD/Fs), endocrine disrupting substances, limnochemical parameters and the concentration of heavy metals were recorded. To identify organic contaminants causing effects in sediment toxicity assays, (v) effect directed analysis (EDA) was applied.

235 Identification of mechanisms involved in high cadmium tolerance in *Chironomus riparius*. E.M. Leonard, L.M. Pierce, C.M. Wood, M.J. O'Donnell, Biology, McMaster University, Hamilton, Ontario, Canada. Chironomids have been identified as one of the first species to repopulate aquatic environments contaminated by heavy metals such as cadmium. The LC50 values of chironomid larvae are more than 50,000 times above the U.S. EPA's Criterion Maximum Concentration, suggesting that the larvae have an extraordinary capacity to excrete or sequester cadmium as a means of avoiding metal toxicity. Characterization of these protective mechanisms was therefore necessary to further advance the understanding of toxicological effects of cadmium on aquatic organisms at lower trophic levels. Previous studies have determined that most cadmium is found in gut tissues; therefore the focus of this study was on the role of the gut, Malpighian (renal) tubules and anal papillae in cadmium tolerance. We have characterized basolateral and apical transport of cadmium in different gut segments. We have also determined the kinetic parameters (J_{max} and K_t) for cadmium uptake by isolated tissues as well as whole chironomids. We have developed a modified Ramsay assay for collection of fluid secreted by Malpighian tubules *in vitro* to determine cadmium concentration using cadmium-selective microelectrodes. Using this technique it was concluded that the Malpighian tubules are able to eliminate the total hemolymph cadmium burden within minutes, therefore greatly contributing to chironomids' tolerance to cadmium. The tubules and gut also sequester cadmium in intracellular compartments. Cd-selective microelectrodes and the scanning ion electrode technique (SIET) were used to determine regional differences in cadmium transport along the gut, anal papillae and Malpighian tubules. This study shows that excretion and sequestration of cadmium by several tissues contribute to the high cadmium tolerance of chironomid larvae.

236 Nickel toxicity in very soft surface water to field-collected cladocerans and green algae: separating intrinsic sensitivity from the protective effect of water hardness. K. De Schamphelaere, N. Deleebeek, B. Muysen, F. De Laender, C.R. Janssen, Environmental Toxicology, Ghent University, Ghent, Belgium; V. Chepurnov, W. Vyverman, Protistology and Aquatic Ecology, Ghent University, Ghent, Belgium. Biotic ligand models for predicting acute and chronic toxicity of nickel to the green alga *Pseudokirchneriella subcapitata* and the cladoceran *Daphnia magna* have been developed and validated for waters with hardness higher than 25 (alga) and 40 mg CaCO_3/L (*Daphnia*). However, a significant fraction of the surface waters in the European Union has lower water hardness (i.e. 30% below 40 mg/L) and it is therefore important to consider nickel toxicity and bioavailability in such waters as well. Based on considerations about physiological mechanisms of toxicity, we hypothesized that organisms originating from very soft water (5 to 7 mg/L) vs. those originating from harder water (34 to 53 mg/L) would (1) exhibit different intrinsic sensitivities to Ni and (2) experience different protective effects of hardness against toxicity. To investigate this, we isolated 10 different cladoceran species (field populations) and 10 different unicellular green algae species (clones) from very soft (mean hardness: 6 mg/L) and harder lakes (mean hardness: 43 mg/L) in a region 150 km north of Stockholm (Sweden). Acute (48h-survival) and chronic toxicity assays (21d-reproduction) with the cladocerans as well as chronic (72h-growth) toxicity assays with the algae were conducted at three hardness levels (6, 16 and 43 mg/L). For the cladocerans 48h-LC50's varied between 97 to 5,500 $\mu\text{g Ni/L}$ and 21d-EC50's varied between 4.1 and 125 $\mu\text{g Ni/L}$. For green algae 72h-EC50's varied between 59 and 560 $\mu\text{g Ni/L}$. Variation was both due to interspecies differences and to the protective effects of hardness. Contrary to our hypothesis, however, statistical analysis revealed that organisms (both algae and cladocerans) from very soft and harder water did not exhibit a

different intrinsic sensitivity to Ni. Increased hardness had a similar protective effect against Ni toxicity to algae from very soft and harder waters. Increased hardness had a significantly larger protective effect against the acute toxicity of Ni to cladocerans from soft water (compared to organisms from hard water), but this was not the case when reproductive toxicity to cladocerans was considered. Potential explanations for these similarities and differences, as well as the regulatory implications, will be discussed.

237 Evaluation of Water Quality on Acute Pb Toxicity and Molecular Mechanisms of Chronic Pb Toxicity in the Fathead Minnow. E. Mager, M. Grosell, Marine Biology & Fisheries, University of Miami, RSMAS, Miami, FL; K. Brix, EcoTox, Jacksonville, FL; H. Wintz, C. Vulpe, Nutritional Sciences & Toxicology, University of California, Berkeley, CA; M. Bayaa, S. Perry, Department of Biology, University of Ottawa, Ottawa, Ontario, Canada. Although previous evidence indicates Ca^{2+} and DOC likely represent two key water quality parameters influencing Pb toxicity, a precise relationship has yet to be fully characterized. Furthermore, the extent to which the influences of water chemistry are consistent among acute and chronic exposures remains unclear. Acute (96 h) bioassays were carried out to further characterize the roles of Ca^{2+} , DOC as humic acid (HA), HCO_3^- , and NaCl in mediating waterborne Pb toxicity. Additionally, sublethal, 150 d Pb exposures ($\sim 35 \mu\text{g/L}$) were conducted in 0.6 mM CaSO_4 , 0.15 mM DOC, or low ionic strength base water alongside treatment-matched controls without Pb. Calcium did not protect against chronic Pb accumulation when compared to base water but, did offer clear protection against acute mortality. Maximum protective effects appeared to plateau near 0.4 mM Ca^{2+} (LC50 $\sim 1000 \mu\text{g/L Pb}$). Humic acid provided strong protection against both acute and chronic Pb toxicity. A distinct linear relationship of LC50s and DOC concentrations was observed ($r^2=0.98$) with an LC50 of 3250 $\mu\text{g/L Pb}$ obtained at the highest HA concentration (0.42 mM DOC). Time courses for whole body ion analysis and gene expression using custom microarrays and qPCR were established from chronic exposures. Lead accumulation appeared to plateau by 10d in all treatments. Analysis of whole body Ca^{2+} , K^+ , and Na^+ content revealed no major ionic disturbances. Microarray analysis was carried out using RNA from fish exposed to base water +/-Pb at all time points out to 30d. Four candidates showing Pb-induced expression changes were sequenced revealing ferritin, G6PD, GST, and β -globin. Quantitative PCR analyses were performed for the 4 microarray candidates as well as for ECaC, DMT1, and ALA-D. Results were consistent between the two methods ($r^2=0.82$) and strongly reflected the influence of water chemistry as indicated by whole body Pb accumulation for 3 of the 4 genes identified by microarray. Whole mount *in situ* hybridizations were also performed to distinguish tissue-specific responses. Preliminary results suggest Pb-induced expression for the genes analyzed may arise primarily in the gut, liver and kidney. (Research and laboratory supported by ILZRO & NIEHS)

238 Development of a chronic biotic ligand model for copper toxicity to rainbow trout: effects of toxicity modifying factors. M.J. Chowdhury, M.N. Girgis, J. Klink, C.M. Wood, Biology, McMaster University, Hamilton, Ontario, Canada. Copper (Cu) is an essential nutrient for all biota but also a toxicant in the environment due to anthropogenic elevations. Short-term toxic effects of Cu have been well-studied, and a biotic ligand model (BLM) predictive of acute toxicity has been developed. However, information on chronic Cu toxicity is limited. In order to develop a chronic BLM for Cu, we are examining the effects of waterborne Cu on juvenile rainbow trout (*Oncorhynchus mykiss*; 5-10 g) in softwater conditions ($\text{Na}^+ = 70 \mu\text{M}$, $\text{Ca}^{2+} = 150 \mu\text{M}$, $\text{Mg}^{2+} = 50 \mu\text{M}$, DOC = 0.8 mg C/L, pH = 7) in 30-d chronic tests. After pre-acclimation to softwater, fish are exposed to a wide range of Cu concentrations (2 – 200 $\mu\text{g/L}$) in a flow-through system with or without (baseline) alterations of potential toxicity-modifying parameters (Na^+ , Ca^{2+} , Mg^{2+} , DOC, or pH). Chronic endpoints include growth, survival, tissue Cu burden, whole body sodium status, and expression of ion transport genes. Calcium exhibited a strong protective effect against Cu toxicity. Compared with baseline Ca^{2+} (0.15 mM), there were 8-10 fold increases of 96h-LC50, 30d-LC50, and 30d-LC10 for Cu at 3 mM Ca^{2+} ; the increases were linear with $[\text{Ca}^{2+}]$. Elevated $[\text{Ca}^{2+}]$ also ameliorated the effects of Cu on the mRNA expression and activity of Na/K-ATPase in the gills. Contrary to $[\text{Ca}^{2+}]$, elevated $[\text{Na}^+]$ did not protect fish from Cu toxicity. Chronic exposure to Cu (5-10 $\mu\text{g/L}$) altered Cu gill binding characteristics with changes of binding affinity ($\text{Log } K_{\text{Cu-gill}}$) and site density (B_{max}). We are now examining the effects of $[\text{Mg}^{2+}]$ and $[\text{DOC}]$ on chronic Cu toxicity. (Supported by NSERC CRD,

ICA, CDA, ILZRO/IZA, NiPERA, Noranda-Falconbridge, Teck-Cominco, Inco).

239 Gill-copper binding, acute copper toxicity, and oxidative stress in the tropical freshwater zebrafish *Danio rerio* as a function of water chemistry. C.M. Wood, P. Craig, G.B. McClelland, Biology, McMaster University, Hamilton, Ontario, Canada; N. Franklin, Land and Water, CSIRO, Lucas Heights, New South Wales, Australia. In an effort to extend the acute Biotic Ligand Model (BLM) for fish, the effects of a wide range of key water quality parameters (Na⁺, Ca²⁺, Mg²⁺, K⁺, pH, DOC) on gill Cu binding and acute toxicity were studied using the freshwater teleost fish, zebrafish *Danio rerio*. The zebrafish answers the need for a tropical species, is softwater tolerant, and offers the additional advantage of a well-characterized developmental biology and publicly available genomic information. Classic gill binding techniques developed by Playle and coworkers were used to derive short-term gill metal binding constants (LogK_{binding}), and compared to constants derived from toxicity tests (LogK_{toxicity}). Copper accumulation on the gill at 20 µg L⁻¹ dissolved Cu (in softwater) decreased with increasing DOC and most water ions, although to varying degrees. The 3 h gill ⁶⁴Cu burden was reduced by approx. 80% by both 10 mM Na⁺ and 3.3 mM Ca²⁺, and >95% by 10 mg C L⁻¹ DOC. This decreased gill binding was associated with marked decreases in acute Cu toxicity (up to 30-fold increases in 96-h LC50). Given the well-established mechanism by which Cu enters the fish gill (via a Na transport site), the surprisingly large protective effect of water Ca²⁺ on gill-Cu binding and toxicity was explored using mechanistic physiology studies. Both Ca²⁺ and Na⁺ proved protective in attenuating indices of oxidative stress at the protein and mRNA level. (Supported by NSERC CRD, ICA, CDA, NiPERA, ILZRO, IZA, Noranda-Falconbridge, Teck Cominco, and Inco).

240 The effect of water composition on copper sensitivity in glochidia: Expanding the Biotic Ligand Model to include the sensitive larvae of freshwater mussels. P.L. Gillis, G.L. Mackie, J.D. Ackerman, Integrative Biology, University of Guelph, Guelph, Ontario, Canada. Freshwater mussels, are among the most endangered groups of organisms. Many factors have contributed to their decline including habitat alteration, loss of fish hosts, and environmental contamination. Although the early life stages of mussels are sensitive to a range of contaminants, they are particularly sensitive to waterborne copper. This study assessed the influence of water chemistry on Cu sensitivity in glochidia, the larvae of freshwater mussels. Using a standardized (ASTM) acute toxicity test, Cu toxicity was examined in the glochidia of eight (including six endangered) species of mussels. In exposures conducted in reconstituted soft water (40-48 mg CaCO₃/L) the Cu EC50s ranged from 5 to 22 µg Cu/L. Glochidia from a common species, *Lampsilis siliquoidea* (Fatmucket), were used to assess the effect of water hardness and dissolved organic carbon (DOC) on Cu sensitivity. There was a significant linear relationship between water hardness and the Cu EC50 ($r^2 = 0.95$, $p = 0.025$). The Cu EC50 in moderately-hard reconstituted water (175 mg CaCO₃/L) water was 3 fold higher than the EC50 in very soft water (12 mg CaCO₃/L). Similarly, additions of natural organic matter resulted in a significant increase in the Cu EC50 ($r^2 = 0.98$, $p = 0.0009$). An increase in DOC from <1 to 4.4 mg C/L resulted in a 5 fold increase in the Cu EC50. Toxicity testing using eight field-collected, Cu-spiked natural waters also demonstrated that the Cu sensitivity of the larvae (EC50) was significantly related ($r^2 = 0.94$, $p = 0.0008$) to the concentration of inherent DOC in the water. These data demonstrate that Cu sensitivity of glochidia is strongly affected by the complexity of the exposure water. Efforts are underway to calibrate the Biotic Ligand Model to facilitate site-specific predictions of Cu toxicity to glochidia in order to ensure the protection of all life stages of freshwater mussels.

241 Validation of nickel Biotic Ligand Model predictions for selected non-standard organisms. E.J. Van Genderen, W. Stubblefield, Parametrix, Albany, OR; K.A. De Schampheleere, Laboratory of Environmental Toxicology and Aquatic Ecology, Ghent University, Ghent, Belgium; C.E. Schlekert, Nickel Producers Environmental Research Association, Durham, NC. The current approach in the European Union for regulating metals concentrations in surface waters has acknowledged the consideration of site-specific influences (e.g., hardness, pH, dissolved organic matter, etc.) on toxicity to aquatic organisms. As such, Biotic Ligand Models (BLM) have been developed and validated for several organisms that represent different trophic levels within natural waters. In the case of nickel (Ni), chronic BLMs have been developed and validated for an algae (*Pseudokirchneriella*

subcapitata), two invertebrates (*Ceriodaphnia dubia* and *Daphnia magna*), and a fish (*Oncorhynchus mykiss*). However, to justify full cross species BLM extrapolation, quantitative evidence is needed to confirm the applicability of the existing BLMs to predict toxicity to several dissimilar taxonomic groups. The goal of this study was to determine if the *C. dubia* and *D. magna* chronic nickel BLMs could validate/confirm intra-species difference in chronic nickel toxicity for invertebrate species for which no BLM exists. To facilitate this objective, five natural waters with varying levels of hardness, pH and dissolved organic carbon were used to conduct chronic toxicity tests with an insect (*Chironomus tentans*), a snail (*Lymnaea stagnalis*), and a rotifer (*Brachionus calyciflorus*). Test results illustrated that *L. stagnalis* was the most sensitive of the three species with effective concentrations for decreased growth (EC10 and EC20) ranging from 2 to 70 µg/L dissolved Ni. Effective concentrations for *C. tentans* (biomass) and *B. calyciflorus* (population growth rate) ranged from 100 to > 1000 µg/L dissolved Ni. Modeling results showed that the nickel BLMs developed for *C. dubia* and *D. magna* predicted toxicity for the three non-BLM organisms within a factor of two. The capacity of the BLMs to predict toxicity for non-covered species over a wide range of abiotic and bioavailability conditions supports the extrapolation of the crustacean BLMs to the other invertebrates in the nickel ecotoxicity database.

242 Field validation of a Biotic Ligand Model-derived toxic unit model. Are water quality criteria protective of macroinvertebrates in mountain streams of Colorado? T.S. Schmidt, Mineral Resources Program, U.S. Geologic Survey, Denver, CO. Two toxic unit models that estimate toxicity of mixtures of trace metals to aquatic organisms were compared in a regional-scale assessment of the geochemical and biological impacts of trace-metals in streams of the central Colorado Rocky Mountains. The Cumulative Criteria Accumulation Ratio (CCAR) is a toxic unit model derived from the Biotic Ligand Model (BML) of trace-metal toxicity. This model accounts for the modifying and competitive influences of a suite of major cations and anions, and dissolved organic carbon (DOC) in determining that fraction of metal that is available for accumulation on gills or other body surfaces of aquatic biota in streams contaminated by metal mixtures. The Cumulative Criterion Unit (CCU) model of metal toxicity is based on empirical relationships between Ca²⁺ and Mg²⁺ concentrations (hardness) and the toxicity of dissolved trace metals. In most cases, CCAR predicted less toxicity than that predicted by CCU by accounting for that fraction of metal that is bound to DOC. CCAR explained more variance in benthic macroinvertebrate community richness ($R^2 = 0.32-0.69$) and abundance ($R^2 = 0.32-0.72$) metrics when compared with CCU ($R^2 = 0.28-0.56$ for richness metrics & 0.24-0.57 for abundance metrics). Changes in benthic macroinvertebrate communities were found to occur at levels of trace metal contamination previously thought to be safe. Specifically, a 5% loss in taxa richness occurred at CCAR = 0.11, with loss of taxa increasing to 25% at CCAR = 1, the predicted threshold for ecological effects based on continuous chronic criteria. A 65% decrease in abundance metrics was also observed at CCAR = 1. These data suggest the BLM can be used to predict responses of native benthic macroinvertebrate communities to trace-metal mixtures in natural waters. However, substantial changes in benthic macroinvertebrate communities were observed at trace metal concentrations below water quality criterion. These data do not suggest that the approaches used to set water quality criteria or develop the BLM are improper. Alternatively, benthic macroinvertebrates are generally under-represented in toxicity databases used to develop water quality criteria and the BLM. Benthic macroinvertebrate sensitivity to trace metals is not adequately represented in these databases and therefore the criteria derived from them are not protective.

243 The Applicability of Biotic Ligand Approaches to Canadian Shield Waters. J. McGeer, M. Clifford, A. Mancinni, Biology, Wilfrid Laurier U, Waterloo, Ontario, Canada; T. Kozlova, Biology, McMaster U., Hamilton, Ontario, Canada. The sensitivity of aquatic ecosystems varies depending on the species and on water chemistry parameters. Therefore eco-regional and site-specific environmental risk assessments need to account for the unique nature of each receiving water. The biotic ligand model (BLM) approach to predicting metal toxicity in aquatic media has proven to be successful in explaining the variability that arises due to the influence of water chemistry on bioavailability. BLM models have primarily been derived using standard test species in water of medium to high hardness and it is uncertain whether these models can be applied to low ionic strength waters typically found on the Canadian Shield or if they can be considered relevant in the context of the native species living in those waters. Our research project is focused on understanding the

applicability of BLM based toxicity predictions in Canadian Shield waters. We have recently developed models for the acute effects of Ni and Zn on *Daphnia pulex* in very soft waters and have validated these in natural soft waters. For Zn the protective effects of Ca and Mg are stronger than standard hardwater BLMs would predict. In the case of Ni, the effects of competitive cations and complexation were consistent with expectations and the effects of natural organic matter varied with source. Current work is focusing on native fish species such as brook trout (*Salvelinus fontinalis*), lake trout (*Salvelinus namaycush*) and brown trout (*Salmo trutta*), their relative sensitivity for metals (Cu and Cd for example) compared to standard test species such as rainbow trout, and the applicability of BLM approaches.

244 Perchlorate Exposure and Thyroid Function in the US Population. B. Blount, L. Valentin, CDC, Suwanee, GA. Perchlorate is commonly found in the environment and can impair thyroid function at pharmacological doses. Because of the potential for widespread human exposure to this biologically active chemical, we developed an ion chromatography, tandem mass spectrometry-based method to quantify perchlorate and other anions relevant to perchlorate toxicity (iodide, nitrate, thiocyanate) in different human matrices. By measuring these environmental toxicants and iodide in human matrices, we can better assess exposure and the potential for adverse health effects. The presentation will include a description of the magnitude and prevalence of perchlorate exposure based on a nationally representative population of 2,820 U.S. residents, ages 6 years and older, during 2001 and 2002 as part of the National Health and Nutrition Examination Survey (NHANES). We found detectable levels of perchlorate ($>0.05 \mu\text{g/L}$) in all 2,820 urine samples tested, indicating widespread human exposure to perchlorate. Urinary perchlorate levels were distributed in a log-normal fashion with a median of $3.6 \mu\text{g/L}$ ($3.38 \mu\text{g/g}$ creatinine). We estimated total daily perchlorate dose for each adult (ages 20 years and older), and found the 95th percentile of exposure was $0.234 \mu\text{g/kg-day}$ (below the EPA reference dose of $0.7 \mu\text{g/kg-day}$). Subsequently, we evaluated the relationship between urinary levels of perchlorate and serum levels of thyroid stimulating hormone (TSH) and total thyroxine (T_4) in a subset of 2299 men and women. Multiple regression models found that urinary perchlorate was a significant negative predictor of T_4 ($p < 0.0001$) and a positive predictor of TSH ($p = 0.001$) for women with urinary iodine $<100 \mu\text{g/L}$. These effects of perchlorate on T_4 and TSH are coherent in direction and independent of other variables known to affect thyroid function, but are at perchlorate exposure levels unanticipated based on previous studies.

245 The Occurrence of Natural Perchlorate and its Implications for Exposure. W.A. Jackson, S. Rajagopalan, Civil and Environmental Engineering, Texas Tech University, Lubbock, TX; T. Anderson, The Institute for Environmental and Human Health, Texas Tech University, Lubbock, TX; G. Orris, U.S. Geological Survey, Tucson, AZ; G. Harvey, Wright Patterson AFB, U.S. Air Force, Wright Patterson AFB, OH. Perchlorate (ClO_4) occurrence in groundwater has previously been linked to industrial releases and the historic use of Chilean nitrate fertilizers. However, recently a growing number of reports have demonstrated that there is a significant pool of natural perchlorate in the US and other international locations. These reports include occurrences of natural perchlorate in ground water, deep unsaturated sediments, surficial soils, and native vegetation. The possibility that ClO_4 contamination of surface water, groundwater, soils and/or sediments may have multiple origins (military, industrial, agricultural, or natural) complicates site characterization and efforts to assign responsibility for remediation. Other complications arise when assessing potential exposure to ClO_4 , especially if affected waters are used for drinking, livestock, wildlife, or irrigation of food crops. For example, human exposure to ClO_4 has been documented thru consumption of vegetation and in dairy milk. This presentation will summarize the current understanding of natural perchlorate deposition and occurrence with particular emphasis on the potential for historical deposition to impact groundwater. Data to be presented include the current wet deposition rate of perchlorate, examples of major occurrences in groundwater, and the potential for flushing of subsurface reservoirs in arid areas. This data will be put in context of the potential for exposure.

246 Perchlorate in the Root Zones of Arid and Semi-Arid Regions Across the World. S. Rajagopalan, A.W. Jackson, Civil and Environmental Engineering, Texas Tech University, Lubbock, TX; T.A. Anderson, The Institute of Environmental and Human Health, Texas Tech University, Lubbock, TX; G.J. Orris, U.S. Geological Survey, Tucson, AZ; G. Harvey, U.S. Air Force, Wright-Patterson, OH; B.J. Andraski, U.S. Geological Survey,

Carson City, NV. Perchlorate (ClO_4^-) is an emerging pollutant that has been detected in soil, vegetation, milk, and ground and drinking water supplies at various concentrations across the world, where it can potentially have adverse effects on wildlife and human health. Perchlorate interferes with normal iodide uptake by the thyroid and reduced iodide uptake can disrupt normal thyroid function, especially in susceptible subpopulations. Recent reports of perchlorate in edible plants, milk, and even apparently unexposed human populations indicate that multiple diffuse exposure paths may exist. This study evaluated the presence of perchlorate in the shallow root zone ($<3 \text{ m}$) of over 30 locations in arid and semi-arid regions across the world. Perchlorate was ubiquitous in all sampled locations with concentrations ranging from sub ppb levels to sub ppm levels. Presence of perchlorate in root zones of undisturbed sites indicates a non anthropogenic surface source most likely to be of atmospheric origin. Results from this study have important implications to the national perchlorate issue and may aid in understanding the source of perchlorate in plants, milk, and other reported exposure pathways as well as in estimating background exposure. This study is part of a larger effort to estimate the source(s) and distribution of perchlorate in various environmental matrices across the world.

247 Natural perchlorate variability in easily transported near surface sediments and soils. G.J. Orris, U.S. Geological Survey, Tucson, AZ; G.J. Harvey, US Air Force, Wright-Patterson, OH; W.A. Jackson, Texas Tech University, Lubbock, TX. Naturally occurring perchlorate is ubiquitous in near surface soils and sediments, albeit commonly at low levels. Perchlorate within the top few centimeters of soils and sediments is most likely to be mobilized and transported by agents of erosion, especially wind and water. Understanding the distribution of natural perchlorate and the conditions under which it is concentrated should help us to determine the extent to which natural perchlorate contributes to perchlorate exposure levels in humans, animals, and plants. The USGS, TTU, and USAF are in the third year of a SERDP study on the distribution of natural perchlorate and the processes of concentration. Initial results indicate that natural perchlorate distributions in near surface soils and sediments vary with climate, age, geology, hydrology, and vegetation. Much of the perchlorate originates in the atmosphere and reaches the surface via precipitation. The relative amounts of perchlorate in a given area are grossly dependent on the total amount of perchlorate-bearing precipitation over time. Other factors aside, perchlorate concentrations in surface materials tend to increase over time. However, precipitation that is heavy or constant enough to lead to runoff or infiltration to groundwater tends to prevent accumulation or decrease the perchlorate content in the surface materials. In semi-arid and arid areas, evapotranspiration and incomplete infiltration contributes to concentration of perchlorate. The impacts of geology, vegetation and other factors also tend to increase near surface perchlorate under some conditions and decrease it under others. Overall, natural perchlorate levels in near surface soils and sediments are most likely to be elevated in arid and semi-arid climates. This leads potentially lead to elevated perchlorate levels in dust in these climates and spiking of perchlorate levels in surface or ground waters after unusually heavy precipitation.

248 Unconventional Sources of Perchlorate. G. Harvey, USAF, Wright-Patterson AFB, OH; A. Jackson, S. Rajagopalan, Texas Tech University, Lubbock, TX. Perchlorate is an ubiquitous oxyanion that can inhibit the uptake of iodide and impair thyroid function. Having both industrial (electrochemical) and natural (photochemical) sources the origin of widespread low level perchlorate remain currently unresolved. Lightning is an energetic electrical event generating ozone, oxides of nitrogen, high voltages (100 million to one billion volts), high amperage (10,000-200,000 amps) and high temperatures up to 30,000 degrees C. Lightning strikes the Earth's surface one hundred times a second or 8.6 million times a day. Lightning striking sandy soils produce a natural glass fulgurite. To determine if lightning could produce perchlorate fulgurite several samples from several different location (Africa, Australia, AZ, CO, TX, and FL) were obtained. These samples were prepped and analyzed by Texas Tech University. Perchlorate was detected in concentrations ranging from less than 1 ppb to approximately 5 ppb. Fulgurites are very resistant to weathering and can persist for millions of years under certain circumstances. Can the formation of fulgurites over geological time be a significant source of environmental perchlorate is unknown. Perchlorate is also used as a source of oxygen and found in hypochlorate. Analysis of various paper products (towels, coffee filters, feminine hygiene products, bandages, and sponges) revealed perchlorate up to 60 ppb. Self lighting charcoal briquettes and cigarette papers contain up to 25,000 ppb.

This is consistent with their ease of ignition and sustained combustion. They are designed to burn. Further studies on these paper products, fulgurites, and other natural glass like tectites need to be conducted to determine their relevance to human exposure to perchlorate.

249 Perchlorate Monitoring in California. K.P. Mayer, Superfund Division, SFD-7-2, U.S. Environmental Protection Agency, Region 9, San Francisco, CA; R.L. Holub, Santa Ana Regional Water Quality Control Board, California EPA, Riverside, CA. US EPA and several state agencies in California have reviewed perchlorate monitoring data from approximately 6000 public water supply wells throughout the state. Using a reporting limit of 4 ppb, perchlorate was detected in approximately 4 percent of these wells. Analysis of the distribution of the occurrence data indicated that most perchlorate was associated with particular perchlorate users such as propulsion and munition facilities. Some detections were not readily explained. Some possibilities include historical use of imported nitrate from the Atacama Desert in Chile for citrus.

250 Perchlorate Risk: Has the Horse Already Left the Barn? S.R. Clough, Risk Assessment, Haley & Aldrich, Inc., Manchester, NH. The risk of decreased iodine uptake and the subsequent potential for thyroid hormone deficiency due to the competitive inhibition by perchlorate (following ingestion of food or water) is a highly controversial subject. Low levels of perchlorate are virtually ubiquitous in the environment and, given that current analytical methods can now measure perchlorate in the part per trillion range, this compound can be detected in the urine of the vast majority of people, or any other medium sampled. The most recent debate has centered on the risk to nursing infants, as perchlorate has been measured at low levels in human breast milk (the sodium-iodide transport system has also been shown to exist in mammary tissue). A recent study (using NHANES data) presents information where perchlorate apparently correlates with decreased T4 and increased TSH in the urine of a small number of "iodine deficient" mothers (men are not affected). These observations (already debated at the Congressional level) may lead to widespread paranoia that breast feeding an infant may be detrimental to the baby's health, and is reminiscent of past warnings by the USEPA to decrease fish intake in order to decrease exposure to dioxins/furans (even though consumption of fish and associated oils is part of a healthy diet). This discussion will focus on the many lines-of-evidence that show that perchlorate has been in the environment for decades and that, despite all the attention in the media, the current USEPA RfD is scientifically defensible, and that, at current levels, perchlorate presents a negligible risk to humans in any age group. Additional discussion will focus on the ADME aspects of perchlorate and how many scientists are ignoring the basic biology of endocrine gland function.

251 Assessment of vegetated agricultural drainage ditches for irrigation runoff mitigation in California. D.L. Denton, US EPA Region 9, Sacramento, CA; M.T. Moore, C.M. Cooper, USDA Agricultural Research Service, Oxford, MS; J. Wrynski, P. Robins, Yolo County Resource Conservation District, Woodland, CA; J.L. Miller, Aqua-Science, Davis, CA; K. Reece, Aquatic Toxicology Laboratory, University of California at Davis, Davis, CA; D. Crane, California Department of Fish and Game, Rancho Cordova, CA. Widespread contamination of California water bodies by the organophosphate insecticides diazinon and chlorpyrifos is well documented. While their usage has decreased over the last few years, a concomitant increase in pyrethroid usage (e.g. permethrin) (replacement insecticides) has occurred. Vegetated agricultural drainage ditches (VADD) have been proposed as a potential economical and environmentally efficient management practice to mitigate the effects of pesticides in irrigation and storm runoff. Three ditches were constructed in Yolo County, California for a field trial. A U-shaped vegetated ditch, a V-shaped vegetated ditch, and a V-shaped unvegetated ditch were each amended for 8 h with a mixture of diazinon, permethrin, and suspended sediment simulating an irrigation runoff event. Water, sediment, and plant samples were collected spatially and temporally and analyzed for diazinon and permethrin concentrations. Pesticide half-lives were similar between ditches and pesticides, ranging from 2.4-6.4 h. Differences in half-distances (distance required to reduce initial pesticide concentration by 50%) among pesticides and ditches were substantial, indicating importance of vegetation in mitigation. Cis-permethrin half-distances ranged from 22 m (V-vegetated) to 347 m (V-unvegetated). Half-distances for trans-permethrin were similar, ranging from 21 m (V-vegetated) to 239 m (V-unvegetated). Diazinon half-distances demonstrated the greatest differences (55 m for V-vegetated and 1155 m for V-unvegetated). Such economical and

environmentally successful management practices will offer farmers, ranchers, and landowners a viable alternative to more conventional (and sometimes expensive) practices currently suggested by conservation organizations.

252 Use of harvested rice (*Oryza sativa*) fields for diazinon runoff mitigation. M.T. Moore, C.M. Cooper, R. Kroger, S. Smith, M.A. Locke, R.F. Cullum, USDA Agricultural Research Service, Oxford, MS. In landscapes defined by intensive agriculture, management practices are often needed to abate effects of potential non-point source pollution. Innovative research focuses on using rice (*Oryza sativa*), a wetland cereal crop, for pesticide mitigation both pre- and post-harvest. Because rice fields are delineated by water-retaining levees, water control can be manipulated to alter hydraulic residence time as needed for effective mitigation. Portions of two ponds at the University of Mississippi Field Station were drained, tilled, and planted with rice in May 2006. A third (unvegetated) pond was also drained and used as a control. A simulated storm event was conducted, introducing diazinon as runoff into the rice fields in November 2006. Amount of diazinon used was based on recommended field application rates and observed concentrations in previously collected runoff studies. Water, sediment, and plant samples were collected both spatially and temporally for 72 hours post-application. There was no statistically significant difference in the outflow diazinon mass between the two planted ponds. Although the control pond exhibited greater outflow diazinon mass than both the planted ponds, it was only statistically greater (slightly) than pond 1. Based on comparisons of inflow versus outflow concentrations, both rice ponds (1 and 2) mitigated 26-72% of diazinon concentrations. According to the mass balance, only a small fraction overall of the diazinon concentrations were associated with the rice (plant material). Current studies are evaluating pre-harvest pesticide processing capacities of rice ponds, as well as the impact of manipulation of hydraulic residence time on diazinon and other pesticide mitigation. Information generated from these studies will provide farmers and other natural resource conservation entities valuable options for efficient use of various management practices.

253 Development of a low cost crushed concrete media treatment system for copper removal from roof runoff: addressing mechanism, design and applicability in California. A. Sondhi, P.T. Imhoff, H.E. Allen, Civil and Environmental Engineering, University of Delaware, Newark, DE; R.W. Arnold, Copper Development Association, New York, NY. Leaching of copper from architectural and roofing material is among the top three sources of copper in San Francisco Bay, CA. Recent findings estimate that about 7,000 lb/year of copper is leached from copper used in architectural and roofing material. The concentrations of copper mobilized from these sources often exceed the U.S. EPA criteria for fresh and marine waters (USEPA, 2002) by more than 1-2 orders of magnitude. Rainwater mobilizes significant amounts of copper in this urban area. Most of the copper leached is in dissolved form thus causing a potential risk to sensitive aquatic plants and organism in the surrounding water bodies. A low cost treatment system using crushed concrete (2mm > dp > 4mm) was tested for its ability to remove dissolved copper from roof runoff. Removal efficiencies as high as 90% and 95% was observed for total and dissolved copper respectively. Due to the alkaline nature of crushed concrete, the pH of runoff flushed through the system was raised significantly (> 11). One specific issue that is central to understanding of copper removal using crushed concrete is the primary removal mechanism of copper. A predominant blue-green precipitate was observed on the crushed concrete particles in the reactor indicating a carbonate precipitate of copper. Preliminary results from equilibrium modeling software MINEQL+ suggest the formation of copper carbonate precipitate. Though high pH values suggest precipitation of copper as the removal mechanism, sorption of the copper by alumino-silicates in crushed concrete is also plausible. Independent analysis using spectroscopy was performed to confirm the actual removal mechanism. To be able to propose a practical design, issues such as longevity of media and the influence of rainfall intensity on removal capability have been evaluated and discussed.

254 Restoring Biological and Ecological Integrity to the Copper Basin Mining District; Polk County, TN. C. Zeller, L. Carr, Atlanta Federal Center, US EPA - Region 4, Atlanta, GA. Over 150 years of copper, zinc and iron mining; beneficiation/mineral processing; and sulfuric acid/chemical production left more than 30 square miles of barren, deforested, and severely eroded landscape in southeastern Tennessee and northern Georgia. The study area involves 10,000 acres of the Davis Mill Creek and North Potato Creek watersheds, and a 25 mile reach of the Ocoee River. The challenges posed by environmental investigation, ecological risk assessment, and remediation

of a site this size and complexity required US EPA - Region 4 to implement many unique project management strategies. This case study will discuss the technical framework of the short and long-term environmental approaches employed to reduce the metals/acidity loading to the Ocoee River, and the restoration of the biological/ecological function of the Davis Mill and North Potato Creek watersheds.

255 Reduction in metal leachability of soils treated with cement and calcium hydroxide. R. Lambert, B. Hale, Land Resources Science, University of Guelph, Guelph, Ontario, Canada. Cement reduces soil-metal solubility by increasing the soil pH and by encapsulating metals at macro and micro (molecular) scales. The amount of water provided to cement affects the hydration process and is also believed to affect metal immobilisation. Precipitation of metals as pH increases is likely to be reverted upon acidification, while metals encapsulated within the cement matrix can be resistant to acidification. The studied soils are from an old contaminated site containing Cd, Co, Cr Cu, Ni, Pb, Sb, and Zn. To assess metal leachability (solubility), the TCLP method (method 1311, EPA) was used. From 0, 2, 5, 10 and 15% of the soil's weight in cement was added to the soil. For each level of cement, 0, 10, 40 and 80, 175 and 250 ml of water was added. Amended soils were mixed and cured for 28 d in a controlled temperature chamber. The same experiment was repeated with 0, 0.01, 0.1 and 1% cement. After curing, soils were acidified and leached. The experiment was repeated with calcium hydroxide only, main product of cement hydration responsible for the pH increase. By comparing the reduction in metal solubility in soils treated with cement with soils treated with calcium hydroxide only, the importance of the encapsulation mechanism can be evaluated. Finally, soils treated with 0 to 15% cement were moistened and left open to the atmosphere for 20 weeks. The pH and leachability were regularly recorded. The addition of cement to soil significantly reduced leachability of all metals, and increased soil pH up to 12.3. For Cd and Pb, whose concentrations in non-treated soil exceeded guideline value, 5 and 8 % cement additions respectively, were sufficient to reduce the concentrations to values which met the guidelines. The addition of cement was between 70 and 100% more efficient than the addition of calcium hydroxide alone at reducing metal leachability, depending on the metal. The addition of small amounts of cement to soils also reduced metal leachability, but the effect was not significant. After 20 weeks of contact with the atmosphere, the pH of the treated soils decreased by 3 pH units. The acidification of cement-amended soils however did not lead to increased leachability. The concentrations of Cd, Cu and Pb in the TCLP leachate were unchanged after the re-acidification, while TCLP concentrations of Co and Zn were modified variably, depending on the % cement treatment.

256 In Situ Stabilization of Zinc in Soil and Groundwater. B. Rehm, ReSolution Partners, LLC, Madison, WI; R. Kondelin, Environmental Alliance, Inc., Wilmington, DE; S. Markesic, Redox Technology, LLC, Downers Grove, IL. A 21-acre parcel in the Mid-Atlantic United States hosted several industrial operations from 1907 to 1982. Groundwater is present at 5 feet bgs in heterogeneous alluvium and saprolite. Flow rates are on the order of 100 feet per year. Groundwater at a pH of 5 SU and containing as much as 30 mg/L of zinc discharges to a small stream on one edge of the facility. The site surface was remediated and redeveloped into an apartment complex. Groundwater remediation to a goal of 2.0 mg/L zinc was deferred until after the apartment complex was built. In situ stabilization technologies that could be applied with minimal interference with site use were evaluated in bench-scale and in-field pilot tests. A slurry reagent that could be injected below the developed site was identified. The bench scale testing using site soil and groundwater samples found a 4 weight percent (wt. %) slurry dose increased pH to 10 SU and reduced zinc concentrations from 14.7 to 0.013 mg/L. The proposed remedial design took the form of a reactive zone at the edge of the facility, which required an evaluation of the long-term stability of an injected reactive zone. Multiple extractions found an extractant pH of 8.5 SU and zinc concentration of 0.088 mg/L of zinc following about 1,200 aquifer pore volumes of leaching, equivalent to 400 years at the site groundwater flow rate. Pilot testing was completed with direct-push injection methods. Approximately 7.3 tons of reagent slurried in 4,205 gallons of water was injected at six points. Temporary well samples within the injection zone had post-injection zinc concentrations of <0.020 mg/L. A monitoring well downgradient of the injection zone yielded 21 mg/L of zinc prior to the injection. Three months later the zinc concentration at the downgradient well was 5.4 mg/L. Groundwater monitoring is continuing.

257 Performance of Pilot Scale Constructed Wetland Treatment Systems for Flue Gas Desulfurization (FGD) Waters. D.A. Eggert, J.H. Rodgers, Forestry and Natural Resources, Clemson University, Clemson, SC; C. Muarry-Gulde, ENTRIX, Atlanta, GA; G.M. Huddleston, ENTRIX, Pendleton, SC. Flue gas desulfurization (FGD) waters are produced in wet scrubbing of flue gases from thermoelectric power generation, and these waters can contain potentially toxicity constituents including arsenic, boron, cadmium, chemical oxygen demand, chloride, chromium, copper, cyanide, lead, mercury, selenium, sulfates, total suspended solids, and zinc. The resulting by-product waters (FGD waters), can differ in chemical composition due to the type of FGD scrubber, coal burned, chemical additives (e.g. flocculants, coagulants, and pH stabilizers), and scrubbing water source. Due to the Clean Water Act, these waters must be treated before discharge into aquatic receiving systems. The specific objectives of this research were to: 1) characterize FGD waters in terms of chemical composition and constituents of concern; 2) design pilot-scale constructed wetland treatment systems (PS-CWTS) for remediation of constituents of concern in FGD waters; and 3) measure the performance of PS-CWTS for formulated and actual FGD waters based on National Pollutant Discharge and Elimination System (NPDES) permits. Based on chemical composition data from six actual FGD waters, constituents of concern identified in these waters were boron, cadmium, chemical oxygen demand, chloride, copper, mercury, nitrate, selenium, and zinc. PS-CWTS were designed using biogeochemical modeling software (Geochemist Workbench) and consisted of an equalization basin and two reducing and oxidizing wetland reactors in series. Four FGD waters (i.e. formulated, actual-amended, and two actual FGD waters) were introduced into the PS-CWTS and performance was assessed by measuring the targeted constituents of concern as well as the toxicity of pre- and post-treatment waters to *Ceriodaphnia dubia*. Results from these studies indicate that constituents of concern can be decreased to achieve discharge limits (freshwater aquatic systems) using constructed wetland treatment system along with co-management of post-treatment and low ionic strength waters for chloride concentrations.

258 Isolation of Cr 6+ Reducing Bacteria from Industrial Effluents and Their Potential Use in Bioremediation of Chromium Containing Wastewater. D.A. Rehman, A. Zahoor, Microbiology and Molecular Genetics, Punjab University, Lahore, Punjab, Pakistan; D.A. Rehman, A. Zahoor, Microbiology and Molecular Genetics, Punjab University, Lahore, Punjab, Pakistan. Rapid growth of industries, exploding population and agricultural revolutions has affected greatly the man's physical environment. Besides drugs, antibiotics and radioactive substances, industrial wastes contain heavy metals, which are mutagenic, carcinogenic and teratogenic. A specific problem associated with heavy metals in the environment is accumulation in the food chain and persistence in the environment. The present study deals with the isolation, growth and tolerance to heavy metals of bacteria, isolated from industrial waste-water and their ability to reduce Cr6+. Growth conditions (pH, Temp.) of isolated bacteria were ascertained to grow them in laboratory conditions. Resistance of these isolated bacteria against different heavy metal ions was checked. Bacteria showed high resistance against Cr6+ up to 4.3mg/ml. They were also found resistant to heavy metals i.e. Ni2+, Zn2+ and Pb2+ up to concentration of 4.0, 0.4 and 0.8 mg/ml respectively. The reduction in the amount of Cr6+ from the medium after 24 hours was 49%, after 48 hours 74%, after 72 hours 84% and after 96 hours 91%. To check the effect of metal on protein synthesis total proteins of the metal treated and untreated bacteria were analyzed by SDS polyacrylamide gel electrophoresis. The detoxification ability of these isolates indicates that, these can be used for amelioration of metal polluted industrial wastewaters.

259 Efficient use of abundant waste materials for remediation/ prevention of ARD generation and toxic metals release from extractive wastes. I. Twardowska, K. Janta-Koszuta, S. Stefaniak, E. Miszczak, Institute of Environmental Engineering, Polish Academy of Sciences, Zabrze, POLAND. High-volume sulfidic mining waste disposal and use as a common fill results in generation of high-metal ARD (Acid Rock Drainage) due to sulfide oxidation. Emission of potentially toxic elements (PTE) and sulfate loads from these objects during their construction and in the post-closure period can be successfully attenuated with use of abundant bulk wastes such as fly ash (FA) from coal-fired power plants, and of waste organogenic materials (stabilized sewage sludge SS). Properly placed FA: water dense mixtures were found to have excellent sealing properties with respect to air penetration (1-3 orders of magnitude higher than that of natural cohesive

soils). These properties can be effectively utilized for preventing access of air as a basic reagent in sulfide oxidation. Such FA layers play a role of water-permeable barriers that do not distort natural water balance of the construction. In the top of such dump construction, the most susceptible to sulfide oxidation, ARD generation and PTE release due to the extensive exposure to weathering processes, a subsurface layer of organogenic materials (sewage sludge SS) placed over a drainage system can play preventive role against released PTE migration in pore solution. Experiments on metal ions sorption onto stabilized sewage sludge (SS) conducted in batch and flow-through systems, in laboratory and bench scales, from prepared mono- and binary Me-SO₄ solutions at pH 4.0, and from simulated actual polymetallic ARD leachates at pH 1.47, pH 3.0 and pH 4.0, showed high sorption capacity for metal ions of this abundant waste material. Sorption capacity of metal ions from monometallic solution (in g/kg d.m., pH 4.0) followed the ascending sequence: Ni (24.6) < Zn (28.7) < Cd (39.0) < Cu (40.6) < Cr (48.9) < Pb (181.6). Sorption of metal ions from real polymetallic solutions at pH 1.47, 3.0 and 4.0 in flow-through systems confirmed high binding capacity of SS as a protective layer. Incorporation of air-tight permeable layers of dense FA:water mixtures and of a subsurface protective layer of SS over a drainage system can efficiently protect groundwater against long-term contamination by ARD from sulfidic mining (extractive) wastes, usually lasting for decades.

260 Terrestrial Model Ecosystems (TME) - A higher tier semi-field test system to study effects of contaminants on the soil mesofauna. A. Nikolakis, F. Heimbach, T. Leicher, Bayer CropScience, Monheim, Germany; B. Scholz-Starke, A. Schaeffer, M. Ross-Nickoll, RWTH Aachen University, Aachen, Germany. Structural semi-field test systems allow for the investigation of soil communities at different trophic levels and their interactions as well as the evaluation of direct and indirect effects of soil contaminants. Our approach considers sampling of large intact soil cores on undisturbed grassland (= TME; diameter 18.5 inch, depth 15.8 inch, mass ≈ 220 lbs), followed by maintenance in an outdoor test facility under representative environmental conditions. Each TME is kept isolated to prevent direct immigration and emigration of species, however, with ground connection to assure drainage and to avoid water-logging. After general ecological investigations, lindane (lambda-HCH) has been selected as a model contaminant to investigate the capability of our TME approach. More than 40 TME were used per study. During the course of the trials (limit tests, dose-response studies) we evaluated the impact of lindane throughout the year on the most abundant representatives of the soil meso-fauna, i.e. Collembola, Acari, Enchytraeidae and Nematoda. Via a soil corer, various undisturbed replicate sub-samples per treatment level were taken from different TME. In the laboratory, Collembola and Acari were extracted from the samples by high-gradient MacFadyen extraction, wet extraction was used to sample Enchytraeidae and Nematoda. Results including community NOEC's (multivariate statistics, Principal Response Curves) will be presented and discussed in detail. By accounting for the strengths and weaknesses of also other structural higher tier testing options (e.g. SSD, higher tier lab studies, field studies) and by considering our experience gained in over 4 years of experimental TME-testing, we attempt to critically evaluate the possibilities provided by semi-field tests to decrease uncertainty within structural risk assessments in soil ecotoxicology. Also the discussions and the outcome of the PERAS-Workshop ("Semi-Field Methods for the Environmental Risk Assessment of Pesticides in Soil", Coimbra, Portugal, October 2007) will be considered in the critical evaluation.

261 An Ecological Risk Assessment of Burnt Fly Bog Superfund Site Contaminated with Petroleum Hydrocarbons, PCBs, and Lead. L.A. Lyons, Lockheed Martin/REAC, Edison, NJ; R. Henry, U.S. Fish and Wildlife Service, Edison, NJ; D.W. Charters, EPA/ERT, Edison, NJ; T. Porucznik, EPA Region II, Edison, NJ. The Burnt Fly Bog site, situated in Marlboro Township, New Jersey, was contaminated from the direct dumping and spreading of hazardous materials from recycled waste oil operations in the 1950's and early 1960's. The final remedy selected by EPA for one area of this site, known as the Westerly Wetlands, imposed a Declaration of Environmental Restriction that included the natural containment of the residual contaminants within the bog of the Westerly Wetlands. A 1991 baseline study of the bog characterized the site contaminants in the soil, vegetation, and small mammals and performed an earthworm bioaccumulation test. In 1991 the mean soil concentrations of total petroleum hydrocarbons, PCBs, and lead concentrations in the bog were 257,000 mg/kg, 51.8 mg/kg, and 11,575 mg/kg, respectively. A site investigation was performed in 2006 that mimicked the sampling regime of the 1991 baseline study. The objectives of this study were to provide a

comparative assessment between the 1991 and current site conditions and to conduct an ecological risk assessment (ERA). The comparative assessment evaluates the attenuation of site contaminants that has been occurring. The ERA characterizes risk to six assessment endpoints including plants, soil biota, birds and mammals. Food chain modeling to characterize risk of the site to herbivore, invertivore, omnivore, and carnivore birds and mammals is provided.

262 Is there value in measuring bioavailable soil metal extractions in ecological risk assessment? D. Stanbury, M. Gilbertson, C. Wren, Gartner Lee Ltd, Guelph, Ontario, Canada; G. Stephenson, Stantec, Guelph, Ontario, Canada; W. Hendershot, Natural Resource Science, McGill University, Montreal, Quebec, Canada. It is generally unnecessary to conduct a detailed risk assessment for every chemical present on a particular site, as not all necessarily represent a risk to the environment or human health. Therefore, screening criteria are generally employed to rule out those compounds that are not considered to be chemical of potential concern (COPC). Soil quality guideline values, although based on numerous literature reviews and toxicity tests (CCME, 1999) are directly compared to "total" or nitric acid extractable metals. But do these values accurately describe what is occurring in the soil matrix? Nitric acid extraction is a harsh method that extracts more metal than what the biological media might be exposed to. In recent years, numerous new extraction methods have evolved which appear to more accurately mimic the "bioavailable" concentrations of metals in the soil matrix. Soil metal bioavailability has been a hot topic in the risk assessment community for the last 10 years, especially in the use and determination of soil quality guidelines. Taking soils from a northern Ontario community as a case study, five different extraction methods are examined against corresponding toxicity data to determine the most appropriate method for relating soil metal concentrations with plant growth parameters and microbial activity on a site-specific basis. The results of these extractions along with their application to different biological endpoints will be examined to best determine the bioavailable soil metal fraction.

263 Soil Properties and Ecological Risk Assessment of Arsenic Contaminated Soil: Phytotoxicity Adjustments using Plant Metal Upper Critical Values. R.H. Anderson, N.T. Basta, School of Environment and Natural Resources, The Ohio State University, Columbus, OH. Hazardous effects of environmental contaminants on non-human receptors are the focus of ecological risk assessments. Soil matrix properties can mitigate hazardous effects of contaminants through soil chemical sequestration and should be considered when evaluating ecological risk from terrestrial contamination. Empirical models that quantify relationships between chemical/physical properties of soils and hazardous effects of contaminants, such as toxicity, can improve the accuracy of ecological risk assessments. However, differential sensitivities of organisms to various environmental contaminants often inhibit the utility of such models because of the introduction of additional variability. We present a novel approach to dose/response toxicity parameter estimation that normalizes estimates by partitioning the effect due to differential sensitivities of test organisms from that of soil chemical/physical properties. Five soils that ranged in chemical/physical properties were spiked with five concentrations of sodium arsenate. Bioassays were conducted where above ground dry matter growth (DMG) and the corresponding tissue As concentration were evaluated for three terrestrial plants (Alfalfa, Medicago sativa; Perennial ryegrass, Lolium perenne; and Japanese millet, Echinochloa esculenta) each with different sensitivities to As (V). Conventional toxicity parameters and threshold tissue As concentrations which initiated a decline in DMG were estimated for each plant. Threshold tissue As concentrations were estimated using a plant metal upper critical value (PMUCV) algorithm and used to normalize conventional toxicity parameter estimates. The normalization technique and results are discussed within the context of the mitigating effect of soil properties on As phytotoxicity. Adjustment of ecotoxicity parameters by PMUCV is a promising approach to account for soil As (V) sequestration.

264 Toxicokinetics of Cadmium and Hexachlorobenzene in Earthworms - Preliminary Results of an International Bioaccumulation Ring Test for Terrestrial Oligochaetes. R. Lanno, Entomology, Ohio State University, Columbus, OH; P. Egeler, D. Gilberg, J. Roembke, ECT Oekotoxikologie GmbH, Floersheim/Main, Germany. An international ring test was performed to standardize and validate a method for the assessment of bioaccumulation of chemicals in terrestrial oligochaetes from spiked artificial and natural soils. Fourteen laboratories from seven countries contributed to

this international effort. Earthworms (*Eisenia fetida/andrei*) were used to determine bioaccumulation kinetics of cadmium chloride or ¹⁴C-labelled hexachlorobenzene (HCB) used as model substances. Chemical uptake kinetics examined and biota-soil accumulation estimated using a one-compartment first order kinetics (1CFOK) model. Preliminary results from tests with earthworms suggest that a 1CFOK model adequately describes bioaccumulation kinetics for HCB. Cd bioaccumulation was not described as consistently, primarily due to the often linear uptake phase. The ring test results also showed that soil properties can affect uptake of chemicals by earthworms from soils spiked with chemicals. The project was funded by the German Federal Environmental Agency (R&D no. 204 67 458).

265 Toxicity of Methanol, Amines and Glycols to Soil-dwelling Organisms. N. Feisthauer, G. Stephenson, Stantec Consulting Ltd., Guelph, ON, Ontario, Canada; M. Tindal, Axiom Environmental Inc., Canmore, Alberta, Canada; L. Checknita, ALS Environmental, Edmonton, Alberta, Canada; D. Crosby, ALS Environmental, Waterloo, Ontario, Canada; M. Morden, Petro Canada, Calgary, Alberta, Canada. Chronic ecotoxicity tests with clean soil freshly amended with alkanolamines, glycols and methanol were conducted in order to generate chemical-specific toxicity data for plants and soil dwelling organisms and these compounds. The five compounds were monoethanolamine (MEA), diethanolamine (DEA), diethylene glycol (DEG), triethylene glycol (TEG) and methanol (MeOH). All five compounds are use extensively in the petroleum industry in Alberta or are by-products of the industry. The ecotoxicity assessment was conducted in order to generate terrestrial toxicity data that will be used, in part, to derive new soil quality criteria for the five compounds listed above. The plant (alfalfa, barley and northern wheatgrass) tests were early seedling emergence and growth tests and the definitive (chronic) invertebrate tests were chronic survival, growth and reproduction tests with one earthworm (*Eisenia andrei*) and one collembola (*Folsomia candida*) species. In addition to toxicity testing, the soil concentrations of amines, glycols, and methanol to which test organisms were exposed were also measured by chemical analyses. Subsamples of the amended test soils were collected for all compounds and submitted for analyses at the beginning, middle and end of selected toxicity tests. Quantitative measurements of the compounds in amended soils were possible for glycols and methanol; however, concentrations of amines in soil could not be measured successfully despite numerous attempts. This lack of success supports the claim that there currently are no standard methods that can quantitatively and reliably measure the concentrations of amines in soil. It also illuminates the need to develop analytical methods for this group of chemicals.

266 Wildlife Toxicity Reference Values for Ecological Soil Screening Levels (Eco-SSLs). J. Burris, Syracuse Research Corporation, Denver, CO; C. Russom, D. Hoff, USEPA, Duluth, MN; D. Charters, M. Sprenger, USEPA, Edison, NJ; E. Steve, USEPA, Washington, DC. Wildlife Toxicity Reference Values were developed by the USEPA Superfund for the calculation of Ecological Soil Screening Levels (Eco-SSLs) protective of terrestrial wildlife. The wildlife Eco-SSL is the soil contaminant concentration where the Effect Dose (TRV) and Exposure Dose are equal (amount of contaminant in the diet that is taken up from soil). The TRV is defined as the dose above which ecologically relevant effects might occur to wildlife species following chronic dietary exposure and below which it is reasonably expected that effects will not occur. A four-step process was used to derive TRVs: 1) Literature search, 2) Literature review and data extraction, 3) Data evaluation, and 4) TRV derivation. This presentation provides the results of the final TRV derivation processes and subsequent Eco-SSLs for polynuclear aromatic hydrocarbons (PAHs) and DDT and metabolites. The extracted toxicological data is classified by effect type for six classes of endpoints including mortality, reproduction, growth, biochemical, behavioral, and physiological. Each extracted result is assigned a data evaluation score ranging from 30 to 100 indicating the quality of the study. Studies with scores above 65 are then plotted by effect type and used to derive the wildlife TRV (Step 4) according to a pre-established selection and calculation hierarchy. The derivation process and results (both TRV and associated Eco-SSL) are discussed for each new contaminant specific document issued in 2006 and 2007 including DDT, copper, manganese, PAHs, nickel, silver, selenium, and zinc.

267 Resolving Data Issues in the Development of Canadian Soil Quality Guidelines for Ecological Receptors. K. Potter, National Guidelines and Standards Office, Environment Canada, Gatineau, Quebec, Canada. In 2006, a new scientific protocol was published by the Canadian Council of Ministers of the Environment for the development of Canadian Soil Quality

Guidelines (CSOQGs) for the protection of environmental and human health. CSOQGs are science-based benchmarks for contaminants in soil. At concentrations below the CSOQGs, soils should be supportive of a healthy functioning ecosystem capable of sustaining current and likely future uses of the site, and there should be minimal adverse effects on humans or ecological receptors (e.g., plants, invertebrates, wildlife). The CSOQGs take into consideration various different ecological receptors and exposure pathways. One of the pathways is direct soil contact for plants and soil-dwelling invertebrates. Under the new protocol, there are four possible methods for deriving CSOQGs for the protection of plants and invertebrates that are in direct contact with soil. The choice of which method to use depends on the quality and quantity of toxicity data available. Each of these four methods will be described using examples from recently developed CSOQGs. In addition, various issues encountered in the guideline development process pertaining to these methods will be discussed, including: (1) data gaps and limited suites of test species; (2) endpoints based on hypothesis testing (NOEC, LOEC) versus regression (EC_x); (3) evaluation of toxicity studies, and common problems encountered; and, (4) approaches for dealing with redundant data.

268 Development of soil screening values for the UK: total petroleum hydrocarbons. B. Versoonen, A. Ghekiere, M. Vangheluwe, P. Van Sprang, EURAS, member of Arcadis, Gent, Belgium; S. Fishwick, G. Merrington, Environment Agency, Westbury on Trym, United Kingdom; A. Redman, HydroQual, East Syracuse, NY. The aim of this project was to derive screening values for widespread use in contaminated soils in England and Wales (Environment Agency), affording an adequate level of protection to both terrestrial species and critical ecological functions. These may, in case of exceedance, prompt further risk assessment. Draft soil screening values for priority contaminants of single compounds were developed according to the EU Technical Guidance Document. However, for total petroleum hydrocarbons (TPHs) a different approach was needed. For TPHs, quality assessed terrestrial ecotoxicity data together with other relevant test parameters were stored in a database. This database was further used to validate the derivation of soil screening values using equilibrium partitioning (EqP) and the narcosis target lipid model (nTLM) developed for aquatic organisms. Additivity for different 'hydrocarbon blocks' with relatively homogeneous environmental chemistry was assumed. A comparison between both approaches showed that PNEC values derived with the nTLM and EqP were generally within one order of magnitude compared with PNECs derived from the more limited terrestrial toxicity dataset; Confidence associated with draft screening values, data gaps and research needs are indicated.

269 Sustainable Sediment Management. D.W. Moore, S. Anghera, Weston Solutions, Carlsbad, CA; J.Q. Word, Newfields, LLC, Port Gamble, WA; K. Frederick, Weston Solutions, Westchester, PA. Long-term management of sediment has been a central feature of navigational dredging programs. The questions of how to limit the amount of dredging, increase the amount of time between dredging events, and where to manage the material once it's dredged have long been intertwined with the economic growth of waterborne commerce. These issues have been complicated by the fact that sediments in the areas associated with commercially important ports and harbors often have legacy contamination issues as a result of adjacent or upstream land-use (urban/industrial) that predates environmental regulation. Only recently (within the last twenty five years) have we begun to incorporate considerations for the treatment and management of contaminated sediments to reduce environmental risk with an increased emphasis on management alternatives other than disposal. A more recent phenomenon has been a shift to macro-scale approaches (e.g., watershed and regional sediment management planning). Such approaches attempt to understand "natural" sediment budgets and use this information in framing discussions for the future management of sediments at a watershed or regional scale. Implicit within these approaches is the recognition that sediments are a critical resource for deltas and estuaries carrying nutrients to sustain the ecosystems that support important fisheries in these areas. A hard learned lesson has been the consequences of channelization on the valuable resources of our delta areas with perhaps no clearer example than Coastal Louisiana. Coastal Louisiana channelization efforts result in the loss of miles of wetland and barrier island habitats annually while sediment is transported into deeper offshore environments where the increased sediment load overwhelms those environments. The question of how to balance the pragmatic needs of commerce, flood protection, and ensuring the sustainability of the associated ecosystems is the challenge this paper is intended to frame. In this paper we will provide an overview of the historical

management of sediments with case studies of long-term programs for dredged material management, a discussion of the recent PIANC document on alternative uses of dredged materials, and introduce the concept of sustainable sediment management on a watershed basis.

270 Use Impairment Decision-making Approach for Assessment of Sediments. J. Conder, ENVIRON International Corporation, Irvine, CA; G. Klepper, Conestoga-Rovers & Associates, Inc., Lansing, MI; L. Martello, R.J. Wenning, ENVIRON International Corporation, Emeryville, CA; P. Fuchsman, ENVIRON International Corporation, Cleveland, OH; M. McCulloch, Honigman Miller Schwartz and Cohn LLP, Detroit, MI. Decision-making frameworks for addressing chemically-impacted sediments often rely on conservative sediment quality guideline (SQG) values derived either from "consensus-based" observations of impairment in a wide range of aquatic environments contaminated with a complex milieu of contaminants or "non-site specific" ecological risk models addressing theoretical risks to benthic biota, plants, fish, or fish-eating birds. Despite the widely-recognized caveat that SQGs should only be used in the initial stages of a sediment investigation, regulatory decision-making approaches often misapply these conservative values as triggers for investigation or remedial actions. This approach can lead to undue public alarm and/or unnecessary remediation efforts that limit the ability of stakeholders to focus their resources on truly egregious impairments related to chemically-impacted sediment. The concept of use impairment is particularly important to restoration initiatives in the Great Lakes region, where regulatory actions are triggered by conditions deemed different from background and, in most cases, attributable to chemically-impacted sediments. Considering the relationships between chemically-impacted sediment and aquatic resources, we present a decision-making framework for evaluating the cause-effect relationships between chemically-impacted sediments and 16 different use impairments identified by the State of Michigan. Using a tiered approach, the framework begins with a simple screening against SQGs and ecological benchmarks, then proceeds to considerations of more site-specific factors and determinations of probable linkages between sediments and specific use impairments. The intent of the framework is to place screening and investigative tools in the proper context and facilitate a more efficient characterization of water bodies suspected to be influenced by chemically-impacted sediment.

272 Solidification/Stabilization Treatment : Applications in Remediation and Beneficial Re-Use of Contaminated Sediment. C.M. Wilk, Portland Cement Association, Skokie, IL; C. Dickson, Cement Association of Canada, Halifax, Nova Scotia, Canada. This presentation will discuss Solidification/Stabilization (S/S) technology and provide examples of S/S use to treat contaminated sediment. S/S is an increasingly popular technology for remediation of contaminated sediment, sustainable redevelopment of port facilities, and treatment of dredged material permitting the beneficial re-use of the material as fill and pavement base. S/S treatment involves mixing a binding reagent into the contaminated media or waste. The treatment protects human health and the environment by immobilizing hazardous constituents within the treated media. Successful treatment is accomplished through physical changes to the waste form, and often, chemical changes to the hazardous constituents themselves. S/S has been used to treat a large variety of hazardous constituents in many different forms of waste and contaminated media. The U.S. Environmental Protection Agency (EPA) considers S/S to be an established treatment technology. EPA has identified S/S treatment as Best Demonstrated Available Technology (BDAT) for a variety of listed hazardous wastes and has selected S/S treatment for 24% of its Superfund site source control remedies. S/S has also been used to facilitate landfill of dredged sediment in lower-cost Resource Conservation and Recovery Act (RCRA) subtitle D landfills. The technology is well suited for treatment of contaminated sediment. S/S prevents release of hazardous constituents, quickly dewater, and improves physical properties of treated dredge. Immobilized hazardous constituents and improved construction properties of S/S-treated dredge allow beneficial re-use of the material. S/S treatment has also been accomplished while the contaminated sediment remains in-place. This presentation will discuss: (a) applicability of the technology to contaminated sediment, (b) basic cement chemistry relating to S/S, (c) basics on implementation of the technology in the field, and (d) examples of successful full-scale S/S treatment of contaminated sediment both in-place (in-situ) and on dredged material.

273 Beneficial Use of 'Contaminated' Dredged Material: Testing and Evaluation. R.A. Price, USAERDC-EP-R, Vicksburg, MS. Increasing

restrictions on open-water placement of dredged material and decreasing space for confined upland disposal has hastened the need to find sustainable alternatives. One solution is increasing the use of dredged material for upland beneficial uses. However, beneficial use has been increasingly scrutinized over the last 30-40 years as analytical chemistry capabilities have improved and public awareness of contaminants of concern (COCs) has widened. A general lack of knowledge concerning the bioavailability of COCs from dredged material placed in upland environments has led to dredged material being determined unsuitable for beneficial uses based solely on the presence of COCs. The result is relatively clean dredged material simply being disposed into confined disposal facilities, occupying valuable space needed for more contaminated material. The potential for contaminants of concern (COCs) to migrate in the environment through various pathways (surface and groundwater, volatile and particulate emissions, plant and animal bioaccumulation) is determined not by contaminant concentration but by various physicochemical characteristics of each dredged material. Factors such as organic carbon, black carbon, cation exchange capacity, pH, clay content and chemical interaction affect the availability and transport of any given COC. The USACE Upland Testing Manual provides exposure/effects testing for evaluating disposal of dredged material in upland environments to determine potential adverse effects of COCs through the various contaminant pathways. Results of exposure testing are compared to applicable standards, compared to background conditions or subjected to ecological or human health risk analysis. While this testing guidance is used routinely to assess simple disposal in the terrestrial environment, assessment for beneficial use acceptability is typically evaluated by comparing dredged material COC concentrations to various state approved numerical criteria. Increasing the use of exposure/effects testing is needed to facilitate scientifically sound management of dredged material through beneficial uses. Current guidance on the regulatory structure and data from case studies will be presented.

274 Application of the MycoRemediation Process to Contaminants of Concern. J.Q. Word, NewFields Northwest LLC, Port Gamble, WA; P. Stamets, Fungi Perfecti, Shelton, WA; D.W. Moore, M. Witt, Weston Solutions, Carlsbad, CA. Historical contamination of harbor sediments creates legacy issues that require treatment or isolation from ecological receptors. MycoRemediation uses fungi as a part of a complex community to breakdown recalcitrant organic contaminants. There are many species of fungi that are capable of degrading complex compounds characterized by benzene ring structures. Lignin and cellulose are complex organic compounds composed of complex associations of ring structure compounds (lignin) or long chains of carbon and hydrogen (cellulose) that are very resistant to degradation by most organisms. Fungi are the principal degraders of these complex chemical compounds and their degradation products form the primary energy resource of certain species of fungal organisms. Though lignin and cellulose are highly resistant to decay by normal physical and natural chemical processes as well as by other organisms, selected fungal species are uniquely adapted to produce various suites of enzymes that degrade these compounds. The observation that lignin and cellulose molecules are structurally similar to some anthropogenic pollutants led to the discovery that metabolic processes for decomposing recalcitrant plant tissues can also be applied to selected organic contaminants in the environment. Fungal-based remediation of biological and chemical agents, nitrogenous based explosive compounds, petroleum related compounds, chlorinated pesticides, and PCBs have been successfully demonstrated in sediment and soils using various species of fungi as keystone remediators. In general, this fungal remediation process has been very effective and rapid resulting in 60 to 97% remediation over periods of 8-14 weeks for the various compounds and treatment materials. The experimental laboratory and field procedures that have been developed for this process, the successes of the experimental trials and the next steps in development of these methods for larger scale application will also be presented and discussed. Application to dredged materials to create sediment that can then be used in more ways can be a significant component to sustainable harbor development.

275 Optimizing Management of PAH-Contaminated Sediments from the Appomattox River. G. Tracey, G. Berman, SAIC, Newport, RI; S. Insalaco, SAIC, Twinsburg, OH; S. Powell, R. Pruhs, R. Reali, Norfolk District, USACE, Norfolk, VA; C. Carter, Weanack Land Partners, Charles City, VA. The USACE Norfolk District (NAO) is assisting the City of Petersburg, VA in a navigation dredging project intended to restore the former federal navigation channel. In this effort, ~360,000 cy of deposited sediment will be removed from -14 MLLW up to +6 MLLW over ~1 mile

reach of the Appomattox River. Historical industrial uses have resulted in PAH contamination exceeding 500 ppm on average, with hotspots detected in excess of 10,000 ppm. SAIC is supporting NAO in assessing the contaminant distribution, dredge sequencing, upland source control measures, sediment capping requirements to address residual contaminants, and the beneficial reuse options for the dredged material. In support of beneficial reuse as agricultural soil SAIC has completed a lab treatability study to assess biodegradation potential and has designed and will implement a field pilot landfarm study demonstration during summer 2007. Results of these activities as well as the technical and regulatory issues being resolved to allow eventual placement of the material at a mine reclamation site for agricultural purposes will be presented.

276 Pressure Washing Armored Sediments on Beaches in Prince William Sound Impeded Recovery of Oiled Intertidal Clam Assemblages. D.C. Lees, Littoral Ecological & Environmental Services, Leucadia, CA; W.B. Driskell, Driskell & Assoc., Seattle, WA. Beaches in Prince William Sound (PWS) were pressure washed after the Exxon Valdez oil spill. Based on studies from 1989 through 1996 evaluating washing effects on mixed-soft beaches, we hypothesized that clam assemblages and sediments on treated beaches were severely injured by high-pressure washing. In 2002, we conducted a follow-up study to determine if these effects persisted and were widespread. We found that our initial conclusions were accurate; a large proportion of mixed-soft beaches in treated areas of PWS remained highly disturbed and exhibited functional impairment in terms of ability to support foraging by humans and nearshore vertebrate predators such as sea otters. Large, long-lived hardshell (primarily littleneck and butter) clams remained 66% less abundant at Treated sites than at Reference sites. Based on the apparent recovery trajectory, we predict that recovery to pre-spill status will take several more decades. The factor most likely responsible for delayed clam recovery was unsuspected at the time of the cleanup or initially during this study. In contrast to our initial hypothesis, we found that standard sediment properties were not implicated in lagging recovery. However, we observed that sedimentary components and biota in mixed-soft sediments did not respond in accordance with paradigms typically describing homogeneous sediments. Relationships between grain size, content of fines and organics, and biodiversity in PWS sediments, diverging dramatically from conventional paradigms and often behaving differently at Reference and Treated sites, do not appear to have been reported previously. An armored layer formed by organization of the coarse fractions at the sediment's surface appears to be an important factor causing these differences. Based on several lines of evidence, we ultimately deduced that disruption of armoring caused by high-pressure beach washing was a major cause of the greatly delayed recovery of hardshell clam assemblages. In view of the apparent importance of armoring to sedimentary and infaunal relationships on mixed-soft beaches that support a rich, stable infauna, we suggest that pressure washing to remove stranded oil is unacceptable in such habitats. Since it appears that armored sediments are widely distributed in the world, this new concept should be incorporated into cleanup strategies.

277 Integrating Sediment Quality Metrics to Prioritize UXO Clearance in an Aquatic Ecosystem. B. Zajdlík, Zajdlík & Associates Inc., Rockwood, Ontario, Canada; I. Young, J. Rebiniczak, S. Barrett, B. Brady, Quality Engineering Testing Establishment, Department of National Defence, Gatineau, Quebec, Canada; P. Robidoux, G. Sunahara, H. Fanous, Biotechnology Research Institute, National Research Council of Canada, Montreal, Quebec, Canada; M. Braid, UXO Clearance and Legacy Sites, Department of National Defence, Ottawa, Ontario, Canada. Historical Canadian Forces activities have resulted in UXO present at a Canadian Forces base in the St. Lawrence River. These UXO will be cleared following a prioritization scheme comprised of multi-part criteria such as: 1) probability of human interaction with UXO, 2) UXO type and 3) site ecological risks. The latter of these prioritization criteria is in part, measured using experimental and standard toxicity tests at a variety of levels of biologic integration and sediment chemistry. The integration of this information over the 120km² site using geostatistical and multivariate tools will be discussed.

278 Linkage Between Land-Based Contaminated Sites and an Estuarine TMDL: PCBs in the Delaware River Watershed. V.J. Bierman, LimnoTech, Greensboro, NC; S.C. Hinz, LimnoTech, Austin, TX; J.R. Yagecic, N.S. Suk, T.J. Fikslin, S. Liao, Delaware River Basin Commission, West Trenton, NJ. The Delaware River Estuary is listed as impaired due to elevated levels of PCBs in fish tissue. A Stage 1 total maximum daily load (TMDL) was developed using an integrated mass balance model for

hydrodynamics, organic carbon dynamics, and PCB transport and fate. Under current conditions, the principal external sources of PCB loadings are the following, in order of decreasing importance: non-point source runoff, point discharges, Delaware River at Trenton, Schuylkill River, runoff from contaminated sites, the sum of all other tributary inputs, atmospheric wet and dry deposition, and CSOs. Current water column concentrations of PCBs in the Delaware are approximately 500 times higher than the applicable water quality standard and substantial reductions will be required in external PCB loadings. Furthermore, external PCB loadings from each individual source category, including runoff from land-based contaminated sites, are substantially higher than the TMDL for the entire estuary and each source category will require substantial reduction. The PCB loadings from land-based contaminated sites include 49 different sites, located between the tributary monitoring stations and the mainstem Delaware River Estuary, and they constitute approximately 10 percent of the total external loadings of PCBs. Cleanup standards for PCBs at these sites were developed independently of water quality standards for the TMDL in the estuary and do not necessarily ensure compliance with these water quality standards. The objective of this study was to determine PCB loads from these 49 land-based contaminated sites for existing site cleanup standards and to investigate whether these PCB loads will meet water quality standards in the estuary. Results from forecast scenarios with the integrated mass balance model indicated that for these 49 sites, remediation to a surface soil cleanup level of 1 ppm will result in PCB loads that will exceed the Stage 1 TMDL load allocations by 1-2 orders of magnitude, depending on location, and violate the water quality standard in the middle portion of the estuary by greater than a factor of four. The cleanup levels required for these 49 sites to meet the Stage 1 TMDL load allocations ranged from 0.001 to 0.055 ppm, depending on location in the estuary.

279 Occurrence and partitioning of current-use pesticides in the Alamo and New Rivers near the Salton Sea, California. K.L. Smalling, J.L. Orlando, K.M. Kuivila, U.S. Geological Survey, Sacramento, CA. Previous studies have measured a variety of pesticides at relatively high concentrations in water and sediments from the Salton Sea in Southern California. The Salton Sea is a primary wintering habitat for migratory birds along the Pacific Flyway and receives freshwater via the Alamo and New Rivers from the south. The southern watershed is predominately agricultural with greater than 1.3 million kilograms of pesticides applied annually to approximately 60 different types of crops. Surface water and suspended sediments were collected monthly at the two river inlets to the Salton Sea during peak pesticide-application periods in 2006-2007. Dissolved pesticides were analyzed using solid-phase extraction and gas chromatography/mass spectrometry (GC/MS). Suspended sediments were extracted using microwave-assisted extraction, cleaned with carbon/alumina followed by gel-permeation chromatography, and analyzed by GC/MS. Current-use pesticides with log K_{oc} values ranging from 2 to > 5 were detected in water and suspended sediments. Carbofuran, chlorpyrifos, DCPA, diazinon, EPTC, pendimethalin and trifluralin were detected in both water and suspended sediments. Atrazine and malathion were detected only in the water while the more hydrophobic pesticides such as the legacy organochlorines and several pyrethroids were detected more frequently and at higher concentrations in the suspended sediments. Sediment concentrations can be estimated using aqueous pesticide concentrations and simple equilibrium-partitioning models. However, measured pesticide concentrations in suspended sediments are typically greater than these predicted values suggesting non-equilibrium conditions. Therefore, it is important to measure both the dissolved and sediment bound fractions to understand the fate and transport of current-use pesticides in the environment. This is especially important in a watershed with very high use of a wide variety of pesticides with different physical-chemical properties.

280 Development of a Chemical Mass Balance for Sediments of the Lower Passaic River. E.A. Garvey, S.S. Gbondo-Tugbawa, J. Atmadja, FIER, Malcolm Pirnie, Inc, Fair Lawn, NJ; A. Accardi-Dey, Malcolm Pirnie, Inc, White Plains, NY; S. McDonald, Malcolm Pirnie, Inc, King of Prussia, PA. For two centuries, urban and industrial development has resulted in a significant environmental impact on the Lower Passaic River and adjacent waterbodies in northern New Jersey. Coincident with this development was the construction and subsequent lack of maintenance of a shipping channel along most of the Lower Passaic. As a result, sediments of the Lower Passaic are contaminated with a variety of chemicals including dioxins, PCBs, pesticides, polycyclic aromatic hydrocarbons (PAHs), and metals, to depths greater than 15 ft in the river bed. An empirical mass balance model using a receptor-type modeling

approach was developed to understand the fate and transport of sediment-bound contaminants in the Lower Passaic River. The model is formulated as an overdetermined set of linear mass balance equations for nine chemicals representing the five contaminant classes listed above. The model quantifies the relative contaminant and solids contributions to the river's recently deposited surface sediments from the following sources: the upper Passaic River, the tributaries, combined sewer overflows (CSO) and storm water outfalls (SWO), tidal input from Newark Bay and in-river sediment resuspension. The model results indicate that the external sources alone cannot account for the observed chemical concentrations; an internal source, specifically sediment resuspension, is contributing to the contaminant burden of recently deposited surface sediments. As a fraction of the total solids flux to the Lower Passaic, resuspension of legacy sediments (i.e., the historical inventory) comprises about 10 percent of the total annual deposition. However, resuspension accounts for over 95 percent of the dioxin burden, and at over 40 percent of PCBs, pesticides and mercury burden in the Lower Passaic. By contrast, over 60 percent of the PAH burden in the lower river originates from the upper river. Finally, CSO/SWOs and the tributaries play only minor roles for contaminants like dioxin, PCB, and DDT; however, taken together, their contributions may represent about a third of the total flux for contaminants like lead, copper, dieldrin, and chlordane. The results of this model provided the basis to assess early action remedial alternatives for the Lower Passaic River.

281 Tidal Marshes in Urban Environments: Historical Reconstruction of Chemical Loadings and Ecosystem Effects. D. Velinsky, J. Ashley, D. Charles, Patrick Center for Environmental Research, Academy of Natural Sciences, Philadelphia, PA; C. Sommerfield, College of Marine and Earth Studies, University of Delaware, Lewes, DE; J. Ashley, School of Science and Health, Philadelphia University, Philadelphia, PA; R. Greene, DNREC, State of Delaware, Dover, DE. Sediment cores were obtained from tidal marshes in the St. Jones River, a tributary of the Delaware Estuary, to estimate historic loading of chemical contaminants, nutrients and their potential ecosystem impact. The cores exhibited regular and congruent geochronology of (8-11 mm/yr based on Cs-137 and Pb-210) and sediment pollution records extending back through much of the past century. Each site recorded a dramatic increase in sedimentary PCBs, DDTs, phosphorus and industrial metals starting in the late 1930s, with peak concentrations in the 1960s to 1970s. Peak concentrations of tPCBs were 218 to 780 ng/g dw whereas surface concentrations ranged from 40 to 170 ng/g dw. The distribution pattern of PCBs reflects changes in sources and possibly biodegradation over time. The pattern of DDT and chlordane over time were similar but were offset by ~10 years most likely due to historical use and environmental controls. Similar to other DE marshes, sediment phosphorus concentrations peaked in early 1970s, decreasing to the surface. Diatom metrics exhibited a substantial change over time as the tidal river became more eutrophic. The concentrations from this study will be compared to other tidal marsh systems spanning an urban-non urban gradient in the Delaware Estuary.

282 Integrated Risk Assessment for Contaminated Marine Sediment: Remediation and Decision-making in the case of a naval facility. C.W. Hickey, D. Morrissey, M. Ahrens, J. Cooke, National Institute of Water and Atmospheric Research, (NIWA), Hamilton, New Zealand. Studies carried out over the last two decades in the Devonport Dockyards Management Area (DMA), demonstrated that estuarine sediments were highly contaminated with a wide range of chemicals notably copper (Cu), DDT, lead (Pb), polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), mercury (Hg), zinc (Zn) and tributyl tin (TBT). As a precursor to formulating a site remediation plan, we undertook a site-specific risk assessment to assess the adequacy of previous investigations and to provide the scientific basis for remediation decision making. This involved: (i) spatial mapping of contaminants using GIS; (ii) additional sampling for key contaminants; (iii) sediment toxicity testing; (iii) bioaccumulation testing; and (iv) developing a conceptual food chain model. Contaminant concentration profiles showed multiple 'hits' (exceedance of the Probable Effects Level – PEL) at a number of the 48 sampling locations, particularly for copper, lead, mercury and zinc. There were far fewer hits for the organic contaminants (e.g. DDT, PCB, PAH, TBT) though there was a patchy distribution of some extremely high concentrations at a number of sites. Metal measurements on particle size fractionated samples showed that, contrary to expectations, the majority of contaminants were associated with the larger particulate fractions. The observation of extensive numbers of assorted paint flakes in sieved samples support the contention that much

of the chemical contamination is associated with particulate paint material. Chemical analysis of paint flakes confirmed high levels of Pb, Hg, Zn, TBT, PCBs and DDT. Leachate and bioavailability testing were used to further demonstrate the ecological risk of these contaminant fractions. The integrated risk assessment used a 'weight-of-evidence' approach including: (i) chemical contaminant levels in sediments; (ii) sediment toxicity testing; (iii) infaunal biological diversity and abundance; and (iv) contaminant bioaccumulation in biota and measures of impairment in those species; to score probable levels of impairment over the spatial scales appropriate to the study site. The outcome of this assessment process was greatly influenced by the finding of major contaminants of concern (ie mercury, PCBs) in paint flakes with low bioavailability.

283 Development of a 2,3,7,8-tetrachlorodibenzo-*p*-dioxin sediment-based preliminary remediation goal using the reproductive endpoint in the eastern oyster (*Crassostrea virginica*, *Gemlin*) for the Passaic River/Newark Bay and Raritan Bay Complex, New Jersey. T. Kubiak, C. Stern, M. Foster, U.S. Fish and Wildlife Service, Pleasantville, NJ. We have integrated publicly-available oyster toxicity, bedded sediment and suspended solids data developed by others to produce a sediment-based preliminary remediation goal (PRG) for eastern oyster exposure to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). A controlled laboratory study published in 2003 demonstrated that the eastern oyster was the most sensitive animal reported to date, based on tissue concentrations of TCDD and reproductive impairment. In a complementary field-deployed pollution gradient exposure test within Newark Bay, Arthur Kill, and Raritan Bay, New Jersey, corroborative evidence was obtained showing reproductive performance was dramatically altered when actual TCDD tissue exposures exceeded 2 pg/g on a wet weight basis. We investigated available bedded sediment and suspended solids data sets analyzed for TCDD that could be time- and geospatially-matched with the field-deployed oysters described above. Two independent data sets representing bedded sediment and suspended solids were matched with Arthur Kill field-deployed oysters. BSAF and target tissue residue levels were calculated and a sediment-based PRG was derived. With environmentally realistic organic carbon concentrations, the dry weight sediment-based PRG was calculated to be approximately 3.18 pg/g for bedded sediments and 3.67 pg/g for suspended solids. While other dioxin-like compounds have been detected or are assumed to be present in field-deployed oysters, considerable uncertainty remains regarding the toxicological significance of these co-occurring contaminants because no uniform toxicity equivalency factors (TEF) have been generated with any invertebrate. Proteins similar to the vertebrate Ah receptor in binding, but less so in structure, have been found to be abundant in the gills and gonads of several bivalve mollusks. Although this evidence suggests a receptor-mediated mechanism may be involved in the reproductive toxicity of TCDD in oysters, a toxicity equivalency factor (TEF) approach using vertebrate-based TEFs is inappropriate and a new direction for invertebrates will be needed to assess cumulative exposure to dioxin-like hazardous substances.

284 Preliminary Evaluation of the Effects of Coal Fly Ash Amendments on the Toxicity of a Contaminated Marine Sediment. R.M. Burgess, M.G. Cantwell, M.C. Pelletier, K.T. Ho, J.R. Serbst, S.A. Ryba, Atlantic Ecology Division, U.S. EPA, Narragansett, RI; M.M. Perron, Department of Environmental Health, Harvard School of Public Health, Boston, MA; E.M. Suuberg, K.G. Pennell, Division of Engineering, Brown University, Providence, RI; C.L. Friedman, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI. Contaminated sediments are recognized as a global environmental problem with adverse ecological and economic effects. Approaches for cleaning-up contaminated sediments range from dredging to in situ treatment. In this research, we discuss the toxicological and geochemical effects of amending reference and contaminated sediments with coal fly ash in an effort to reduce the bioavailability and toxicity of polycyclic aromatic hydrocarbons (PAHs). Five fly ashes and a coconut charcoal (an activated carbon) were evaluated in seven day whole sediment toxicity tests with a marine amphipod (*Ampelisca abdita*) and mysid (*Americamysis bahia*). The fly ashes with high carbon content, based on loss on ignition measurements, and the coconut charcoal showed proficiency at reducing toxicity. Some of the fly ashes demonstrated toxicity in the reference treatments. We suspect this toxicity is related to the presence of ammonia associated with fly ashes as a result of post-oxidation treatment to reduce nitrous oxides (NOx) emissions. Although not evaluated exhaustively in this study, relatively simple methods are available to remove ammonia from fly ash

prior to use. Fly ashes were also shown to effectively reduce concentrations of several PAHs in water overlying the contaminated sediments. There was no evidence of the release of the metals cadmium, copper, nickel or lead from the fly ash into the toxicity testing system during the study. These preliminary data show fly ashes with high carbon contents may represent viable remedial materials for reducing the bioavailability of organic contaminants in sediments. Further research is needed to fully assess potential ammonia toxicity from fly ash, possible ecological effects of fly ash amendments in the field, and importance of carbon on fly ash performance.

285 Monitoring Performance of the Anacostia Active Capping Project. D. Reible, D. Lampert, Civil, Architectural, and Environmental Engineering, The University of Texas at Austin, Austin, TX. An active capping demonstration project in Washington DC is testing the ability to place sequestering agents on contaminated sediments using conventional equipment and evaluating their subsequent effectiveness relative to conventional passive sand sediment caps. Sampling and analysis of a variety of contaminants including polycyclic aromatic hydrocarbons (PAHs) have been conducted after placement. Post-cap monitoring indicates that all cap materials effectively isolated contaminants on the basis of bulk sediment loading, and it is not possible to differentiate between intermixing of sediment and contaminant migration at this time using this parameter. However, the relatively high affinity of PAHs and PCBs for sediment versus sand can distort this result. In addition apparent recontamination of the surface of the caps has further complicated the interpretation of cap performance. Studies designed to separate these competing effects and provide an improved assessment of performance will be described. Recent work suggests that pore water, and not bulk sediment loading, will provide a better indication of contaminant migration and also dictates uptake into benthos. For these reasons, the ability to determine pore water concentration profiles in a sediment cap is an important part of evaluating their performance. As part of this study, field solid-phase micro-extraction (SPME) fibers were placed in situ using modified piezometers to evaluate pore water concentration profiles in sediments and placed caps. In addition, analyses of the PAHs at the cap surface provide important clues as to the source and extent of recontamination after cap placement.

286 Temporal effects of dredge-related releases on fish tissue concentrations – implications to achieving net risk reduction. J. Stern, Dept Natural Resources & Parks, King County, Seattle, WA. In a highly urbanized salt-wedge estuary on Puget Sound Washington, fish tissue concentrations of PCBs spiked by a factor of three to five and then returned to previous levels. Several sediment remedial actions occurred in the estuary six to nine months before the sampling that exhibited the high tissue concentrations. Detailed contaminant and fate and transport modeling using EFDC was conducted to investigate how dredge-generated contaminated sediment residuals, along with associated releases of contaminants into the water column, can temporarily increase the bioavailability. Dissolved concentrations needed to generate the measured tissue concentrations using a bioaccumulation model provides insight into the relative contribution of sediment-associated and porewater contaminants released by the dredging projects. Comparison of measured tissue level reductions over time to modeled responses also provides information on the persistence of dredging-related releases in the system. Results can help inform evaluations of short-term increase and longer term reduction in risk to determine the timing of achieving net risk reduction from sediment cleanups.

287 Overview of exposure to dioxin-like compounds and PCBs on developmental, immunosuppressive, and hormone-related effects in mammals, including humans. L.S. Birnbaum, Environmental Toxicology Division / NHEERL, U.S. Environmental Protection Agency, Research Triangle Park, NC. Exposure to TCDD and related compounds leads to a plethora of effects in multiple species, tissues and stages of development. The response spectrum ranges from simple biochemical alterations to overtly toxic responses, including lethality. Many of the effects of TCDD and related compounds are associated with relatively high doses: lethality, wasting, lymphoid and gonadal atrophy, chloracne, hepatotoxicity, adult neurotoxicity and cardiotoxicity. Developmental effects of TCDD and related dioxin-like compounds appear to be the most sensitive indicators of exposure including effects on the developing immune, nervous, cardiovascular and reproductive systems. Effects of TCDD on the immune system, learning and the developing reproductive system of multiple animal species occur at body burdens which are close to those present at the high end of the population distribution

in the background human population. Biochemical effects of TCDD on cytokine expression and metabolizing enzymes occur at body burdens within a factor of ten of clearly adverse developmental responses. Functional deficits of TCDD exposure include lethality enhancement from co-exposure to low pathogenicity influenza virus and delays in puberty. Body burden appears to be the preferred dosimetric for such persistent organic pollutants. Similar responses noted in experimental animals have also been detected in mammalian wildlife, and in some cases, in human populations. The multitude of responses will be compared across species and discussed in relation to what is known about similarities and differences between dioxins and PCBs.

288 Overview of dioxin-like compounds, PCB and pesticide exposures associated with developmental heart effects in mammals, fish, and birds. M.K. Walker, A.C. Aragon, P.G. Kopf, College of Pharmacy, University of New Mexico, Albuquerque, NM. The developing cardiovascular system is a sensitive target of many environmental pollutants, including dioxins, dioxin-like PCBs, and some pesticides such as methyl parathion. Laboratory research has utilized a variety of vertebrate models to elucidate potential mechanisms that mediate this cardiotoxicity and to establish the sensitivity of different species for predicting potential risk to environmental and human health. Studies of dioxin and dioxin-like PCBs have illustrated that piscine, avian, and mammalian embryos exhibit cardiovascular structural changes and functional deficits, although the specific characteristics vary among the individual models. Piscine models typically exhibit reduced blood flow, altered heart looping, and reduced heart size and contraction rate. The chick embryo exhibits extensive cardiac dilation, thinner ventricle walls, and reduced responsiveness to chronotropic stimuli, while the murine embryo exhibits reduced heart size. It is notable that in all models the dioxin-associated cardiotoxicity is associated with increases in cardiovascular apoptosis and decreases in cardiocyte proliferation. While the cardiotoxicity in piscine and avian species is associated with overt morbidity and mortality, that is not the case for the murine embryo. However, murine offspring exposed during development to dioxin exhibit cardiac hypertrophy and an increased sensitivity to a second cardiovascular insult in adulthood. Thus, although the mammalian embryo is less sensitive to cardiovascular defects by dioxin and dioxin-like compounds, developmental exposure increases the risk of cardiovascular disease later in life. The impact of developmental exposure to dioxin-like chemicals on human cardiovascular disease susceptibility is not known. However, recent animal research has confirmed human epidemiology studies that dioxin exposure in adulthood is associated with hypertension and cardiovascular disease.

289 Environmental Epidemiology using the Eastern Oyster (*Crassostrea virginica*) Examining Reproductive Endpoints. K.R. Cooper, Biochemistry and Microbiology, Rutgers University, New Brunswick, NJ. Developing novel model systems that examine basic biochemical, molecular and physiological pathways that are common to many species is important for extrapolating biological effects through an ecosystem. An understanding of a chemicals mechanism of action can allow for extrapolation across broad species lines. In the case of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) effects on embryonic development and to a lesser extent effects on gonad development occur in most species. Compounds that interact with highly conserved pathways will impact a broad range of species. 2,3,7,8-TCDD is known to interact with the AHR receptor, but less is known about non-AHR related pathways. Bivalve mollusks have steadily declined in the Northeast as increased development has occurred. The Eastern oyster (*Crassostrea virginica*) and related bivalves serve as important species in aquatic ecosystems throughout the United States and the world. Studies examining the effect of 2,3,7,8-TCDD on reproductive success in our laboratory have shown that doses as low as 2 pg/g wet weight will alter normal gonad development and veliger larvae survival (Wintermyer and Cooper 2007). Interference with normal germ cell maturation or storage of lipids into the larvae can result in poor survival post spawning. Field studies resulted in similar lesions in adults and poor post larval survival, but are likely due to multiple chemical exposures. Alterations in reproductive pathways are likely to have contributed to the decline in bivalve populations seen in the NY/NJ harbor area as well as other sensitive species. Bivalve mollusks can serve as excellent indicators of water and sediment quality based on their ability to successfully reproduce.

290 Overview of Dioxin-like Compounds, PCB and Pesticide Exposures Associated with Sexual Differentiation of Neuroendocrine Systems, Fluctuating Asymmetry, and Behavioral Effects in Birds. M. Ottinger, E. Lavoie, M. Quinn, Animal and Avian Sciences, University of

Maryland, College Park, MD; M. Abdelnabi, Animal Science, University of Assiut, Assiut, Egypt. Although the mechanisms involved in sexual differentiation appear to differ greatly in mammals and birds, there are common neuroendocrine systems that are likely targets of EDC exposure, especially during embryonic development. Dioxin, PCBs, and pesticides impact neural systems in birds, with differences in the sensitive periods for precocial and altricial birds. It is during this time that most birds are vulnerable to the effects of EDCs, resulting in both short and long term effects on reproductive function. Precocial species such as Japanese quail undergo sexual differentiation of hypothalamic systems during embryonic development; these neural systems direct later endocrine function and behavioral responses. The embryonic exposure to steroid hormones begins from maternally deposited steroids followed by steroids produced by the embryo. Sex differences occur in embryonic androgen to estradiol levels, with higher androgen in males and higher estradiol in females. Embryonic exposure to selected EDCs impacts sexual maturation and behavior in adults by interfering with sexually differentiated responses. Experiments revealed both short term alterations in these neuroendocrine systems as well as some effects on maturation and adult function in quail, with embryonic exposure to estrogen or androgen active EDCs. Studies suggest that altricial species may not be as vulnerable to the effects of EDCs during embryonic development; however seasonal changes in the song systems may remain sensitive. Effects of developmental exposure on neuroendocrine systems will be considered, especially relative to maturation and later HPG axis function. The impact of embryonic EDC exposure will be considered relative to the timing of exposure and potential interference with later HPG axis function.

291 Environmental immunotoxicants: human-wildlife relationships. A. Fairbrother, PERL, Parametrix, Inc., Bellevue, WA. The immune system is well conserved across species, including similar mechanisms for up- and down-regulation of the immune response. Many of the tools and assays developed to study changes in immune responses of humans exposed to environmental contaminants have been successfully transferred to other species, such as various birds (e.g., mallards, kestrels, gulls), marine mammals (e.g., seals), other mammals (e.g., deer mice), and even reptiles (e.g., tortoises). Some of the methods are directly transferable across species while others need optimization of substrates or methods, e.g., for species with different body temperatures. This presentation will review methods for assessing the three parts of the immune response (general inflammatory response, cell-mediate immunity and antibody-mediated immunity) and highlight similarities between humans and wildlife. Long term, low level exposures of wildlife of various ages in the field provide more realistic estimates of potential risk than can be achieved through shorter-term laboratory studies with the rodent model. Results from studies of persistent organic pollutants in various species will be compared to support the conclusion that wildlife are good sentinels and/or models for humans of immunotoxicity from environmental chemicals.

292 Role of immune status in relationship to potential for infectious disease and localized population impacts. K. Grasman, Biology, Calvin College, Grand Rapids, MI. Studies in laboratory animals have demonstrated that the immune system is sensitive to a variety of organic industrial chemicals, pesticides, and heavy metals. Parallel studies have demonstrated associations between exposure to contaminants and altered immune function in free-living fish and wildlife. The purpose of this presentation is to describe the immunological assays most commonly used to assess immune function in wildlife and evaluate the potential for contaminant-induced immunosuppression to cause increased incidence of infectious disease and population-level effects. Immunological methods employed in free-living animals have ranged from general indicators of immunological status (e.g., blood cell counts, immune organ masses) to functional assays (e.g., sheep red blood cell hemagglutination test, phytohemagglutinin skin test). The latter, which integrate the functions of multiple cell types, are similar to assays used to screen for immunotoxicity in laboratory rodents. These functional tests have been shown to be excellent biomarkers of immunotoxicity. While often difficult to implement in field studies, cellular and molecular methods (e.g., lymphocyte culture, apoptosis assays, genomic methods) hold much potential for monitoring immunological effects and providing mechanistic information to link these effects to particular contaminants. Most immunotoxicity studies in free-living wildlife presume that contaminant-associated alterations in general, functional, or mechanistic endpoints are associated with increased rates of infectious diseases. The connection between altered immune assays and resistance to disease challenge is supported by laboratory studies. In several

instances contaminants have been shown to be associated with increased rates of infectious diseases in local populations, and, in some cases, with larger epizootics. Furthermore, increasing evidence from the field of immunocology demonstrates the ecological relevance of reduced immune function in wild birds. Suppressed immune function is often associated with decreased rates of survival and reduced colonization of new habitats. In conclusion, the immune system is a sensitive target of environmental contaminants in wildlife, and contaminant-induced immunological deficits appear to hold ecological relevance to individual animals and local populations.

293 Developmental, reproductive, and behavioral/neurological effects of mercury in fish. J.S. Weis, Biological Sciences, Rutgers University, Newark, NJ. Over the past few decades there have been numerous studies of effects of mercury (primarily methylmercury) on different aspects of fish reproduction and development. We will review studies on effects on sexual maturation, gametogenesis, fertilization, and embryonic development that have been performed on a number of species of fishes. Developmental abnormalities include craniofacial, cardiovascular, and skeletal, as has been observed in human exposures at Minamata and in other vertebrates. Some studies of development showed delayed effects, in that embryos that appear to develop and hatch normally later exhibit delayed mortality or abnormal behavior ("behavioral teratology.") Some cases of abnormal behavior were reversible when larvae were kept in clean water, while others persisted years later. In addition to studies of developmental effects on behavior, there have been many studies of effects of mercury on behavior of adult fishes. Some of these have been laboratory-based, while some examined behavior of fish from contaminated sites, an epidemiological approach. Behaviors such as prey capture, predator avoidance, activity level, swimming performance, and aggression have been examined. Abnormal behaviors have been associated with changes in neurotransmitters and the thyroid gland. Neuro-behavioral effects have been observed in other vertebrates including humans. These behaviors are important to survival and can have ecological consequences at the population and community level. There have also been studies of effects on fish reproductive behavior that suggest that it may be a more sensitive endpoint than other reproductive parameters such as endocrine disruption.

294 Overview of developmental, reproductive, and behavioral/neurological effects of mercury exposures in wildlife. G.H. Heinz, D. Hoffman, J. Klimstra, K. Stebbins, Patuxent Wildlife Research Center, Beltsville, MD. We review wildlife/mercury literature and our own research findings that demonstrate the relevance of wildlife toxicity data in protecting human health. Methylmercury affects wildlife through reduced adult survival and reproduction, aberrant behavior, immune system effects, and teratogenic effects. Methylmercury can readily cross the blood-brain barrier, is excreted into eggs in birds, and is transferred to young mammals across the placenta and in milk. Its principal effect on wildlife is on neurological functions. Wild mink (*Mustela vison*) and otter (*Lutra canadensis*) have died from methylmercury poisoning, with signs of poisoning including anorexia, loss of weight, incoordination, tremors, and convulsions, which are symptoms similar to those experienced by mercury-poisoned humans. Mammals also may experience tonic and clonic convulsions and an increase in fetal anomalies, again paralleling toxic problems in people. Antibody-producing cells can be suppressed by methylmercury. Microscopically, the most notable lesions are in the cerebrum. Extensive vacuolation of hepatocytes in the liver and necrosis and other changes in the appearance of the proximal convoluted tubules of the kidneys are often noted. When harp seals (*Pagophilus groenlandicus*) were dosed with methylmercury chloride the number of circulating erythrocytes decreased and white blood cell counts greatly increased. The poisoned seals also suffered from uremia, hyperproteinemia, hypercholesterolemia, hyperbilirubinemia, and elevations in lactic dehydrogenase and alkaline phosphatase. In birds, signs of methylmercury poisoning included emaciation and weakness in the extremities, which progressed until the birds died. Mercury poisoning in birds and mammals can be diagnosed from a combination of the signs of poisoning if the animal is still alive, the pathological effects seen in a gross necropsy, the histopathological effects seen with a microscope, and the concentrations of mercury in various tissues. Our studies with mallards (*Anas platyrhynchos*) suggest that the dietary concentrations of mercury that cause toxicity are lower than those set in fish consumption advisories to protect humans. Because wild mammals and birds are so sensitive to methylmercury poisoning and cannot escape dietary exposure the way humans can, guidelines set to protect wild birds and mammals may very well provide a margin of safety for human health.

295 Epidemiological evidence of outbreaks of congenital Minamata disease in several Canadian Areas of Concern in the Great Lakes. M. Gilbertson, Nursing and Midwifery, Occupational and Environmental Health Research Group, Stirling, United Kingdom. Though many communities are exposed to high levels of methyl mercury, diagnosis of Minamata disease remains problematic because of a lack of pathognomonic endpoints at any level of biological organization. There are similar difficulties in diagnosing effects of methyl mercury exposures in other vertebrate species. Health Canada, as part of its responsibilities under the Great Lakes Water Quality Agreement, compiled health data and statistics for more than 70 health endpoints that "might be associated with exposures to Great Lakes pollutants." One of the health endpoints was cerebral palsy because of the association with congenital Minamata disease. Neurological development in males is more susceptible to the effects of methyl mercury exposures than in females. The hospitalization rates for males in several Canadian Areas of Concern were markedly elevated compared to the rest of the Province of Ontario. Application of Hill's guidelines to these preliminary observations suggested that male hospitalization rates for cerebral palsy might be a reliable indicator of outbreaks of congenital Minamata disease from methyl mercury exposure in communities within jurisdictions that collect local, regional and national health data. This indicator could be used not only as an early warning of previously unsuspected outbreaks and as a measure of the effectiveness of fish consumption advisories but also as an evaluation of the effectiveness of regulatory action to prohibit discharges, and of remedial actions to remove mercury pollution from historic sources. This indicator based on functional deficits in humans might have application for identifying endpoints in other organisms exposed to high levels of methyl mercury.

296 Effects and fate of soil-bound TNT and RDX in selected native grass and forb species. E.P. Best, A.J. Torrey, Environmental Laboratory, U.S. Army ERDC, Vicksburg, MS; T. Smith, F.L. Hagen, Construction and Engineering Laboratory, U.S. Army ERDC, Urbana-Champaign, IL; J. Dawson, University of Illinois, Urbana-Champaign, IL. Explosives, including TNT and RDX have been released from military operations in the environment of military ranges. The long-term environmental impacts of exposure to elevated levels of these compounds are of concern. The U.S. Department of Defense recognized the need for information on the environmental impact of explosives and related compounds, and is involved in studies aimed at minimizing their environmental effects. Promising in-situ technologies for contaminated soils include phytoextraction—the use of plants to take up (accumulate) and remove contaminants from the soil—and phytostabilization—the use of both plants and soil amendments to prevent the contaminants from migrating from the source area. Either phytoextraction or phytostabilization or a combination of both would be cost-effective, aesthetically pleasing, and not disruptive of range use, but the fate and transport characteristics of energetics in vegetated soils must be understood before phytoremediation can be effectively used with confidence. We report on an ongoing study to advance the capabilities for phytoremediation of explosives-contaminated soil using native herbaceous plants. This study is composed by three phases. In the first phase, rapidly colonizing, resilient, and potentially explosives-tolerant grasses and forbs were identified through a literature review, followed by a short-term tolerance screening experiment. Based on these results, five grass and five forb species were selected for the second phase in which longer-term screening for explosives tolerance, degrading activity, and growth trait response is conducted. Dose-response experiments form the basis for the evaluation of the explosives toxic effects and fate. In the latter tests, plants are exposed for up to 90 days to explosives-spiked soil starting from seeds, and biomass production, root characteristics, and explosives parent compounds and degradation products will be determined. Once identified, two species, i.e., one with the highest explosives tolerance and one with the highest degradation capacity will be further characterized and explored for use in soil-based phytoremediation systems.

297 Comparative toxicity of TNT and RDX to the reproductive capacity of the earthworm *Eisenia fetida* in soils with contrasting physical and chemical characteristics. M. Simini, R.T. Checkai, R.G. Kuperman, C.T. Phillips, J.E. Kolakowski, U.S. Army Edgewood Chemical Biological Center, Aberdeen Proving Ground, MD. We investigated the comparative toxicity of 2,4,6-trinitrotoluene (TNT) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) to the reproductive capacity of the earthworm *Eisenia fetida* in five natural soils that vary in organic matter, clay content, and pH: Sassafra sandy loam (SSL), Teller sandy loam (TSL), Kirkland clay loam (KCL), Webster clay

loam (WCL), and Richfield clay loam (RCL). Earthworm reproduction tests (ISO 11268-2:1998) were performed with TNT or RDX that was weathered-and-aged (alternating wet/dry cycles for 10-14 weeks) in each of the five soils. We selected nonlinear regression models that fit earthworm data for TNT or RDX concentrations causing a 20% (EC₂₀) or 50% (EC₅₀) reduction in survival, total cocoons, and total juveniles. Preliminary results showed that EC₂₀ and EC₅₀ (EC₂₀:EC₅₀) TNT concentrations (mg/kg) for production of cocoons in the respective soils were: 4:12 in SSL; 26:35 in TSL; 6:9 in KCL; 27:42 in WCL; and 9:18 in RCL. Preliminary EC₂₀:EC₅₀ TNT concentration values (mg/kg) for total juveniles produced in the respective soils were: 3:9 in SSL, 6:20 in TSL, 1:4 in KCL, 19:33 in WCL, and 4:12 in RCL. Preliminary EC₂₀:EC₅₀ RDX concentrations (mg/kg) for production of cocoons in the respective soils were: 19:60 in SSL, 9:27 in TSL, 3632:9082 in KCL, 6:20 in WCL; and 8:24 in RCL. Preliminary EC₂₀:EC₅₀ RDX concentrations (mg/kg) for total juveniles produced in the respective soils were: 5:15 in SSL, 4:12 in TSL, 3:10 in KCL, 7:20 in WCL; and 9:29 in RCL. RDX toxicity to cocoon production was significantly less ($p < 0.05$) in KCL soil compared to the other soils. However, the respective EC₂₀ and EC₅₀ values for production of juveniles were not significantly different ($P < 0.05$) among all soil types. Correlation analyses did not show a strong relationship between respective ECp concentrations of TNT or RDX and soil organic matter, clay content, or pH, among soils tested

298 Uptake and Effects of Chronic Exposure to Metal and Energetic Materials on Earthworm Fertility and Metallothionein Accumulation. P. Robidoux, V. Bérubé, M. Blanchard, G.I. Sunahara, Biotechnology Research Institute, National Research Council Canada, Montreal, Quebec, Canada; P. Robidoux, M. Blanchard, Research Center for Environmental Toxicology, University of Quebec at Montreal, Montreal, Quebec, Canada. Several military training areas are contaminated by relatively high concentrations of metal and energetic materials (EM). Biological parameters such enzyme of detoxification may be used to assess the bioavailability of these contaminants. Metallothionein-like proteins (MTLPs) are a group of metal-binding proteins involved in metal homeostasis and in the protection against metal toxicity. Heavy metals such as Cd, Cu and Pb, are known to induce MTLPs in many species, including invertebrates. Organic compounds causing an oxidative stress can also affect the concentration of these proteins. Thus, the quantification of MTLPs in biological samples could offer an interesting tool in the evaluation of contaminant exposure (particularly metals) to soil invertebrates. In the present study, a highly sensitive method for MTLPs quantification from invertebrate extracts has been used. This method measures MTLP-SBD levels using a HPLC-UV detector. SBD-F (ammonium-7-fluorobenz-2-oxa-1,3-diazole-4-sulfonate) is a marker that links MTLPs following a derivatization reaction. Terrestrial earthworms (*Eisenia andrei*) were exposed to single metal-spiked soils, and soil samples contaminated by different metals and EM. Body burdens (bioaccumulation assessment) and MTLPs levels in tissues are compared to soil concentrations as well as standard chronic endpoints.

299 Toxicological Responses in the Western Fence Lizard (*Sceloporus occidentalis*) Following Oral Exposures of Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX). C.A. McFarland, M.A. Bazar, M.J. Quinn, M.S. Johnson, US Army / Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, MD; L.G. Talent, Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK. Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) has been widely used as an explosive in U.S. Army munition formulations since World War II. High production levels and widespread dispersal has resulted in considerable contamination of potential wildlife habitat on military installations and at Superfund sites. Many of these areas are used by reptiles; however, no data currently exist for exposure of this taxon to RDX. To estimate health effects for reptilian species, acute, subacute and subchronic oral toxicity studies were conducted using the western fence lizard (*Sceloporus occidentalis*). Oral LD₅₀ values (95% CI) for RDX in corn oil were 72 (49, 106) and 88 (65, 119) mg/kg body weight (BW) for male and female lizards, respectively. As in other studies, clinical toxicity of RDX in lizards identified the neurological system as the primary target following oral exposure. Central nervous system signs were observed within 12 hours of dosing and included depression/hyperactivity, tremors, ataxia and paresis, and intermittent generalized seizures. Initially, animals would become inactive and non-responsive to handling. Based on results from the acute tests, a 14-day subacute RDX study followed with lizards dosed orally (corn oil) at 0, 10, 20, 25, 30, 45, and 60 mg/kg BW-d. Reduced RDX dosing

concentrations were frequently associated with a characteristic body posture (i.e., tail extended, back arched dorsally, and forelimbs extended posteriorly against the body wall). A significant dose-survival curve was seen over the range of exposures in the subacute study; no lizards dosed ≥ 20 mg/kg-d survived to the end of the 14-day study. The number of survival days decreased significantly when comparing the 10 to the 20 mg/kg-d dose group (13.2 to 7.3). Blood and plasma chemistry analyses were unremarkable in the subacute study. Results from the 60-day subchronic exposures will also be presented.

300 A Review of RDX Toxicity in the Northern Bobwhite. M.J. Quinn, C.A. McFarland, M.A. Bazar, M.S. Johnson, Health Effects Research Program, U.S. Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, MD; E.J. Perkins, K.A. Gust, Engineer Research and Development Center, U.S. Army Corps of Engineers, Vicksburg, MS. A review of RDX toxicity in the northern bobwhite will be given with emphasis on the most recent sub-acute oral exposure study. Soil concentrations of the explosive 1,3,5-trinitro-1,3,5-triazine (RDX) at levels up to 14,000 mg/kg have been found at military installations. Although avian species represent an important wildlife class of management concern at many of these areas, very few studies have been performed to determine the effects of short and long term exposure to RDX. Due to their distribution in a variety of habitats at installations, birds are likely to experience short-term exposures to RDX on the order of days as opposed to weeks. As such, a 14-day exposure to RDX may provide more ecologically relevant toxicology data than longer term exposure scenarios. The objective of this study was to determine the sublethal effects from short-term, repeated oral exposures (gavage) of RDX in the northern bobwhite (*Colinus virginianus*). The northern bobwhite is a local ground foraging species and is a good representative of birds that are likely to be exposed to RDX through soil ingestion. Treatment levels, determined from previous oral exposure studies, were 0, 0.5, 3, 8, 12, and 17 mg/kg-d. Mortality was observed at doses higher than 3 mg/kg with clonic and tonic convulsions preceding death. Significant reductions in body weight were observed at doses higher than 8 mg/kg. The reductions in body weight were caused by a combination of significantly reduced feed consumption and severe and persistent diarrhea. Although no additional adverse effects were observed, this study offers further evidence for the development of tolerance to RDX exposure, as evidenced through weight gain and increased feed consumption in survivors. Additionally, this study reports a lower subacute mortality LOAEL (8 mg/kg-d) than initially reported from feeding studies.

301 Neurotoxicogenomic Investigation of RDX Effects on Fathead Minnow. K.A. Gust, E. Perkins, US Army Corps of Engineers, Vicksburg, MS; X. Guan, L. Escalon, SpecPro Inc., Vicksburg, MS; L. Yoo, CH2M HILL, Houston, TX; H. Wintz, University of California, Berkeley, CA. Cyclotrimethylenetrinitramine (RDX) is among the most extensively used explosives in the military. Production, usage, and disposal of RDX have led to environmental releases on military facilities. The chemical attributes of RDX are conducive for leaching to surface water which may put aquatic organisms at risk of exposure. RDX has been observed to elicit aberrant neuromuscular behaviors and neurotoxicity across a wide range of animal phyla. We investigated whether RDX exhibited similar effects in the Fathead minnow (*Pimephales promelas*) using a 4K brain cDNA microarray developed using suppressive subtractive hybridization PCR to enrich for differentially expressed genes resulting from RDX exposure. All cDNAs were sequenced and putative gene functions assigned using BLASTX. FHM were exposed to RDX in a dose-series (0.625, 1.25, 2.5, 5, 10 mg/L) and time-series (exposed to 5 mg/L for 1, 2, 6, 12 hours and 1, 2, 4, 6, and 10 days) experiments. Acute toxicity of RDX in fathead minnow occurred at relatively high concentrations (10 mg/L caused 50% mortality in a 10d bioassay). However, microarray experiments indicated significant alterations in gene expression patterns observed at RDX concentrations as low as 0.625 mg/L. Changes in gene expression patterns at sublethal concentrations of RDX did not readily reflect expression corresponding with lethal RDX concentrations. Gene expression patterns were observed to be highly gene-class specific and dynamic over time. For example, both alpha- and beta-hemoglobin subunit gene copy number were highly similar among fish exposed to 5 mg/L RDX relative to controls. Further, the expression pattern was characterized by a spike at 1h (~2-fold greater than control expression) then returning to control levels by 2d, suggesting acclimation at the sub-acute dose. At the 10 mg/L level of RDX, acclimation of hemoglobin expression was not observed. A reduction in mitochondrial cytochrome C oxidase expression was also observed and may have spurred the compensatory increase in expression of genes related

to oxygen transport (hemoglobin subunits) to mitigate toxicity. Above that threshold acute toxicity ensued.

302 Fate, toxicity, and bioaccumulation of explosives under realistic exposure scenarios in marine systems. G.R. Lotufo, US Army Engineer Research and Development Center, Vicksburg, MS; G. Rosen, W. Wild, Environmental Quality, SPAWAR Systems Center San Diego, San Diego, CA. It is anticipated that explosives will leak from underwater unexploded ordnance (UXO) over time, resulting in slow discharge of these chemicals into the surrounding water and sediment on a relatively localized scale. In this study, a realistic microcosm exposure scenario was utilized in order to improve the level of accuracy in assessment of risk associated with the presence of UXOs and munitions constituents (MC) in the marine environment. The fate of 0.5 g "chunks" of the common military formulation Composition B (59.5% TNT, 39.5% RDX, 1% wax) was determined in 20 L aquaria containing clean sediment and seawater over a period of 21 days, followed by the addition of marine amphipods (*Eohaustorius estuarii*, *Leptocheirus plumulosus*), polychaetes (*Neanthes arenaceodentata*), mussels (*Mytilus galloprovincialis*), fish (*Cyprinodon variegatus*), and solid phase microextraction fibers (SPMEs) for up to 10 days. In treatments in which the chunk was placed at the sediment surface and the overlying water was not exchanged, the concentrations of TNT (~0.5 mg L⁻¹) and RDX (~1 mg L⁻¹) in the overlying water reached an apparent plateau after a few days in the exposure, and were well below concentrations attainable given the MC loading. Overlying water concentrations were reduced by two thirds under a gentle flow (0.5 turnover day⁻¹), illustrating the dramatic reduction in exposure under rather conservative flow. Burial of chunks approximately 2 cm below the sediment surface resulted in nearly no release of explosives into the water column under both static and flow-through conditions. Mussel embryo-larval development success, among the known most sensitive endpoints to TNT, was negatively affected in the static, sediment surface-exposed treatments, where TNT concentrations approached previously reported thresholds for that test (EC50 = 0.750 mg L⁻¹), but was not affected in any other treatment. The fate, toxicity, and bioaccumulation associated with these exposure conditions will be presented and tissue concentrations will be related to recently developed critical body residues for these chemicals.

303 Ecotoxicological Assessment of Sediments from a CF Firing Range. P. Robidoux, V. Berube, C. Fournier, P. Bergeron, K. Kalomiris, J. Hawari, G.I. Sunahara, Biotechnology Research Institute, National Research Council Canada, Montreal, Quebec, Canada; C. Bastien, Centre d'expertise en analyse environnementale du Québec, Ministère du développement durable, de l'environnement et des parcs, Québec, Québec, Canada; B.A. Zajdlik, Zajdlik & Associates Inc, Rockwood, Ontario, Canada; I. Young, H. Fanous, Quality Engineering Testing Establishment, Department of National Defence, Gatineau, Québec, Canada. Some operational activities of the Canadian Forces (CF) such as firing practice and munition testing have led to the dispersion of energetic materials (EM) and metals in the Canadian environment. Sites contaminated by EM and metals may present a risk to humans and/or the ecological receptors. A CF Firing Range located on the St. Lawrence River, potentially contaminated by different EM (such as HMX, RDX and TNT) and metals, resulting from the presence of unexploded explosive ordnances (UXO) and/or historical contamination, was recently investigated. The general objectives of the study were to: 1) assess the effect of sediments (and pore water) on selected receptors (e.g., microphytes, macrophytes, invertebrates) using rapid and/or sensitive toxicity tools (e.g., Microtox SP, SOS Chromotest, *L. minor* growth test, *Hyalella* survival growth or reproduction, *L. variegatus* bioaccumulation test); 2) develop and characterize (chemistry and toxicology) artificial sediments, based on CF Firing Range sediment characteristics (particles size, organic matter), to use as a reference sample for comparison with CF field samples; 3) assess the effect of re-suspended sediments on selected receptors (e.g., Microtox, macrophyte *L. minor*, microphyte *Pseudokirchneriella subcapitata*) using elutriate samples; and 4) develop a bioaccumulation assay using freshwater mussel (*E. complanata*) and assess by exposure to selected sediment samples. This paper presents the approach, the selected toxicity tests and parameters of measurement as well as some key results.

304 Sediment Equilibrium Partitioning Benchmarks for Energetic Compounds: A Cautionary Note and Alternate Approaches. D. Jones, ARCADIS, Knoxville, TN; C. Lutes, ARCADIS, Durham, NC. The ecological risk assessment process uses ecological screening values (benchmarks) to identify constituents of potential ecological concern

(COPECs). The relative lack of sediment screening values for energetics and other polar non-ionic compounds has led to the use of the equilibrium partitioning (EqP) method for the derivation of benchmarks. That method is intended for use with organic compounds for which hydrophobicity dominates the pore water-to-particle partitioning relationship. However, other intermolecular forces may increase the partitioning to sediment particulates for compounds with a low octanol-water partition coefficient (log Kow), such that the EqP model may substantially overestimate the potential for exposure (and therefore risks). A recent EPA procedure for deriving EqP benchmarks states that this method should be applicable to nonionic organic chemicals with a Kow above 3.0. Yet some published sediment screening values include EqP benchmarks for nitroaromatic explosives and other chemicals with log Kow values less than 3. The resulting benchmarks are on the order of 10 to 100 parts-per-billion in whole sediment. The unrestricted use of such conservative benchmarks may lead to limited resources being wasted on detailed evaluations or remediation of spurious COPECs. Alternative approaches for evaluating sediment concentrations of energetic compounds include using literature-derived Kd values for similar systems, measuring site-specific pore water concentrations, and performing site-specific biological tests. Understanding the factors that influence partitioning of these compounds will help the risk assessor evaluate the uncertainties associated with the available benchmarks and alternative methods of evaluation.

305 Growth-promoting implants increase the toxicity of cattle wastes: you gotta beef with that? A.S. Kolok, M.K. Sellin, S.T. Gustafson, Department of Biology, University of Nebraska at Omaha, Omaha, NE; A.S. Kolok, M.K. Sellin, Center for Environmental Toxicology, University of Nebraska Medical Center, Omaha, NE; D.D. Snow, School of Natural Resources, University of Nebraska at Lincoln, Lincoln, NE; G.E. Erikson, Animal Sciences Department, University of Nebraska at Lincoln, Lincoln, NE. Recent publications in the popular literature have suggested that growth-promoting compounds used by the beef cattle industry pose a significant threat to aquatic ecosystems. The primary objective of this study was to compare the toxicity of wastes from trenbolone acetate: estradiol benzoate (TBA:E) implanted steers to that of wastes from unimplanted steers. To accomplish this objective, two experiments were conducted in which fathead minnows (*Pimephales promelas*) were exposed to urine or feces collected from TBA:E-implanted or unimplanted steers. In the first experiment, minnows were exposed for seven days to one of eight concentrations of fecal matter from either implanted or unimplanted steers, while in the second experiment, minnows were exposed to one of four concentrations of urine from either implanted or unimplanted steers. Following exposures, hepatic vitellogenin (vtg) mRNA expression was measured. Male minnows exposed to the highest concentration of fecal matter from implanted cattle experienced a significant increase in hepatic vtg mRNA expression relative to both unexposed minnows and minnows exposed to fecal matter from unimplanted cattle. This finding suggests that steroids associated with the implant have a feminizing effect on male fish. Exposure to urine caused a significant reduction in female vtg mRNA expression at each of the concentrations tested relative to unexposed females, regardless of whether the urine was from implanted or unimplanted cattle. Clearly this defeminization cannot be due to steroids in the implants, as it occurs in females exposed to urine from both implanted and unimplanted cattle. This defeminization is likely caused by an endogenous steroidal metabolite excreted via urine, such as progesterone. Overall, the findings of this study indicate the presence of endocrine-disrupting compounds in the urine and feces of cattle and suggest that implant history alters the steroidogenic activity of steer feces.

306 Distribution of Chemical Contaminants within a Large Wastewater Treatment Plant and in Downstream Surface Waters. T. Nettesheim, Great Lakes National Program Office, USEPA, Chicago, IL; L.B. Barber, J.L. Gray, USGS, Boulder, CO; L. Zintek, W. Whipple, Chicago Regional Laboratory, USEPA, Chicago, IL; C.P. Rice, Agricultural Research Service, USDA, Beltsville, MD; D. Lordi, Metropolitan Water Reclamation District of Greater Chicago, Chicago, IL; J.E. Loyo-Rosales, Department of Civil and Environmental Engineering, University of California, Berkeley, CA. Chemical Contaminants can enter the wastewater stream from commercial and residential wastewater, industrial effluent, or air deposition and runoff into urban stormwater drains. During the wastewater treatment process, these substances will be released back to the environment through the final effluent or biosolids product, recycled within the plant, or lost due to transformation or degradation. To better understand the fate and distribution

of chemical contaminants in a wastewater treatment plant, a study was recently performed on the Calumet Water Reclamation Plant in cooperation with the Metropolitan Water Reclamation District of Greater Chicago. Aqueous samples were collected of the influent, primary effluent, mixed liquor, final effluent, centrate, and various supernatants. Solid samples were collected of the primary sludge, waste activated sludge, primary digestion sludge, secondary digestion sludge, centrifuge sludge, lagoon sludge, and final dried sludge. These samples have been analyzed for mercury, PCBs, PBDEs, alkylphenol ethoxylates (APEs), hormones, pharmaceuticals and personal care products, and trace elements. Results of the 3 major sampling events will be presented.

307 Fate of Antibacterial Agents in Wastewater Treatment Plants and Transformation by Aqueous Chlorine. C. Huang, School of Civil & Environmental Engineering, Georgia Institute of Technology, Atlanta, GA. Investigations at a range of wastewater treatment plants showed that sulfonamide, trimethoprim and fluoroquinolone antibacterial agents were ubiquitous in wastewater effluents. The median concentrations of these antibacterials ranged from 0.13 to 0.59 micrograms per liter in the secondary effluents. Compared to the secondary treatment, microfiltration removed little antibacterials and UV disinfection did not affect sulfonamides. Chlorination and advanced treatment processes (i.e., granular activated carbon, ozonation, and reverse osmosis) were effective in removing the antibacterials. The removal of antibacterials by chlorination was investigated further at bench-scale experiments to elucidate how aqueous chlorine transforms the antibacterials. Reactions with aqueous chlorine resulted in rapid transformation of four very different structural classes of antibacterials (sulfamethoxazole, ciprofloxacin, enrofloxacin, trimethoprim, and carbadox), yielding a wide variety of lower and higher mass and chlorinated degradates. Reaction rates were highly pH dependent due to protonation/deprotonation of antibacterials' functional groups and chlorine oxidant. Investigations with sub-structure model compounds effectively identified the reactive functional groups of the antibacterials. The identities, evolution and distribution of reaction intermediates and products were determined using a combination of LC/MS, GC/MS, 1H-NMR, and other techniques. The potential in removing the biological activity of antibacterials was evaluated based on the knowledge of transformation products.

308 Fate factors and emission flux estimates for emerging contaminants in surface waters. C. Lastoskie, H. Trinh, P. Adriaens, Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI. Pharmaceuticals and personal care products are identified as emerging environmental contaminants because of their potential for endocrine disruption at a very low chronic exposure level. Lately, research has been conducted on the environmental occurrences of these emerging contaminants in water, soil, sediment and biota in European nations and the United States. This work reports an emission and fate assessment to characterize the potential environmental and health impacts of thirty compounds listed in the National Reconnaissance of the United States Geological Survey (USGS, 1999-2000) as the most frequently detected organic wastewater contaminants in U.S. streams and rivers. Analysis of the environmental fate and surface water concentrations of the thirty compounds was carried out using Level II (equilibrium) and Level III (non-equilibrium) multimedia fugacity models for a 1000 km² model environment, the size of a typical county in the eastern United States. For the non-equilibrium fugacity model, two emission scenarios were considered: one in which release to the environment occurs by discharge of treated wastewater effluent to surface waters, and the other in which emission into the environment occurs by land application of dewatered sludge. The thirty compounds are categorized into three groups based upon the sensitivity of their predicted surface water concentrations to uncertainties in their physicochemical property values and landscape parameters. For the first group, the surface water fate factor is most sensitive to the sediment-water partition coefficient; for the second group, the air-water mass transfer coefficient is the controlling factor; and for the third group, the aqueous phase degradation half-life is the most significant input parameter. For this latter subset of compounds, it is observed that conventional treatment strategies such as air stripping or adsorption on activated carbon may be ineffective for their removal from wastewater. The environmental fate factors, mass distributions, and loss pathways of the compounds are strongly affected by their mode of entry into the environment. From a comparison of surface water fate factors predicted by the fugacity models and the concentrations measured in the USGS reconnaissance, emission flux estimates for the thirty contaminants into U.S. streams and rivers are reported.

309 Application of wastewater sludge (biosolids) on forestlands. R. Hale, D. Luellen, E. Harvey, E. Bush, M. Mainor, G. Mears, Environmental & Aquatic Animal Health, Virginia Institute of Marine Science, Gloucester Point, VA. Residual constituents in wastewater effluents have been identified that have endocrine disrupting potentials. Some partition favorably to solids and hence may accumulate in sludge. Stabilized sludge (biosolids) is increasingly used as an agronomic amendment due to high N, P and organic matter contents. Sludge application has been the focus of recent concern due to reports of associated human illnesses and potential for environmental degradation. The original risk assessment, underpinning the CFR503 regulations governing application, did not consider emerging contaminants such as personal care products, pharmaceuticals, flame retardants and detergent degradates present in biosolids. In addition, the application scenario generally evaluated considers sludge soil-incorporation, resulting in reduced potential for exposure and >100-fold dilution. Application on managed forests is also increasing. In these situations sludge may be flung or sprayed, resulting in a veneer on trunks, foliage and soil. This material is more available for contact with wildlife. Exposed organisms include terrestrial (e.g. soil organisms, mammals and birds), aquatic or semi-aquatic species (e.g. inhabitants of vernal pools such as amphibians). Persistent, bioaccumulative pollutants, such as polybrominated diphenyl ethers (PBDEs), may be particularly problematic

310 Octyl- and nonylphenol ethoxylates and their transformation products in the Back River, Maryland. J.E. Loyo-Rosales, Civil and Environmental Engineering, University of California, Berkeley, Berkeley, CA; A. Torrents, Civil and Environmental Engineering, University of Maryland, College Park, College Park, MD; C.P. Rice, Environmental Management and Byproducts Utilization Laboratory, U.S. Department of Agriculture, Beltsville, MD. The Back River is a sub-estuary of the Chesapeake Bay that receives effluent from a wastewater treatment plant (WWTP) and urban runoff from the metropolitan area of Baltimore, MD. In order to study the fate of the alkylphenol ethoxylates (APEOs) and their transformation products, including those that have been found to be weakly estrogenic, the concentrations of nonylphenol and octylphenol ethoxylates (NP1-16EO and OP1-5EO respectively), nonylphenol (NP), octylphenol (OP), and the carboxylated derivatives NP1-2EC and OP1EC were measured in water samples collected in the Back River and the WWTP effluent in September and October 2004, and in March 2005. In all sampling events, the most abundant of the alkylphenolic compounds (APEs) were the carboxylates (APECs, > 95%), followed by NP in September and October, and NP1-2EO in March. NP concentrations found in this study, $0.087 - 0.69 \mu\text{g/L}$, were below acute toxicity thresholds, and generally below the U.S. EPA water quality criteria; although in March concentrations were approximately 30 to 50% of the chronic exposure limit ($1.4 \mu\text{g/L}$) for saltwater. Total NPE concentrations in the estuary seemed to be a function of the concentrations in the WWTP effluent, especially in the case of the APECs. However, a closer analysis of the data suggested that in the fall sampling events, when rain occurred, the long-chain ethoxylates present in the particulate matter originated in the river's tributaries carrying urban runoff and not in the WWTP.

311 Survey of PBDEs in Biosolids and Soil from Farms that Receive Biosolids Application. N.A. Andrade, A. Torrents, University of Maryland, Beltsville, MD; L. McConnell, United States Department of Agriculture, ARS, Beltsville, MD; M. Ramirez, District of Columbia Water and Sewer Authority, Washington, DC. Polybrominated diphenyl ethers (PBDEs) are persistent, hydrophobic, endocrine-disrupting chemicals which are used as additives in a variety of consumer products for their fire-retardant properties. While significant efforts are underway to determine concentrations in wastewater and biosolids samples, little is known on their fate throughout the wastewater treatment plants (WWTPs). As the wastewater moves through primary and secondary treatment processes, PBDEs are concentrated in the resulting biosolids. In the U.S., biosolids are often used as soil amendments in agriculture. The objective of this study is to examine the potential fate of selected PBDE congeners in soils treated with biosolids. Surface soil samples were collected from thirty fields at eleven commercial farms in the Mid-Atlantic region. Eleven fields had never received biosolids, ten had received a single biosolids application, and nine fields received multiple applications over the past five to fifteen years. All the fields were used for pasture with the exception of two fields. The Mid-Atlantic WWTP which is the source for the biosolids utilized on all fields receives influent from both industrial and residential communities. Concurrently, PBDE congener concentrations were

measured over 8 months in surface soil from a field (2954 m²) which received a known application rate of biosolids from the same WWTP. High spatial resolution sampling from this experimental field will allow for an examination of variability in soil concentrations. Biosolids samples from the source WWTP were also collected every two months over one year to evaluate typical PBDE concentrations. The preliminary data shows that the concentration of PBDE congeners in biosolids are consistently higher than the concentrations in soil samples. In addition, the data shows that after two weeks after biosolids application the concentration of PBDEs remains approximately constant and the background concentrations vary a great deal depending on the location of the field and the number of biosolids applications received.

312 Nationwide Application Rates of Triclocarban and Triclosan on U.S. Soils from Sludge Recycling. T.R. Miller, J. Heidler, R.U. Halden, Center for Water and Health, Department of Environmental Health Sciences, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD. Triclocarban (TCC) and triclosan (TCS) are halogenated active ingredients of antimicrobial personal care products that persist during municipal sewage treatment and are subsequently distributed onto agricultural fields as well as into aquatic environments as a result of municipal sludge recycling and, to a lesser degree, wastewater reclamation. We are conducting a nationwide mass balance for these biocides and other suspected endocrine disruptors in wastewater treatment plants across the United States using volumetric flow data and results from isotope dilution liquid chromatography (tandem) mass spectrometry. This multi-year study includes influent, effluent and sludge samples obtained from multiple wastewater treatment plants (WWTPs) in more than a dozen states, representing a wide range of climates and sewage treatment strategies. Preliminary results indicate that, nationwide, levels of TCC are similar to TCS in influent (5.4 ± 4.2 and $7.0 \pm 6.1 \mu\text{g/L}$, respectively) and effluent ($0.5 \pm 0.4 \mu\text{g/L}$ and $0.2 \pm 0.2 \mu\text{g/L}$, respectively) and concentrations among WWTPs varied by less than one and two orders of magnitude in influent and effluent, respectively. A significant fraction of both compounds were sequestered into sewage sludge, where TCC was generally more abundant than TCS. Conservative estimates were obtained for the annual loading of TCC and TCS onto agricultural fields in the U.S. based on the reported land application rates of sewage sludge and concentrations of TCC and TCS in representative nationwide sludge samples. Study results indicate that both biocides are widely distributed in agricultural soils due to inadvertent annual, combined input rates of several hundred thousand pounds of active ingredient.

313 Fate of Triclosan and Triclocarban in Land-Applied Biosolids. N. Lozano, C.P. Rice, N. Andrade, L. McConnell, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, MD; J. Loyo-Rosales, Civil and Environmental Engineering, University of California, Berkeley, CA; A. Torrents, Civil and Environmental Engineering, University of Maryland, College Park, MD; M. Ramirez, Biosolids Management, DC Water and Sewer Authority, Washington DC. The heavily-used antimicrobials, triclosan and triclocarban, are commonly present in biosolids generated in waste water treatment plants. A common practice for handling biosolids is to use them as soil amendments. We have embarked on a cooperative study with a waste water plant in the DC metropolitan area to determine the presence of these contaminants in commercially run farms that have received multiple biosolids applications, some for more than 4 years. Soils from these sites are being examined to see what typical concentrations of triclosan and triclocarban are observed. Initial data suggest that the triclocarban is more recalcitrant than triclosan. These data are being compared to a control site where no biosolids have been applied. Additionally results for a timed study will be reported where biosolids with known levels of triclosan and triclocarban were applied and soils are being sampled and analyzed over time in order to determine their fate.

314 Modeling the exposure of engineered nanoparticles in the environment. B. Nowack, N. Mueller, B. Wuertth, C. Som, Empa-Materials Science and Technology, St. Gallen, Switzerland. Assessing the risks of engineered nanoparticles in the environment requires an understanding of their mobility, reactivity, bioavailability, persistency and toxicity. A lot of research is currently devoted to these topics. This basic knowledge is needed but is not sufficient to allow for a realistic risk assessment of nanoparticles in the environment. It is also necessary to make an evaluation of the expected quantities and concentrations of nanoparticles in environmental systems. To date nothing is known about this issue, neither from an analytical point of view (e.g. actual measurements of nanoparticles in the environment) nor

with respect to theoretical or modeling studies. The aims of this project were to assess potential forms and quantities of released nanoparticles (exposure scenarios) from a life-cycle perspective of nanoparticle-containing products and model the expected concentrations of nanoparticles in environmental media (particularly water and soil). The focus was mainly on three types of engineered nanoparticles: nano-Ag, nano-TiO₂ and carbon nanotubes. The expected concentrations of the three nanoparticles in different environmental compartments vary widely, determined by the different life cycles of the nanoparticle-containing products. The results of this study allow for the first time to make a realistic and quantitative risk assessment of nanoparticles in the environment.

315 Metal and Metal Oxide Nanoparticle Interactions with *Pseudomonas* Bacteria. P.A. Holden, A.M. Horst, A.C. Neal, J.H. Priester, Bren School of Environmental Science & Management, University of California, Santa Barbara, CA; P.K. Stoimenov, W.H. Suh, G.D. Stucky, Chemistry and Biochemistry, University of California, Santa Barbara, CA. Synthetic nanoparticles released into the environment are subject to transport and fate processes that depend on nanoparticle chemistry, size, morphology and environmental conditions. Interactions with bacteria are probable, including toxic effects and nanoparticle transformations. Our group is studying interactions of CdSe, TiO₂, and other metal oxide nanoparticles with bacteria cultured in liquid and solid media to simulate aquatic and soil environments. In experiments with *Pseudomonas*, toxicity is observed, as evidenced by longer lag times, slower growth rates, and lower yields, with the extent depending on nanoparticle chemistry, dose, and culture conditions. Generalizable stress responses are also observed, as indicated by dose-dependent shifts in virulence factor production. Nanoparticle breakdown, but also formation, are observed in some cases. Nanoparticles are observed to adhere to bacteria; bacteria also appear to interfere with nanoparticle agglomeration and to colonize aggregates. When considering releases of engineered metallic nanoparticles into the environment, the spectrum of interactions with bacteria including toxicity and propagation of toxic effects to larger scales, nanoparticle breakdown, and constituent metal sequestration and mobilization are important to understand.

316 Microbial Growth Affects Zinc Oxide Nanoparticle Structure and Toxicity. B. Neely, P.M. Bertsch, P.J. Morris, Marine Biomedicine and Environmental Sciences Center, Medical University of South Carolina, Charleston, SC; B. Neely, P.J. Morris, Hollings Marine Laboratory and Center for Coastal Environmental Health and Biomolecular Research, U.S. National Oceanic and Atmospheric Administration, Charleston, SC; J.P. Shields, Center for Ultrastructural Research, The University of Georgia, Athens, GA; A.G. Sutter, College of Charleston, Charleston, SC; D.W. Bearden, Hollings Marine Laboratory, National Institute of Standards and Technology, Charleston, SC; P.M. Bertsch, Savannah River Ecology Laboratory, The University of Georgia, Aiken, SC. As the production and use of nanomaterials increases, their concentration in the environment will also invariably increase. Previous research on nanoparticle (NP) toxicity to microorganisms has focused primarily on the acute (<5 h) effects of NPs. Since many manufactured NPs utilize counter-ions or functionalized surfaces for stability, exposure of NPs to growing cells across longer time courses may result in changes to NP structure and toxicity. To address this we have developed a model system to examine NP-microorganism interactions. Uncoated 4 nm manufactured ZnO-NPs were selected as our model NP. These NPs, commonly used in sunscreens, personal care products, and biological and chemical sensors, are one of the most diverse families of nanostructures. *Burkholderia vietnamiensis* PR1₃₀₁ (PR1), a Gram-negative constitutive TCE-degrader previously characterized by our laboratory for its resistance to divalent metals including Zn, was selected as our model microorganism. The manufactured ZnO-NP aqueous solution contained a high concentration of acetate (3.1 M) as a counter-ion and we determined that PR1 can utilize 10.7 mM acetate at pH 6 and 7. Additionally, in a series of growth-response assays we have found that at pH 6, the median effective concentration (EC₅₀) values of ZnO-NP and free Zn⁺² were similar at 159.9 ± 35.5 mg L⁻¹ and 148 ± 38.6 mg L⁻¹, respectively. At pH 7, the EC₅₀ of ZnO-NP and free Zn⁺² values were also similar at 66.67 ± 7.02 mg L⁻¹ and 64.80 ± 4.71 mg L⁻¹, respectively. In order to further investigate whether acetate utilization by PR1 affects ZnO-NP structure, TEM/EDX will be used to evaluate NP localization at 4, 8, and 24 h during growth of PR1. Additionally, acetate loss will be monitored to correlate changes in NP structure to loss of its counter-ion. These results will help develop a better understanding of the fate and toxicity of NPs released into the environment.

317 The geochemistry of ferric iron oxyhydroxide nanoparticles as a model for the fate and transport of nanomaterials in the environment. B. Gilbert, Earth Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA; C.S. Kim, Department of Physical Sciences, Chapman University, Orange, CA. Novel nanomaterials released into the environment will be subjected to numerous geochemical processes that may strongly affect their stability, effective reactivity, and the ultimate potential for human or organism exposure. In recent years, it has become more widely understood that natural nanomaterials are continuously created by microbial and abiotic processes. Thus, knowledge of the geochemical transformations of these natural substances may provide a paradigm for understanding the fate and transport of engineered nanomaterials. Ferric iron oxide and iron oxyhydroxide (FeOOH) nanoparticles are among the most common and important environmental nanomaterials, and are good candidates for providing insight into general features of the environmental impacts of transition metal oxide nanoparticles. Because of the redox activity of iron, FeOOH nanoparticles participate in numerous biogeochemical cycles, including microbial metabolism and photoreductive dissolution. Because of the high considerable sorption capability of iron (oxyhydr)oxide surfaces, FeOOH nanoparticles have the potential to either sequester or facilitate the long-range transport of many contaminants. Recent research on synthetic analogues of natural materials has contributed to a better understanding of the effects of particle size on these important areas. We studied how the small particle size affects the colloidal properties of FeOOH nanoparticles. We show that these nanomaterials in water exhibit unusual cluster forming behavior that is likely to affect aqueous transport but which does not significantly reduce the effective surface area for adsorption and surface chemistry. In addition, we discuss the application of new and established techniques of interfacial geochemistry to determine surface contributions to nanoparticle reactivity. Finally, we critically evaluate the premise that observations of the geochemistry of iron oxyhydroxide nanomaterials may be applied to other nanomaterials.

318 Panning for gold in terrestrial food webs: analytical approaches for examining bioavailability of metal nanoparticles. J.M. Unrine, L. Newman, S. Hunyadi, A. Willis, P. Bertsch, Savannah River Ecology Lab, University of Georgia, Aiken, SC; L. Newman, T. Sabo-Attwood, Department of Environmental Health Sciences, University of South Carolina, Columbia, SC; C. Murphy, Department of Chemistry and Biochemistry, University of South Carolina, Columbia, SC; A. Willis, Department of Environmental and Biological Sciences, Antioch College, Yellow Springs, OH. Few studies have investigated the potential for bioaccumulation and food chain transport of manufactured nanomaterials released to the environment. Among the studies that have examined bioavailability of metal containing nanomaterials in plants and wildlife, even fewer have explicitly demonstrated the accumulation of intact nanomaterials in tissues rather than accumulation of ions resulting from the oxidation and/or dissolution of the particles. Analytical techniques such as laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), synchrotron based x-ray microspectroscopy and liquid chromatography coupled to ICP-MS have been frequently applied to determine the chemical forms, binding and spatial distribution of trace elements in environmental and biological samples. These techniques also have the potential to compliment electron microscopy for examining the mechanisms of uptake, distribution, and fate of engineered metal nanomaterials. We have explored the potential utility of these techniques by examining bioaccumulation of nanosized Au spheres in earthworms (*Eisenia fetida*) and tobacco plants (*Nicotiana xanthi*). Our preliminary results have suggested that Au nanoparticles are potentially bioavailable to at least some terrestrial organisms and that particle size may be an important determinant of the extent of their uptake and distribution of among tissues.

319 Detection and measurement of semiconductor nanocrystals in aqueous solutions using DRC-ICP-MS. T.M. Ingle, Molecular Biosciences, Arkansas State University, State University, AR; L.O. Cox, R.E. Hannigan, Environmental Sciences, Arkansas State University, State University, AR; R.A. Buchanan, Arkansas BioSciences Institute, Arkansas State University, State University, AR. Because of their utility as fluorescence markers, the use of semiconductor nanocrystals (quantum dots) in biomedical applications has increased significantly. These nanoparticles contain the potentially toxic metals Cd and Se along with other metals. Unlike most carbon-based nanoparticles, commercially available aqueous soluble quantum dots are readily available. The low level of these metals combined with being highly soluble in water makes them difficult to detect at low concentrations in environmentally

relevant matrices including water and sediment. We developed techniques using Dynamic Reaction Cell™ inductively coupled plasma mass spectrometry (DRC ICP-MS) to detect Cd from semiconductor nanocrystals in aqueous solution. Water samples containing various concentrations (5-100ppt) of commercially available semiconductor nanocrystals (Qdots®) with carboxyl groups on the outer surface were microwave digested in ultrapure HNO₃ and H₂O₂. Standards were prepared by dissolving known amounts of Cd in 2% HNO₃. The cadmium in the resulting solutions was measured using a Perkin Elmer DRC II. Analyses were conducted using a sample flow rate of 1mL/min (Meinhard) with 6 replicates of 10 sweeps per sample. Measured mean intensities are concentration dependent and show that Cd from Qdots® at concentrations as low as 1 ppt can be measured. Keywords: Quantum dots, cadmium, nanoparticle detection

320 Bioavailability and toxicity of nanosized ZnO particles in the nematode *Caenorhabditis elegans*. H. Ma, P.L. Williams, Environmental Health Science, University of Georgia, Athens, GA; P.M. Bertsch, T.C. Glenn, J.M. Unrine, Savannah River Ecology Laboratory, University of Georgia, Aiken, SC. Manufactured nanosized ZnO structures and composites are currently used for a broad range of applications. Yet little is known concerning its bioavailability, toxicity, and potential for trophic transfer in the environment. In this study, we evaluated the bioavailability and toxicity of manufactured ZnO nanoparticles (1.2 nm diameter as determined by dynamic light scattering) as referenced to ZnCl₂ using the nematode *Caenorhabditis elegans*. The endpoints measured included lethality (LC50), behavior (EC50), metal spatial distribution and gene expression response. For lethality, 24h assays were conducted both with and without food. Zn spatial distributions within the nematodes after exposure to ZnO nanoparticles or ZnCl₂ were mapped using a synchrotron-based x-ray fluorescence microprobe (beamline X26A, NSLS, Brookhaven National Laboratory, USA). Behavior was evaluated by tracking the movement of nematodes after 4h exposure using a video camera interfaced with a Macintosh computer. A mtl-2:GFP transgenic strain of *C. elegans* with the metallothionein-2 promoter and GFP reporter was used to evaluate the gene expression response to ZnO nanoparticles and ZnCl₂. Results suggested that there was no statistical difference between ZnO nanoparticle and ZnCl₂ either in LC50s (n=6, p=0.29) or EC50s (n=3, p=0.59). Spatial distribution of Zn displayed similar patterns in nematodes treated with ZnO nanoparticles and ZnCl₂: at lower treatment concentration, Zn distribution was similar to control nematodes with most of Zn localized in posterior region of the organism; as concentration increased, Zn distribution spread throughout the organism. The maximum intensity of Zn was independent of treatment concentration, but was nearly twice as high in ZnCl₂ treated nematodes as in those treated with ZnO. This may suggest their different bioavailability. Both ZnO nanoparticles and ZnCl₂ induced GFP expression in the transgenic nematodes, and there was no significant difference in the magnitude of GFP intensity. Our findings suggested that ZnO nanoparticles showed similar toxicity and bioavailability in *C. elegans* as compared to ZnCl₂. Future work will focus on investigation of the mechanism of nano ZnO toxicity and bioavailability. Key words: ZnO nanoparticle, Bioavailability, Toxicity, *Caenorhabditis elegans*, Synchrotron X-ray microprobe

321 Laboratory biomonitoring to determine food chain transfer and aqueous toxicity of engineered nanoparticles. J.L. Bouldin, Ecotoxicology Research Facility, Arkansas State University, State University, AR; T.M. Ingle, R.E. Hannigan, R.A. Buchanan, Arkansas Biosciences Institute, Arkansas State University, State University, AR. Environmental fate of engineered nanoparticles is determined in part by their aqueous solubility. Rapid partitioning of particles from the water column provides a degree of safety by limiting aquatic transport. However, reasonable potential exists for environmental impact to aquatic systems by the release of highly soluble nanoparticles. Commercially available fluorescent semiconductor nanocrystals that contain toxic metals have the potential for detrimental environmental effects. Using US EPA test protocol and fluorescent microscopy the environmental fate of these particles may be assessed using standard aquatic test organisms. While no measured 48-h acute toxicity to *Ceriodaphnia dubia* was measured, fluorescence of these organisms increased significantly after a 4-h exposure to 200 ppt nanocrystals. Changes in fluorescence were time and dose dependent indicating particle uptake by *C. dubia*. Preliminary evidence of plant uptake was confirmed using *Raphidocelis subcapitata*. Chronic 96-h exposures revealed no measured toxicity and fluorescent microscopy suggests uptake by single-cell algae. Subsequent algal uptake by *C. dubia* dosed with

nanocrystals was used to indicate food chain transfer of such particles. Inductively coupled plasma mass spectrometry (ICP-MS) was used to detect and measure Cd and Se in organisms exposed to these nanocrystals at levels that routinely result in measured toxic endpoints. Although these results indicate that coatings present on nanocrystals provide a protective measure from toxic metals during laboratory exposures the potential exists for release of toxins following environmental degradation.

322 Fate and Toxicological Effect of Fullerene Ingestion in *Fundulus heteroclitus*. T.M. Blickley, B. Fair, D. Rittschof, Division of Marine Science and Conservation, Duke University Marine Lab, Beaufort, NC; T.M. Blickley, D. Rittschof, P. McClellan-Green, Integrated Toxicology and Environmental Health Program, Duke University, Durham, NC; P. McClellan-Green, Environmental & Molecular Toxicology, Center for Marine Science & Technology, North Carolina State University, Morehead City, NC. The appealing physical, chemical, and optical properties of nanomaterials has prompted their incorporation into many commercially-available products including cosmetics, sunscreens, sporting equipment, tires, and electronics. They are also being tested as diagnostic tools and therapies for cancers, diseases, and viral infections. Unfortunately, their success may be hindered by a lack of knowledge about the fate and toxicological effects of these materials and their degradation products. Our study investigates whether fullerene, a carbon-based nanomaterial, can be absorbed via ingestion, how it is distributed throughout the tissues, and whether reproductive effects including maternal transfer occur. Nine sexually mature mating pairs of *Fundulus heteroclitus* were fed food cubes containing de-ionized water (control), water-soluble fullerene (nC60), or raw fullerene powder (C60) for 5 weeks. No effects were observed in the number of eggs spawned between treatments and controls. Development and hatching success of embryos were not altered. Initial assessment of embryos for fullerene content indicated that maternal transfer does not occur via dietary exposure; however, traditional methods of fullerene extraction exhibit low recovery from lipid-rich embryonic tissues. A comparison of standard fullerene extraction methods versus other extraction techniques was done. Current methods employed for extraction of fullerenes (oxidizer plus toluene) resulted in up to 2% recovery of spiked material (nC60) from biological samples. The addition of glacial acetic acid increased the extraction efficiency by an additional 5-21% depending on the oxidizer being used. Extraction via a modified Bligh and Dyer lipid extraction protocol resulted in approximately 52% of the spike being recovered. This highlights the limitations of current methods for detection of unlabeled (non-fluorescent) nanomaterials and the difficulties investigators face when assessing distribution, fate, and toxicity.

323 The effects of duration and concentration of episodic zinc exposure to the fathead minnow, *P. promelas*. J.H. Bisesi, S.J. Klaine, Biological Sciences, Clemson University, Pendleton, SC. There are many waterways in the US that are listed as exceeding water quality criterion for zinc (Zn), but still support robust ecosystems. These apparent discrepancies provide uncertainty in the current method for water quality criteria development. In the environment, organisms often experience discontinuous exposure scenarios of varying duration and concentration from nonpoint sources during rain events. The current approach for development of water quality criteria uses acute exposure scenarios (e.g. 96h LC50) to examine the toxicity of substances. These continuous exposures often result in higher toxicity at lower concentrations. Therefore, water quality criteria are based on toxicity values that may not be environmentally relevant. The goal of this research was to examine if shorter, environmentally relevant, exposure durations, followed by a periods of recovery, had an effect on organism survival and growth. Fathead minnows were exposed to Zn concentrations of 100, 200, 400, 800, and 1600 µg/L for 1, 2, 4, 8, 12, and 24 hour(s) and then transferred to clean water and monitored for 21 days. Mortality and weight were taken as endpoints. Initial results have shown exposure duration does have an effect on mortality in concentrations higher than 200 µg/L.

324 Physiological Responses of Larval Fish to Episodic Copper Exposures. H.M. Zahner, S.J. Klaine, Clemson University Institute of Environmental Toxicology, Pendleton, SC. Over the past several decades the physiological mechanisms of copper toxicity on aquatic organisms have been well established. Ultimately, copper exposure results in a net loss of sodium from aquatic organisms, which if great enough, eventually leads to mortality. This toxic mechanism is the underlying assumption of the biotic ligand model, used to predict site-specific water quality criteria for copper. However, the BLM does not directly consider the mechanisms of copper toxicity when

calculating organism response. Paquin et al. (2002) proposed the sodium balance model, which would apply this physiologically based dimension to the BLM. This research presents the biochemical and physiological responses of larval fish to time-varying, episodic copper exposures. Lethal and sublethal responses of larval P. promelas to double pulses of copper were characterized during 21-day bioassays. Organisms were exposed to a combination of three copper concentrations (55, 110, 220 $\mu\text{g Cu/L}$), three exposure durations (3,6,9-hours), and four recovery times (24, 48, 96, 144-hours). There was a significant effect of pulse concentration and duration of the exposure on survival, whole-body sodium concentration, and time to recovery. There were no significant effects on growth. The biochemical mechanisms (Na/K-ATPase, carbonic anhydrase, and metallothionein) affecting whole-body sodium loss and subsequent recovery were also characterized. Results suggest that the first pulse exposure may induce a protective mechanism that alters the organisms' response to the second pulse exposure. This research provides the sodium balance data necessary to add a physiological component to the BLM.

325 Desorption and toxicity of copper following multiple flooding events from agriculture soils. T.C. Hoang, L.J. Schuler, E.C. Rogevich, G.M. Rand, L.A. Gladys, P.M. Bachman, Environmental Studies, Florida International University, North Miami, FL; E.C. Rogevich, Biological Sciences, Florida Atlantic University, Boca Raton, FL. In South Florida, the widespread use of copper (Cu) as a fungicide in citrus agriculture has resulted in elevated Cu concentrations in citrus soils. Under Comprehensive Everglades Restoration Plan, thousands of acres of agriculture land are scheduled to be flooded to maintain hydrologic buffer areas and create storm water treatment areas, water storage reservoirs and wetlands. This study examined the fate and effects of Cu in overlying water following multiple flooding events from field-collected citrus soils. Copper concentrations in these soils ranged from 5 to 234 mg/kg. The desorption of Cu from the flooded soils was examined over a 14-d period. Flooding events were repeated four times with a 7-d drying period between each flood event. Copper concentrations and water hardness, DOC, pH, alkalinity in overlying waters were measured multiple times during each flooding. Additionally, the toxicity of the overlying water to aquatic organisms was also examined. Acute toxicity tests were conducted using overlying waters from the first flooding to characterize the effects of Cu on survival and growth of *Pimephales promelas*, *Daphnia magna*, *Hyalella azteca*, *Chironomus tentans*, and *Lemna minor*. Short-term sediment toxicity tests were conducted using *H. azteca* to the original field-collected soils and soils after four flooded events to characterize the effects of Cu on survival, growth, and Cu uptake. The 14-d Cu concentrations in the overlying water ranged from 9 to 364 $\mu\text{g/L}$ and were related to soil Cu and soil characteristics. Although, Cu concentrations in the overlying water exceeded Cu water quality criteria, there were no adverse effects on survival and growth of the test organisms due to high concentrations of dissolved organic carbon (up to 51 mg/L) and hardness (up to 204 mg/L CaCO_3) in the overlying waters. For the sediment toxicity tests, the original soils with high Cu concentrations significantly affected survival and growth of *H. azteca*. However, the effect was not found for soils after flooding for 4 times. Whole body Cu concentrations from 162 to 294 mg/kg in *H. azteca* were associated with significant reductions in survival and growth. Results of this study indicate that there is risk associated with flooding contaminated soils and route of exposure is an important consideration

326 A Quantitative Model of Metal-Mixture Toxicity to Aquatic Organisms. J.S. Meyer, ARCADIS U.S., Inc., Golden, CO; R.C. Santore, HydroQual, Inc., East Syracuse, NY; W.J. Adams, Rio Tinto, Magna, UT. In most aquatic ecosystems, metals occur in mixtures rather than alone. However, most regulatory guidance for metals (e.g., U.S. Environmental Protection Agency's aquatic life criteria) and most published models of metal toxicity to aquatic organisms [e.g., the biotic ligand model (BLM)] address toxicity only one metal at a time. Moreover, no model exists to quantitatively predict the toxicity of mixtures of metals that concurrently have dose-additive and response-additive mechanisms of toxicity. Instead, only semi-quantitative approaches based on toxic units of aqueous metal concentrations ($\text{TU}_{\text{aq}} = C_{\text{aq}}/\text{LC50}$, where C_{aq} is the aqueous concentration of the metal and LC50 is its median lethal concentration) are used; and that approach usually overestimates mixture toxicity. To remedy those shortcomings, we propose a quantitative model of the toxicity of mixtures containing a variety of cationic metals (e.g., Ag, Cd, Cu, Ni, Pb, Zn). The model concurrently accommodates metals that have the same (dose-additive) and different (response-additive) mechanisms of toxicity. The model incorporates dose-response relationships that are based on toxic units of tissue-residue concentrations of metals ($\text{TU}_{\text{tr}} =$

$C_{\text{tr}}/\text{LA50}$, where C_{tr} is the tissue-residue concentration of the metal and LA50 is its median lethal accumulation); therefore, the model is directly linked to current BLM calculations of tissue residues. We (1) test a key hypothesis that the slope of probit(mortality) vs. $\log_{10}(\text{TU}_{\text{tr}})$ for a given aquatic organism is the same for metals having the same mechanism of action, (2) demonstrate how sigmoid dose-response curves can erroneously lead to apparently less-than-additive, additive, or more-than-additive metal interactions, and (3) why a multi-metal, multi-site BLM is needed to account for the antagonistic metal-metal competition for binding to sites of toxicity on aquatic organisms.

327 Effects of hardness, alkalinity, and dissolved organic carbon on the toxicity of copper to the sensory systems of fish. D.H. Baldwin, T.L. Linbo, N.L. Scholz, Environmental Conservation Division, NOAA Fisheries/NWFSC, Seattle, WA; J.K. McIntyre, School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA; S.A. Hecht, Endangered Species Division, NOAA Fisheries/Office of Protected Resources, Lacey, WA. As a common non-point source pollutant detected in surface waters throughout the United States, dissolved copper is of increasing concern for watersheds and their stream-dwelling fish. Copper is toxic to fish and exposures to even low concentrations (e.g. 5 ppb) of copper have been shown to produce sublethal effects on fish, including disrupting sensory systems. The toxicity of copper can be affected by water chemistry parameters such as hardness, alkalinity, and dissolved organic carbon (DOC). The biotic ligand model (BLM) was developed to predict the effects of water chemistry on the toxicity of metals such as copper. However, the BLM is based on measurements of acute mortality and on the accumulation of copper at the gill and the effects of water chemistry on the sublethal toxicity of copper to the sensory systems of fish are not well characterized. The results of two recent studies examining the extent to which natural variation in water chemistry (hardness, alkalinity, and DOC) might protect against copper sensory toxicity will be summarized. Despite involving different sensory systems and species, the olfactory system of coho salmon (*Oncorhynchus kisutch*) and the lateral line of developing zebrafish (*Dania rerio*), the results of both studies were similar. Increasing water hardness or alkalinity only slightly diminished copper toxicity and increasing DOC provided some protection from copper toxicity to the sensory systems. Importantly, the decreases in copper toxicity with increasing hardness, alkalinity, or DOC seen in both studies were smaller than that predicted by the BLM. These results indicate that the current gill-based parameters of the BLM do not adequately describe the effects of water chemistry on copper toxicity in fish sensory systems. The role of these sensory systems in behaviors essential to fish survival highlights the potential need for the development of alternative BLM parameters.

328 The Effects of Water Quality and Age on the Acute Toxicity of Copper to the Florida Apple Snail, *Pomacea paludosa*. E.C. Rogevich, T.C. Hoang, G.M. Rand, SERC, Florida International University, North Miami, FL. Copper (Cu) containing compounds have been used in Florida as fungicides, herbicides, and soil amendments, resulting in elevated Cu in the aquatic ecosystem. The Florida apple snail (*Pomacea paludosa*), a key species in South Florida, may be adversely affected by Cu. Water quality parameters, such as hardness, dissolved organic carbon (DOC), pH, and alkalinity, affect metal bioavailability and toxicity in aquatic organisms; however, it is uncertain to what extent these factors affect Cu toxicity in the Florida apple snail. The following research characterizes the acute (96-h) toxicity of Cu to the Florida apple snail at various life stages and under different water quality parameters representative of Florida aquatic ecosystems. Cu toxicity decreased as organism age increased. There was no difference between the 96-h LC50 at pH 5.5 and 6.5, however, the 96-h LC50s at pH 7.5 and 8.5 were greater than at lower pHs. The decrease in Cu^{2+} above pH 7, as predicted by the MINTEQ model, accounted for the pH effect. Cu toxicity decreased as DOC increased from 0.2 to 30 mg/L. Unlike other aquatic organisms, hardness had no effect on Cu toxicity to the Florida apple snail, suggesting another mechanism of toxicity. Whole body tissue analysis indicated that 120-d-old snails exposed to lethal Cu levels accumulated up to 30 mg/Kg Cu dw. Multiple regression analysis indicated that Cu toxicity was a function of organism age, DOC and pH.

329 Metal stress to early life stages of the blue mussel and the role of modifying factors. S.R. Nadella, J. Fitzpatrick, C. Bucking, N. Franklin, C.M. Wood, Biology, McMaster University, Hamilton, Ontario, Canada. Marine water quality criteria for metals are largely driven by the extremely sensitive embryo-larval toxicity of *Mytilus trossolus/galloprovincialis*. In 48 h tests, metal-induced toxicity was calculated based on the proportion of live larvae with completely developed shells; deformed larvae exhibited incomplete shells,

protruding mantles and severe retardation. A salinity threshold of > 20 ppt (~ 60% full strength seawater) was required for normal control development. For dissolved metals in 100% seawater, nominal EC50 values were 7.5 µg L⁻¹ (Cu), 3.2 µg L⁻¹ (Pb), 100 µg L⁻¹ (Zn) and 200-500 µg L⁻¹ (Ni, Cd). Further, we evaluated the separate effects of Cu on egg and sperm viability and fertilization success, all of which proved less sensitive than development. Salinity in the 60 – 100% range did not appear to play a role in mitigating Cu toxicity. The influence of dissolved organic matter (DOM) from different sources on Cu toxicity is under evaluation. (NSERC-CRD & ICA; CDA; ILZRO; IZA; NIPERA; Noranda-Falconbridge; Teck-Cominco; Inco.)

330 Mechanisms of Copper Accumulation in Crab Gill Cells. C.L. Paganini, Pós-Graduação em Oceanografia Biológica, Fundação Universidade Federal do Rio Grande, Rio Grande, RS, Brazil; M.M. Souza, Departamento de Ciências Fisiológicas, Universidade Estadual de Londrina, Londrina, PR, Brazil; A. Bianchini, Departamento de Ciências Fisiológicas, Fundação Universidade Federal do Rio Grande, Rio Grande, RS, Brazil. The aim of this study was to evaluate the possible involvement of different mechanisms of ion transport on copper accumulation in isolated gill cells from the blue crab *Callinectes sapidus* acclimated to salinity 30 ppt. A combination of a fluorescence technique (Phen Green) with different pharmacological tools (amiloride, phenamil, furosemide, EIPA, SITS, bafilomycin A₁, ouabain, and acetazolamide) was used. The following mechanisms involved in gill Na⁺ and Cl⁻ homeostasis were evaluated: Na⁺ channel, Na⁺-K⁺-2Cl⁻ co-transporter, and Na⁺/H⁺ and Cl⁻/HCO₃⁻ exchangers. Three key enzymes involved in cellular osmoregulation were also analyzed: V-ATPase, Na⁺,K⁺-ATPase, and carbonic anhydrase. Data obtained clearly indicated that gill copper accumulation in the blue crab *C. sapidus* depends, directly or indirectly, of the activity of some ion transporters and enzymes involved in Na⁺ and Cl⁻ cellular homeostasis.

331 Explaining the bioaccumulation of sediment-bound metals to benthic deposit-feeding animals. Z. Turek, N.S. Fisher, Marine Sciences, Stony Brook University, Stony Brook, NY; G.A. Cutter, Oceanography Dept., Old Dominion University, Norfolk, VA. To evaluate the bioavailability of metals from contaminated sediments to benthic animals, we used gamma-emitting radioisotopes to determine the uptake of Cd, Cr, and As from pore water and surficial sediments collected in the Chesapeake Estuary to the polychaete *Nereis succinea*. The assimilation efficiency (AE) of ingested Cd ranged from 43.7% for freshly labeled sediment to 26.7% for 1.5 months to 15.7% for 3-month aged sediment; the assimilation of Cr and As also declined in aged sediment. The AEs of As and Cr in *N. succinea* correlated well to the fraction lost from sediment into simulated gut fluid, consistent with the idea that these metals must be in a dissolved form before they can assimilate into tissues. The metal AEs also matched their trophic transfer from sediment to worm. For example, As concentrations in surface sediment averaged 15.5 µg/g dry wt while in field-collected polychaetes they ranged from 3-5 µg/g dry wt (or 19-32% of the sediment value), compared to the measured AE for As (27.9% in 1.5-month aged sediment). We also assessed the assimilation of ingested metals as a function of their speciation in surficial sediment. Metal accumulation in *N. succinea* from pore water was generally found to be low relative to accumulation from ingested sediment. These and other experimental results will provide a mechanistic understanding of how sediment-bound metals bioaccumulate in benthic organisms.

332 Gene Expression Biomarkers of Intersexuality in the Amphibian, *Xenopus tropicalis*. A. Olmstead, J.J. Korte, K.K. Woodis, B.A. Bennett, G.W. Holcombe, P.A. Kosian, S. Ostazeski, S.J. Degitz, Mid-Continent Ecology Division, NHEERL, US EPA, Duluth, MN; B. Vallanat, J. Corton, Toxicogenomics Core, NHEERL, US EPA, RTP, NC. The development of intersexed gonads at metamorphosis in amphibian species has been reported in field samples as well as following exposure to endocrine-active compounds in laboratory assays. Current methodology of the assessment of intersexuality in amphibians is limited to histological means. Gonadal gene expression measured by quantitative PCR was investigated as an alternative to histology for identifying and quantifying intersex in the tropical clawed frog, *Xenopus tropicalis*. Candidate genes were chosen that exhibited a sexually-dimorphic expression in developing gonads by either a literature search or gene array analysis of gonadal tissue from tadpoles. The expression of a given gene would be used as a marker for the presence of either ovarian or testicular tissues. Baseline candidate gene expression levels over a range of gonad developmental time points (typically from NF stage 58 to 3 weeks post-metamorphosis) were first measured by quantitative PCR. The genes SOX3, CYP19, and MGC81029 exhibited greater expression levels in female gonads at NF stage

66 at 11, 750, and 13 fold higher copy numbers than male gonads at the same stage. DMRT1 was 3.1 times higher in expression in male gonads than female gonads at 6 weeks post-metamorphosis. Gonadal tissue from NF stage 66 tadpoles and six week post-metamorphic froglets were collected from tadpoles exposed throughout larval development (<24 hrs post-fertilization to NF stage 66) to model endocrine active chemicals: an estrogen (alpha ethynylestradiol), an androgen (beta-trenbolone), and an aromatase inhibitor (fadrozole). Measured gene expression profiles using candidate gene expression biomarkers indicated the development of intersexed gonads as well as complete sex reversal in some of these organisms. These results will be compared to histological results to compare the two techniques for examining intersexuality in developing gonads of *Xenopus tropicalis*.

333 Benzo(a)pyrene-induced expression of CYP1C1 and CYP1A proteins in *Fundulus heteroclitus*. L. Wang, W. Dong, C. Thornton, A. Hailey, K.L. Willett, Pharmacology and Environmental Toxicology, University of Mississippi, University, MS; A. Camus, Pathology, College of Veterinary Medicine, University of Georgia, Athens, GA. Our previous studies found constitutive and benzo(a)pyrene (BaP)-induced CYP1C1 mRNA expression in *Fundulus* embryos and adults. We have hypothesized that CYP1C1 may be involved in the molecular mechanisms of BaP toxicity by generating toxic intermediates. In order to study CYP1C1 protein expression and gene function, we made a CYP1C1 antibody which detected both recombinantly expressed CYP1C1 and CYP1C1 expression in control and BaP-exposed (15 day waterborne, 10 µg/L or 100 µg/L BaP) adult *Fundulus* tissues. By western blot analysis, 100 µg/L BaP-induced CYP1A by 2.2-fold and CYP1C1 3.6-fold in male livers. Immunohistochemistry (IHC) was performed on sections of BaP-exposed 3 month old fish and both CYP1A and CYP1C1 expression was detected in liver, kidney and gill. In order to further investigate the potential CYP1C1 expression in neoplastic tissue, liver tumors were initiated by exposing *Fundulus* fry at 6-8 dpf and again at 13-15 dpf for 6 hr to control, 0.5 mg/L BaP, 5 mg/L BaP, and 5 mg/L dimethylbenzanthracene (DMBA) treatment groups. Fish were euthanized after 8 months, necropsied, and examined for gross lesions. Livers were dissected, processed routinely, and stained with hematoxylin and eosin for microscopic evaluation. Histopathologic findings included the presence of foci of cellular alteration (eosinophilic foci) and hepatocellular carcinoma. IHC will be used to further quantitate CYP1 expression in the BaP or DMBA induced liver lesions. Our results suggest that teleost CYP1C, in addition to CYP1A, is inducible by BaP, and should be further investigated for its role in carcinogen bioactivation. This project is supported by NIEHS funding: R01ES012710.

334 Variance of tandem repeat mutation rates among families and stages of spermatogenesis in the Japanese medaka exposed to ionizing irradiation. O. Tsyusko, T. Glenn, K. Aizawa, Y. Yi, D. Coughlin, K. Jones, T. Hinton, Savannah River Ecology Lab, University of Georgia, Aiken, SC; J. Zimbrick, Environmental and Radiological Health Sciences, Colorado State University, Fort Collins, CO. Different cell types and different families of outbred organisms have different levels of sensitivity to radiation. Mutation rates of simple tandem repeats (STRs, also known as microsatellites) were chosen as the endpoints for studying individual variation in radiosensitivity among families and cells involved in spermatogenesis. Japanese medaka (*Oryzias latipes*) was used as the model fish and, consistent with our previous studies, showed a large variation in mutation rates of STRs among individual families in response to irradiation. To test whether the observed variance was due to variation in mutation rates among different stages of spermatogenesis we performed the following experiment. The baseline mutation rates were measured in offspring of unirradiated breeding pairs of medaka. The same pairs of fish were then exposed to four levels of acute irradiation (0 – 5 Gy). The offspring were grouped according to the stages of spermatogenesis based on the number of days following fertilization after irradiation. Mutation rates of STRs calculated before and after irradiation vary significantly not only among treatments and families, but also stages of spermatogenesis within each family. These results indicate the importance of taking into consideration the stages of the spermatogenesis when studying the effects of ionizing radiation. This finding is also applicable when estimating effects of radiation therapy on induction of germline mutations that can be passed to future generations.

335 Exposure to TCDD during embryonic development and gonad differentiation impairs reproductive capability of zebrafish. T.C. King Heiden, W. Heideman, R.E. Peterson, Molecular and Environmental Toxicology Center, UW-Madison, Madison, WI; J. Spitsbergen, Marine and Freshwater Biomedical Sciences Center, Oregon State University, Portland,

OR. Fish larvae are among the most sensitive vertebrates to the toxic effects of TCDD, and it is thought that exposure to such toxicants may have reduced recruitment of certain wild fish populations. However, little is understood regarding the impacts of sublethal TCDD exposure during early development on the health, survival and reproductive capability of adults. Here we use zebrafish to determine whether transient exposure to sublethal concentrations of TCDD during early development induces such latent toxicity in adults. Zebrafish were exposed to graded concentrations of TCDD (0, 25, 50, 100, 200 and 400 ppt) via waterborne exposure for 1 h/week from 0-7 weeks of age. Survival one week after TCDD exposure was not affected; however, larvae within the 100-400 ppt TCDD groups showed reduced growth and swimbladder inflation. Larvae in the 400 ppt TCDD group also showed classic signs of TCDD developmental toxicity. TCDD dose- and time-dependent increases in mortality were observed, and only zebrafish in the 25 and 50 ppt TCDD groups survived past juvenile stages. While these lower dose TCDD-treated fish did not show altered growth or overt signs of toxicity as adults, some had shorter jaws and minor fin necrosis. Histopathology revealed that the liver, heart, boney structures in the head (i.e., operculum) and gonad exhibited TCDD toxicity. Exposure to 25 ppt TCDD impaired reproductive success. Egg production was reduced by approximately 60% and fertilization success by 8%. Offspring from 25 ppt TCDD treated fish showed increased mortality at 24 and 120 hpf. Surviving larvae showed a 5% reduction in growth, 27% increase in blue sac syndrome, and 80% failed to inflate the swimbladder. TCDD treated males contributed more than females to impaired reproductive capacity, while both TCDD treated males and females likely contributed to poor offspring survival. These findings support the hypotheses that exposure to sublethal levels of TCDD during early development and gonad differentiation can adversely affect health and reproductive capability of adult zebrafish. These sublethal, adverse effects on reproduction of adults and health of their offspring may contribute to population declines for the most TCDD sensitive fish species. (Supported by UW Sea Grant and NIEHS).

336 Exposure of zebrafish embryos to the dithiocarbamate sodium metam results in transcriptional perturbation during somitogenesis and abnormal development of the peripheral nervous system. E. Tilton, Environmental and Occupational Health Sciences, University of Washington, Seattle, WA; R.L. Tanguay, Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR. Dithiocarbamates (DTCs) share a common toxic effect on zebrafish development through an undetermined mechanism of action. The developmental toxicity resulting from exposures within the developmental period of somitogenesis results in obvious visible distortions of the notochord by 24 hours post fertilization (hpf). Protection of the notochord distortion has been shown by genetic rescue, pharmacological agents, metal chelating agents and AChE -/- mutant animals. We hypothesized that transcriptional changes during the critical window of somitogenesis would highlight the major targets of DTC exposure in the whole embryo. Zebrafish embryos were exposed to sodium metam beginning at 4 hpf (1000 cells) and total RNA was isolated from 80 embryos at the 3 somite (11 hpf), 10 somite (14 hpf), 18 somite (18 hpf) and larval (24 hpf) stages of development. Using the Affymetrix zebrafish gene arrays we observed remarkably few mRNAs differentially regulated at least 2-fold at each time point (11 hpf-104 genes, 14 hpf-151; 18 hpf-154; 24 hpf-26). Annotations of these transcriptional profiles lead us to investigate the impacts of DTC exposure on neuronal development. Comparing exposed and control whole embryos using antibodies specific for alpha acetylated tubulin and Zn12, we followed the development of the 'primary' neurons and the peripheral nervous system through the period when the notochord becomes distorted. In addition, transgenic animals that express the green fluorescent protein driven by a neural-specific beta tubulin promoter (NBT) were used to visualize motor neuron development. A clear perturbation of the peripheral nervous system and 'primary neuron' structure is apparent only after the notochord becomes distorted. Similarly, primary motor neurons have no overt structural abnormalities while those secondary motor neurons which develop after the notochord distortion were clearly abnormal. Taken together, early neuronal structural development is largely unimpaired from developmental exposure to sodium metam and is likely secondary to the notochord distortion caused by muscle contractions. A focus on neuronal function during development and early muscle regulation is warranted to more fully explore the mechanism underlying the developmental neurotoxicity of DTCs.

337 Comprehensive higher plant testing for OECD and ISO using LemnaTec image analysis. J. Vandenhirtz, M. Eberius, D. Vandenhirtz,

O. Esser, LemnaTec GmbH, Wuersele, Germany. The OECD guideline 227 (adopted 2006) "Terrestrial Plant Test: Vegetative Vigour Test" and the OECD guideline 208 (adopted 2006) "Terrestrial Plant Test: Seedling Emergence and Seedling Growth Test" are both used to test the influence of chemicals on higher plants. Depending on the chemical and its path into the environment the substances may be applied via spraying or be part of the initial soil mixture. In both cases growth and development of plants should be quantified to allow finally a quantitative measurement of inhibition or toxicity relative to an untreated control. As both test designs include dose response measurement there is a strong need for continuous quantitative data allowing the application of different kinds of statistics including calculation of EC values. Results and conclusions of the successful standardisation of the Duckweed growth inhibition test (OECD 221, ISO 20079) were included in a framework for a comprehensive and reproducible assessment of growth and effects of chemicals or environmental samples on plants. Based on Lemnatecs image processing reproducible non-destructive measurement allows both assessment of growth (and growth inhibition) and quantitative measurement of colour changes and changes in morphology. Due to the non-destructive measurement and the option to use growth rates or other optimised growth models even recovery studies are possible. Using conveyor belts to randomise plants in the greenhouse or larger growth chambers may additionally raise reproducibility of culturing conditions and results. Using quantitative non-destructive measurements can make higher plant testing very effective and reproducible opening new screening and assessment options including data needed for systems biology and other areas where higher plant data are widely missing to model ecosystems under stress. This includes e. g. automated watering to simulate defined drought stress and its effects in connection to chemical stressors.

338 *Daphnia magna* hemolymph metabolomics can distinguish between metal exposures. S. Chan, H. Poynton, C. Vulpe, Univ. of California, Berkeley, Berkeley, CA; K.L. Colson, J. Hicks, Bruker BioSpin Corp, Billerica, MA. Adult female *Daphnia magna* were exposed to 6µg/L copper, 18µg/L cadmium, 500µg/L zinc, and 820µg/L hydrogen peroxide, concentrations equal to the 1/10 LC50, for 24h. Following each exposure, approximately 1µl of hemolymph was extracted from each daphnid. Hemolymph was pooled from 12 daphnids for NMR analysis. Three biologic replicates and two technical replicates were used for each analysis. We utilized the Bruker Biospin Avance III spectrometer to collect NMR spectra. We were able to overcome the limited sample volume (7µl) and analyte concentration (sub millimolar) and identify robust and reproducible spectra for each condition. Furthermore, we were able to identify individual metabolites in the hemolymph by comparison with a database of spectra of metabolites. Principal component analysis using the AMIX program was used to analyze the data and demonstrated a complex spectrum with multiple principal components explaining 98% of the observed variance. Furthermore, these results suggest we are able to distinguish the different exposures on the basis of the metabolic profile of hemolymph. This study demonstrates the capability of monitoring *Daphnia magna* response to pollutant exposure via NMR spectroscopy. The development of NMR based methods will aid in the identification of novel biomarkers of exposure in *Daphnia magna* and other ecologically important organisms.

339 Social status modulates reproductive endocrinology and urine metabolite profiles in the fathead minnow males. D. Martinovic, D.L. Villeneuve, K.M. Jensen, L.S. Blake, M.D. Kahl, G.T. Ankley, Mid-Continent Ecology Division, U.S. EPA, Duluth, MN; D.R. Ekman, Q. Teng, T.W. Collette, Ecosystems Research Division, U.S. EPA, Athens, GA. The fathead minnow (FHM) is a valuable small fish model for genomic research in ecotoxicology. Recent studies have successfully used NMR-based metabolomic analyses to evaluate responses to endocrine disrupting compounds (EDCs) in urine of the FHM, but these initial results indicated an occurrence of substantial individual variation in urine abundance and metabolomic profiles. To improve use of FHM urine metabolomics for EDC research, we investigated whether one source of this variability could be male dominance status. Specifically, we hypothesized that social/territorial status may modulate endocrine-dependent processes (e.g., expression of androgen-dependent secondary sex characteristics (SSCs)), as well as urine abundance and endogenous metabolite composition. To formally test this, we paired two males with two females and one spawning substrate (for which males vigorously competed) and examined their behavior, SSCs and stored urine volume prior to and after territory acquisition. In addition, we measured

plasma androgen concentrations and androgen receptor mRNA transcript abundance in dorsal pad, and conducted NMR-based metabolomic analyses of urine once the territories/and social hierarchies were established. Our results show that circulating androgens, expression of SSCs, and urine abundance increase with territory acquisition and either remain unchanged or decrease in non-territorial, subordinate individuals. Metabolomic analysis using ¹H-NMR spectra of the urine samples clearly distinguished the metabolite profiles of territorial and non-territorial males. Some of the affected metabolites included taurine, creatine, trimethylamine n-oxide, lactate and choline. Differential release of taurine, a strong chemosensory attractant which modulates both aggressive behavior and osmoregulation (and possibly urine release), suggests that urine-borne taurine may serve as an "honest" signal of social status in males. In conclusion, we have identified one of the main sources of variability in urine abundance and metabolite composition in male FHM thereby providing important baseline data for interpretation of the effects of EDCs on fish. Furthermore, we have demonstrated that metabolomic studies are valuable for generating new hypotheses about behavioral and physiological processes. This work may not necessarily reflect official U.S. EPA policy.

340 Toxicogenomic profiling in Rainbow Trout *Onorhynchus mykiss*: are microarray studies environmentally relevant? S. Hook, I.R. Schultz, Batelle PNWD MSL, Sequim, WA. If cDNA microarrays are to be used as an effective tool in ecotoxicology, each contaminant must generate a specific gene expression profiles, these profiles must change with time and with dose, and the arrays have to be able to identify a chemical mixture. We have conducted a series of experiments to test these assumptions. In one study, isogenic (cloned) rainbow trout *Onorhynchus mykiss* were exposed to sublethal levels of a series of model toxicants with varying modes of action, including ethynylestradiol (xeno estrogen), 2,2,4,4-tetrabromodiphenyl ether (BDE-47, thyroid active), diquat (oxidant stressor), chromium VI, and benzo[a]pyrene (BaP) for a period of 1-3 weeks. An additional experiment measured trenbolone (model androgen) induced gene expression changes in sexually mature female trout. RNA was extracted and hybridized against GRASP arrays. The results indicate each toxicant exposure caused between 64-222 genes to be significantly altered in expression. Most genes exhibiting altered expression responded to only one of the toxicants and few were co-expressed in multiple treatments. In a second experiment, we examined changes in the genomic response during continuous exposure to ethynyl estradiol. Isogenic rainbow trout were exposed to nominal concentrations of 100 ng/L ethynyl estradiol for a period 3 weeks. At fixed time points within the exposure, fish were euthanized, livers and testes harvested and RNA extracted. Fluorescently labeled cDNA were generated and hybridized against the GRASP array. Our analysis indicates each exposure time period generated specific gene expression profiles. We exposed isogenic (cloned) rainbow trout *Onorhynchus mykiss*, to sublethal levels of individual ethynylestradiol (xenoestrogen), 2,2,4,4-tetrabromodiphenyl ether (BDE-47, thyroid active), and chromium VI or to a mixture of all three toxicants. Following exposure, fish were euthanized, livers harvested and RNA extracted. Fluorescently labeled cDNA were generated and hybridized against a commercially available the GRASP array. Our analysis indicates that the gene expression profiles resulting from the mixture exposure resemble those of the individual contaminant exposures, but are not a simple additive list. However, patterns of altered genes representative of each component of the mixture are clearly discernible, and the functional classes of genes altered represent the individual components of the mixture.

341 The Bioaccumulation Potential of PFCAs and Comparison With Persistent Lipophilic Compounds. R.A. Hoke, M.H. Russell, R.C. Buck, E.I. duPont de Nemours and Company, Inc., Wilmington, DE; J.M. Conder, ENVIRON International Corporation, Irvine, CA; W. de Wolf, DuPont Coordination Center, Mechlen, Belgium. Perfluorinated acids, including perfluorinated carboxylates (PFCAs) and perfluorinated sulfonates (PFASs), are environmentally persistent and have been detected in a variety of wildlife across the globe. The most commonly-detected PFAS, perfluorooctane sulfonate (PFOS), has been classified as a persistent and bioaccumulative substance. Similarities in chemical structure and perceived environmental behavior of PFOS and the PFCAs that have been detected in wildlife have generated concerns about the bioaccumulation potential of PFCAs. Differences between partitioning behavior of perfluorinated acids and persistent lipophilic compounds complicate the understanding of PFCA bioaccumulation and the subsequent classification of the bioaccumulation potential of PFCAs according to existing regulatory criteria. Based on available research on the bioaccumulation of perfluorinated

acids, four key points are highlighted in this review: 1) bioconcentration and bioaccumulation of perfluorinated acids are directly related to the length of each compound's perfluorinated carbon chain; 2) PFASs are more bioaccumulative than PFCAs of the same perfluorinated carbon chain length; 3) PFCAs with 7 perfluorinated carbons or less (perfluorooctanoate (PFO) and shorter PFCAs) are not considered bioaccumulative according to the range of promulgated "B" criteria of 1,000-5,000 L/kg; and 4) PFCAs with 7 perfluorinated carbons or less have low biomagnification potential in food webs. Especially for PFCAs with 7 fluorocarbons or less, the bioaccumulation potential of all perfluorinated acids appear to be several orders of magnitude lower than legacy persistent lipophilic compounds classified as bioaccumulative (e.g., PCBs, chlorinated pesticides, dioxins, etc.). Thus, although many PFCAs are environmentally persistent and some can be present at detectable concentrations in wildlife, it is demonstrated that PFCAs with 7 perfluorinated carbons or less (including PFO) are not bioaccumulative.

342 Bioaccumulation and biotransformation of 8:2 fluorotelomer acrylate in rainbow trout. C. Butt, S.A. Mabury, Department of Chemistry, University of Toronto, Toronto, Ontario, Canada; D. Muir, Water Science and Technology Directorate, Environment Canada, Burlington, Ontario, Canada. The occurrence of perfluorinated carboxylates (PFCAs) and sulfonates (PFASs) in wildlife and humans has been widely reported. Despite the apparently ubiquitous global presence, including remote regions, their source in biological tissues is not well understood. Recent studies have shown that precursor compounds can be biotransformed by rats and microbes to yield PFCAs and PFASs. The present study investigates the bioaccumulation and biotransformation of the 8:2 fluorotelomer acrylate (8:2 FTOH acrylate), a common monomer used in fluorotelomer based polymers. Fluorotelomer based polymers are incorporated into many commercial products for their stain repellency properties. Further, fluorotelomer based monomers are expected to be present in the environment from residuals in commercial products. In the present experiment, juvenile rainbow trout were purchased from a local hatchery and exposed to the 8:2 FTOH acrylate via commercial fish food dosed at a concentration of 8.5 µg/g. Initial results from 28 day uptake phase show that the 8:2 FTOH acrylate was not detected in the trout liver during any time point, indicating the contaminant was not bioaccumulated. This suggests that the 8:2 FTOH acrylate was poorly accumulated from the food, hydrolyzed within the gut or metabolized very rapidly within the liver. Suspected metabolites of the 8:2 FTOH acrylate were detected in the liver, including perfluorooctanoate (PFOA), 8:2 fluorotelomer acid (8:2 FTCA) and 7:3 fluorotelomer acid (7:3 FTCA). In addition, the conjugated metabolite, 8:2 FTOH glucuronide was detected in the feces. These results indicate the biotransformation of the 8:2 FTOH acrylate may be a source of PFCAs in wildlife.

343 Analysis of Perfluorinated Compounds (PFCs) in Fish Fillet Homogenate by Liquid Chromatography and Tandem Mass Spectrometry. A. Delinsky, M. Strynar, A. Lindstrom, Environmental Protection Agency, Research Triangle Park, NC; J. Varns, NCBA Inc, SEE Program, Durham, NC; S. Nakayama, ORISE, Oak Ridge, TN; X. Ye, NIEHS, IRTA Fellow, Research Triangle Park, NC. Human exposure to perfluorinated compounds (PFCs) is of concern due their widespread presence in human blood and their toxicity in experimental animals. A likely route of human exposure is dietary ingestion of fish which are known to bioaccumulate PFCs (e.g. fish liver). A new method was developed for the analysis of PFCs in fillets, the portion of fish usually consumed. The PFCs measured in this study included three perfluorinated sulfonates (PFBS, PFHS, and PFOS) and the C₆-C₁₂ perfluorinated carboxylic acids. Fish fillet homogenate was digested overnight in 0.01N sodium hydroxide in methanol. An aliquot of this extract was diluted 10-fold with water and then purified and concentrated using solid phase extraction. The analysis was performed by LC/MS/MS. Preliminary data were obtained using blank quality control material (*Tilapia aurea*) spiked with varying levels of the PFCs. The LOD was 1 ng/g PFOS and 0.1-1ng/g for the remaining 9 PFCs. Inter-day accuracy measurements were between 79% and 95% for all 10 target PFCs and inter-day precision values (%CV) were 10% or less for all compounds. The method was evaluated in a small pilot scale study involving sunfish (*Lepomis* sp.) collected from the Haw and Deep Rivers in Central North Carolina in 2006. Sunfish from the Deep River (n=5) had average PFOS concentrations of 99±43 ng/g fillet compared to an average of 33±3.1 ng/g fillet (n=3) from the Haw River. Fish from both rivers contained measurable amounts of the C₁₀-C₁₂ perfluorinated carboxylic acids with concentrations (ng PFC/g fillet) ranging from 1.3-29 in the Deep River

and 6.9–32 in the Haw River. The preliminary data indicate that the current analytical method for PFCs in fish fillet is accurate, precise, and applicable to sunfish samples. Further evaluation of this method with other freshwater species is currently underway. Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

344 Perfluorinated Carboxylic and Sulfonic Acids and Sulfonamide in Fish Tissues. M. Hamilton, L. Haviland, B. Surridge, Axys Analytical Services Ltd., Sidney, British Columbia, Canada. Data will be presented for the analysis of perfluorinated compounds in fish from various locations around North America. The analytical method used for quantification of C4 to C12 carboxylic acids, C4 to C8 sulfonic acids and perfluorooctanesulfonamide (PFOSA) employs multiple isotopically labeled analogues as internal standards, solid phase extraction and LC/MS/MS analysis. Comparison of the performance of this method to the MTBE/ion pair extraction method will be presented. Data for the analysis of over 200 fish samples from sites around North America will be presented. The sample collection sites range from pristine environments to heavily urbanized and industrial areas. Fish livers, fillets and whole body samples are included in the data set.

345 Temporal Trends of Perfluorinated Carboxylic Acid Isomers in Lake Ontario Lake Trout and Niagara River Suspended Sediments Indicate a Shift in Source Inputs. V.I. Furdui, S. Mabury, Department of Chemistry, University of Toronto, Toronto, Ontario, Canada; V.I. Furdui, P.W. Crozier, C. Lucaci, E.J. Reiner, Laboratory Services Branch, Ontario Ministry of the Environment, Toronto, Ontario, Canada; P.A. Helm, Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, Toronto, Ontario, Canada; C.H. Marvin, Environment Canada, Burlington, Ontario, Canada; M. Whittle, Fisheries and Oceans Canada, Burlington, Ontario, Canada; G.T. Tomy, Fisheries and Oceans Canada, Winnipeg, Manitoba, Canada. Perfluorinated compounds (PFCs) including perfluorinated carboxylates (PFCAs; C7-C15) and perfluorinated sulfonates (PFOS) were determined in retrospective samples of lake trout (*Salvelinus namaycush*) from Lake Ontario and suspended sediments from the Niagara River. Lake trout from 1979 to 2004 and suspended sediments collected at Niagara-on-the-Lake from 1980 to 2003 were analyzed. Perfluorooctane sulfonate (PFOS) was the most abundant PFC measured, with concentrations ranging between 7 and 95 ng/g (wet weight). A previously observed temporal trend observed for PFOS in lake trout was confirmed, although different samples and analytical methods were used. The PFCAs exhibited generally similar temporal variation, increasing to the mid-1990s, decreasing in the late-1990s, then a continued increase in the 2004 samples. Mean PFCA concentrations varied from 0.2 to 2 ng/g (wet weight), with the C9-C14 PFCAs generally more abundant than the C8 and C15 compounds. Branched isomers of the C11 and C13 PFCAs were detected lake trout, with early samples showing a greater abundance of the branched isomers, while the most recent samples indicate only linear C11 and C13 PFCAs are present. A confirmatory trend was observed for the suspended sediments collected from Niagara River. These data indicate that PFCs now entering the Great Lakes are produced primarily via the telomerization process, which produces linear PFC isomers, rather than by electrochemical fluorination which also results in formation of branched isomers.

346 Increasing Perfluorinated Acids in East Greenland Polar Bears (*Ursus maritimus*) - a new threat to the Arctic top predator. R. Dietz, F.F. Rigét, C. Sonne, Department of Arctic Environment, National Environmental Research Institute, Roskilde, Denmark; R. Bossi, Department of Atmospheric Environment, National Environmental Research Institute, Roskilde, Denmark; E.W. Born, Greenland Institute of Natural Resources, Nuuk, Denmark. Perfluorinated compounds (PFCs), such as perfluorooctanesulfonate (PFOS) and related compounds, have been identified as global pollutants and have shown their biomagnification into higher trophic levels in the food chain in remote areas such as the Arctic that are far from sources. In a circumpolar study of polar bears East Greenland has been identified as having some of the highest PFC concentrations. In this study temporal trends in the concentrations of selected PFCs were measured using archived liver samples of East Greenland polar bears. An age homogenized subsample of 128 subadult (3-5 years) polar bears was selected among 463 individuals from 19 sampling years within the period 1984-2006. Regression analysis of logarithmic transformed PFC mean concentrations indicated significant increasing concentrations over time in PFOS (5.2%), PFNA (6.4%), PFUnA (6.7%), PFDA (4.7%), PFTTrA (8.6%), PFOA (4.0%), PFDoA (5.2%) while PFOSA did not show any significant trend. For four of the PFCs (PFOS,

PFOSA, PFDA and PFTTrA) a non-linear (lowess smoother) model provided a more precise description of the temporal trend than the linear regression and showed an even steeper increase after year 2000. The 2006 means were: PFOS (2965 ng/n ww) was the major contributor to the burden of PFCs in the bears, followed by PFNA (206 ng/n ww), PFUnA (101 ng/n ww), PFDA (88.1 ng/n ww), PFTTrA (57.2 ng/n ww), PFOSA (25.2 ng/n ww), PFOA (14.0 ng/n ww) and PFDoA (12.5 ng/n ww). In 1984 the order and means were quite different being: PFOS (665 ng/n ww) > PFNA (27.5 ng/n ww) > PFUnA (17.1 ng/n ww) > PFOSA (8.7 ng/n ww) > PFOA (6.1 ng/n ww) > PFTTrA (5.7 ng/n ww) > PFDoA (5.3 ng/n ww). If the detected increasing trend in PFC concentrations continues, ΣPFC and PFOS concentrations, similar to those of PCBs causing adverse health effects in Baltic seals, will be reached within 2-3 decades. Perfluorohexane sulfonate (PFHxS) was not found in detectable concentrations in any of the samples.

347 Perfluoroalkyl Acids in the Egg Yolk of Birds from Lake Shihwa, Korea. H. Yoo, J.P. Giesy, Zoology, Center for Integrative Toxicology, Michigan State University, East Lansing, MI; K. Kannan, S. Kim, Wadsworth Center, New York State Department of Health and Department of Environmental Health Sciences, School of Public Health, State University of New York at Albany, Albany, NY; J.L. Newsted, Entrix, Inc., Okemos, MI; J. Khim, J.P. Giesy, Department of Biomedical and Veterinary Biosciences and Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; S. Kim, K. Lee, J. Lee, J. Lee, NeoEnbiz Co., Seoul, South Korea. Concentrations of perfluoroalkyl acids (PFAs) were measured in egg yolks from three species of birds collected in and around Lake Shihwa, Korea, which receives wastewaters from an adjacent industrial complex. Mean concentrations of perfluorooctanesulfonate (PFOS) ranged from 1.9×10^2 to 3.1×10^2 ng/g ww and there was a size-dependent accumulation of PFOS among species. Measured concentrations of PFOS were similar to those reported for bird eggs from other urban areas. Concentrations of longer-chain perfluorocarboxylic acids (PFCAs) were also measured in egg yolks of these species. Mean concentrations of perfluoroundecanoic acid (PFUnA) in egg yolks of the little egret (*Egretta garzetta*), little ringed plover (*Charadrius dubius*), and parrot bill (*Paradoxornis webbiana*) were 9.5×10^1 , 1.5×10^2 , and 2.0×10^2 ng/g ww, respectively. Perfluorooctanoic acid (PFOA) was detected in some samples (=32/44), but concentrations were 100-fold less than those of PFOS. The pattern of relative concentrations of PFAs in all three species were similar, with the predominant PFA being PFOS (45-50%) followed by PFUnA (25-30%). There was a statistically significant correlation between PFUnA and perfluorodecanoic acid (PFDA) in egg yolks ($r^2=0.54$). This suggests that fluorotelomer alcohols are important contributors to the presence of long chain PFCAs in bird eggs. Using measured egg concentrations as well as concentrations in the diet of the birds, the potential ecological risk of PFOS and PFAs to birds in Lake Shihwa was evaluated using the top-down and bottom-up approaches. Hazard quotients were similar between the two approaches. The 90th centile concentration of PFOS in bird eggs was 100-fold less than the lowest observable adverse effect level (LOAEL) determined for birds and those concentrations were 4-fold less than the suggested toxicity reference values (TRV). Current concentrations of PFOS are less than what would be expected to have an adverse effect on birds in the Lake Shihwa region.

348 Products from Aerobic Biotransformation of ECF-Derived Fluorochemicals Results in Similar Isomer Patterns as Parent Fluorochemical. C.C. Lange, Environmental Laboratory, 3M Company, St. Paul, MN, MN. Results from previous aerobic biodegradability testing with EtFOSE Alcohol demonstrated that less than 1% of the total biotransformation products formed can be as perfluorooctanoate (PFOA). As a result of this observation, it has been speculated that EtFOSE Alcohol-derived fluoropolymers may have been an indirect source of PFOA into the environment. Electrochemical fluorination (ECF)-derived products are traditionally complex as a result of both intra-molecular and inter-molecular rearrangements resulting in a mixture of branched and linear isomer products. Additionally, any longer and shorter chain homolog ECF byproducts possess a unique isomer pattern that may further distinguish them. This is in contrast to fluorotelomer-derived materials which are almost exclusively linear isomer products. Because of these distinct differences between ECF-derived and fluorotelomer-derived materials, it has been speculated that given the appropriate analytical separation technology these differences in isomer and homolog patterns could be used as potential molecular fingerprints to identify sources of these materials. However, it has also been suggested

that biological differentiation may occur during uptake and metabolism of fluorochemicals that could distinguish between branched and linear isomers (e.g. preferring linear isomers), thus limiting the ability to effectively use isomer distributions for source identification in the environment and in biological systems. Microbiological degradation of EtFOSE alcohol mimics the metabolism of higher organism with regard to the biotransformation products formed and thus can serve as an indicator of advanced metabolism. Our results show that microbiological biotransformation of EtFOSE alcohol does not distinguish from branched and linear isomers of the perfluorooctane moiety and that biotransformation products retain similar isomer profiles as the parent material. This was additionally qualitatively confirmed for any larger and shorter perfluorocarbon chain homologs present in this material, each of which has unique isomer patterns which were conserved with their respective biotransformation products. These results suggest that significant metabolic differentiation of linear versus branched perfluorocarbon isomers may not occur and molecular fingerprinting of isomer distributions may be a viable technique for environmental source identification.

349 Decline of perfluorooctanesulfonate (PFOS) and other fluorochemical concentrations in American Red Cross blood donors from 2000 to 2006. G.W. Olsen, J.L. Butenhoff, L.R. Zobel, Medical Dept., 3M Company, St. Paul, MN; D.C. Mair, Medical, American Red Cross, St. Paul, MN; T.R. Church, Environmental Health Sciences, University of Minnesota, Minneapolis, MN; M.E. Ellefson, W.K. Reagen, Environmental Laboratory, 3M Company, Minneapolis, MN. In 2000, the 3M Company voluntarily began phase out of the production of perfluorooctanesulfonyl-based products - used as surfactants, paper and packaging treatments and surface (e.g., textiles) protectants - after perfluorooctanesulfonate (PFOS, C₈F₁₇SO₃-) was reported in human populations and the environment. Ninety-percent of the production phase-out was accomplished by the end of 2000. The period of time since the phase-out exceeds the mean half-life of serum elimination for PFOS of approximately 5 years. This study compares PFOS 2006 blood levels in the general population to previously reported levels in 2000. In 2006, a total of 600 plasma samples were collected from 300 male and 300 female American Red Cross blood donors between the ages of 20-69 from six locations that were originally used to obtain 645 non-paired serum samples in 2000. Plasma and serum have been shown to be comparable matrices for analysis. Sample extraction was accomplished using solid-phase extraction columns. The final eluates were analyzed using high-pressure liquid chromatography interfaced with a triple-quadrupole mass spectrometer. The geometric mean of the serum plasma concentration in 2006 for the 600 samples was 14.5 ng/mL (95% CI 13.9 - 15.2) compared to 34.9 ng/mL (95% CI 35.5 - 40.3) for the 645 serum samples collected in 2000. The upper 95% confidence bound of the 95th percentile was estimated at 37 ng/mL in 2006 compared to 100 ng/mL in 2000. This decline in PFOS concentrations was similar by age, sex, and location and not due solely to the differences in analytical methods between 2000 and 2006. The comparable demographic and geographic decline in PFOS is consistent with the serum half-life of elimination in relation to the phase-out period, and suggests that reduction in related atmospheric exposures is an important explanation. Other plasma concentration declines were observed for N-ethyl perfluorooctanesulfonamidoacetate, N-methyl perfluorooctanesulfonamidoacetate, and perfluorooctanoate (PFOA).

350 Prospective Environmental Restoration / Restoration Up Front: An Incentive-Based Program to Increase Restoration Planning and Implementation in the United States. J. Liu, Corporate Remediation Group, DuPont Company, Schenectady, NY; R. Gouguet, Assessment and Restoration Division, Office of Response and Restoration, National Oceanic and Atmospheric Administration, Seattle, WA; R. Stahl, A. DeSantis, Corporate Remediation Group, DuPont Company, Wilmington, DE; M. Ammann, Chevron Energy Research and Technology Company, Richmond, CA. This presentation describes a concept known as prospective environmental restoration, restoration up front, or restoration banking. An innovative mechanism to increase the restoration and conservation of valuable ecological resources and habitats across the United States, the concept of prospective environmental restoration / restoration up front provides a way to estimate and utilize credits for ecological goods and services. It centers on the ability of an entity, public or private, to gain durable credits for undertaking proactive restoration activities. Once obtained, these credits can be applied to an existing liability, held in the event of a future liability, or traded or sold to others that might have need for the credits. Concepts similar to prospective environmental restoration / restoration up front include wetlands mitigation

banking, conservation habitat banking, and emissions trading. Much of the concept stems from the practice of natural resource damage assessment, although that is not the sole driver for the concept. The credits could be used to offset other environmental liabilities, for example, to provide habitat mitigation where development is being planned. In the case of a natural resource damage claim or response action, possessing or applying the credits does not negate the need for responsible entities to clean up spills or releases of hazardous substances or oil, or address their clean up requirements under applicable federal and state statutes. Prospective environmental restoration / restoration up front could reduce the time and costs associated with restoration and potentially lead to an increase in voluntary restoration and conservation nationally. Currently there are no state or federal regulations or policies that directly provide for this approach.

351 Use of a Novel Risk Assessment Approach as a Tool to Identify Locations for Remedial Investigation. A.M. Neigh, CDM, Inc., San Diego, CA; T. Marcum, J. LaVelle, CDM, Inc., Denver, CO; M. Allen, CDM Federal Services Program, Seattle, WA. The role of the HHRA in the remedial decision process can be ambiguous. Baseline human health risk assessments (HHRAs) are typically conducted during a remedial investigation (RI) phase to describe potential health effects of chemicals left in place and to select appropriate remedial technology. However, HHRAs can be used as a risk manager's tool to support risk management decisions earlier in the site evaluation process and identify the most appropriate response action for a site based upon site-specific risks. Because the site investigation (SI) phase typically collects limited data, a baseline HHRA is seldom employed as a diagnostic tool to assist the lead agencies making risk-based decisions regarding whether an RI is needed, or if a "no further action" decision could be made. For this reason a novel approach to risk assessment was used for seven sites at the Navy's Space and Naval Warfare Systems Center Old Town Campus (SPAWAR OTC). Because the sites are in use under Navy control, the goal of the SI was to provide the Navy with appropriate data for risk-based decisions regarding localized contamination and focus risk-based decisions on sites that could proceed to the RI phase. For each site a location-specific method was used to evaluate risk rather than the typical exposure area method. Because extensive data were not available to evaluate risk by the traditional exposure area approach, a location-specific method was adopted to support remedial decisions within the limitations of the SI phase data. The results of the HHRA suggested that five of the seven sites had manageable or negligible risks and met the requirements for no further action. At two sites, the HHRA indicated that a threat to human health may exist and progression to the RI phase was needed. Initiating a baseline HHRA in the SI phase has facilitated risk-based decisions and has focused the RI on the two sites with the most potential risk. However, because the location-specific method was novel to the regulatory agencies, several set-backs have slowed the remedial decision progress. Although the location-specific baseline HHRA can be practically applied early in the risk assessment process to eliminate sites from consideration that may not pass screening evaluations, indecision regarding interpretation of the data later in the remedial process may impede progress.

352 Restoration in a Contaminated Urban Waterway: If We Build It, They Will Come – But Is That Good? T. Brosnan, R. Mehran, E. Reinharz, L. Rosman, C. Alderson, Office of Response and Restoration, NOAA, Silver Spring, MD. Restoration in less-than-pristine areas or implementation of restoration projects prior to remediation of contaminated sediments can be a battle cry in the heavily urbanized and industrialized watershed of the Lower Passaic River in northern New Jersey. Local constituents have waited too long for restoration along this river and remediation of arguably one of the most contaminated waterbodies in the world may not happen soon enough. Development pressure along the river is strong, opportunities for restoration are limited and dwindling, and yet the potential for recontamination of restored areas (by unremediated areas, the remediation itself, and ongoing urban sources) poses a serious threat to receptors. Restoration planners are forced to weigh the pros and cons of restoring habitat in, and access to, a heavily contaminated river. They must also consider how soon restoration can safely occur, how much can be implemented, how it can be designed to minimize adverse impacts (e.g., attractive nuisance), and what benefits the project can provide. The arguments are strong both for and against restoration in contaminated urban rivers and "restoration before remediation." This presentation will explore the variety of challenges encountered when seeking to conduct habitat restoration in a Superfund site and in urban environments in general.

353 Remediation to Restoration Restoring Ecological Integrity after Sediment Remediation. D. Green, K. Rodriguez, GLNPO, USEPA, Chicago, IL. US EPA Great Lakes National Program Office is conducting ecological restoration work as a follow on to sediment remediation completed under the Great Lakes Legacy Act. In two projects, (Superior, Wisconsin and Muskegon, Michigan) we are developing an Ecological Restoration Master Plan, based on existing conditions analysis, data synthesis and public meetings. The Master Plan contains an assessment of current conditions, restoration goals and objectives, specific restoration actions, cost estimates, and an implementation schedule and timeline. During the course of the project, public input is crucial to define land use priorities among the diverse range of stakeholders. The master plan is intended to guide individual restoration projects. The projects in Superior, Wisconsin and Muskegon, Michigan are in Great Lakes Areas of Concern. The long-term goal is to eliminate the habitat related Beneficial Use Impairments (BUIs) and ultimately delist the site as an Area of Concern. In the presentation, in addition to talking about the ongoing projects, we will discuss lessons learned and propose ecological considerations that should be addressed during the sediment remediation phase. Presenters will be Danielle Green and Karen Rodriguez, USEPA Great Lakes National Program Office. Contact: green.danielle@epa.gov.

354 Using pulp and paper biosolids for the remediation of mine tailings: Assessment of the potential toxicity of biosolid-derived organic carbon to aquatic organisms. B. Vigneault, M. King, S. Krack, G. Prabhakar, B. Tisch, CANMET Mining and Mineral Sciences Laboratories, Natural Resources Canada, Ottawa, Ontario, Canada. Paper mill biosolids (sludge) are increasingly used for the remediation of mine tailings. However, the addition of biosolids-derived organic carbon may be toxic to aquatic species, especially at elevated concentrations. Leachate toxicity tests were used to assess the potential toxicity of biosolids-derived organic carbon (sludge from two Pulp and Paper mills). Both acute toxicity tests (rainbow trout and *Daphnia magna*) and sublethal toxicity tests (fathead minnows, *Ceriodaphnia dubia*, *Pseudokirchneriella subcapitata* and *Lemna minor*) were conducted. Neither of the two leachates were acutely lethal to the R. trout or *D. magna* at the highest concentration tested (i.e. 48h-LC50 or 96h-LC50 higher than 39 mg C / L). Therefore, based on the acute toxicity results, the addition of biosolids to the tailings will not affect discharge limits. In terms of sublethal toxicity, noticeable differences in sensitivity between the two leachates were observed for the test species. Overall, the reproduction of *C. dubia* reproduction was the most sensitive to the leachates, with a 7d-IC25 of 13 mg C / L for one of the leachates. Therefore, it is assumed that at low concentrations, i.e. few mg C / L range, the organic carbon derived from the sludge will actually reduce the sublethal toxicity of the mine site effluent through complexation of trace metals.

355 Are Ecological Receptors Sufficiently Site-Exposed To Matter? - What Deer Have To Say. L.V. Tannenbaum, U.S. Army Center for Health Promotion and Preventive Medicine, Aberdeen, MD. Terrestrial ecological risk assessments (ERAs) commonly evaluate receptors that have home ranges that far exceed the size of the contaminated sites in question. In those cases where the home range dwarfs the site size, opportunities are limited, if not non-existent, for the receptor to spend sufficient time contacting a contaminated area to develop toxicological endpoints (e.g., reproduction). To ensure that receptors are evaluated nevertheless, stakeholders may argue that receptors may be seeking out preferred areas, where considerable contaminated site contact can occur. Using the most sophisticated GPS-based animal-tracking equipment available to date, White-tailed deer, a commonly evaluated terrestrial species in ERAs, had their locations tracked hourly for an entire calendar year. The data reveal that actual deer home ranges far exceed the figures provided in the peer-reviewed literature. Additionally, although deer may have preferred locations, they do not spend sufficient time at these to justify legitimate ecological health concerns. The data suggest that the practice of evaluating wide-ranging mammals in ERAs may largely be unnecessary because the mammals will often be found to be spatially irrelevant at contaminated sites.

356 PCB Bioavailability Reduction in Unsaturated Soil Using Powdered Activated Carbon Amendment. P. Paul, U. Ghosh, Civil and Environmental Engineering, University of Maryland Baltimore County, Baltimore, MD. Cleanup strategies for contaminated soils follow a risk based approach that takes into account several exposure pathways linking sources to potential receptors. Typical exposure pathways for terrestrial environments include contaminant leaching from soil to ground or surface

water, contaminant release from soil due to volatilization, ingestion of contaminated soil or food that has accumulated contaminants from soil. Past research has demonstrated the feasibility of PCB bioavailability reduction in water-saturated sediments through the amendment of activated carbon. This research is evaluating the effect of activated carbon on PCB exposure from unsaturated soils through leaching, volatilization, and bioaccumulation in the earthworm, *Eisenia fetida*. Earthworms are representative organisms at the base of the terrestrial food chain and live in close contact with soil where they may be exposed directly to bioaccumulative chemicals. In this research the bioaccumulation of PCBs from an artificially contaminated soil was studied with and without amendment with activated carbon (80-325 mesh). A 28-day soil exposure study demonstrated 95% reduction in the bioaccumulation of PCBs when activated carbon was mixed in the soil and 68% reduction when activated carbon was layered on top of the soil. Results from this study indicate that treatment of the biologically active layer of contaminated soil with activated carbon may be a promising in-situ stabilization method for reducing the bioavailability of PCBs and other hydrophobic organic compounds in a terrestrial environment.

357 Redox Chemistry of the Perfluorinated Surfactants, PFOS and PFOA. H. Park, C.D. Vecitis, J. Cheng, M.R. Hoffmann, Environmental Science & Technology, Caltech, Pasadena, CA; B.T. Mader, 3M Environmental Laboratory, 3M, Maplewood, MN. Conventional contaminant degradation technologies take advantage of redox chemistry, whether it is biotically or abiotically mediated. For even the most recalcitrant chemicals, the use strong oxidants such as hydroxyl radical or O-atom transfer agents generally solves the problem. However, perfluorinated chemicals present a unique case because of the organofluorine physiochemical properties. Fluorine is the only halogen that can completely replace all of the hydrogens on an alkane with more than two carbons, thus reducing the oxidizing power of hydroxyl radical which acts optimally as an H-atom abstractor. The fluorination also makes the compound more resistant to reduction, since unlike the higher halogens (Cl, Br, I), fluorine does not have a low-lying vacant orbital to accept an electron. We completed a survey of the effectiveness various inorganic oxidants and reductants on PFOS and PFOA. The results of this survey were persulfate photolysis (sulfate radical) was the only oxidant that had a visible effect, iodide photolysis (aqueous electron) was the best reductant and iron formed some sort of complex with the perfluorinated surfactants. Further investigations into these three results will be presented.

358 Optimization of Perfluorinated Surfactant Sonolytic Degradation and Evaluation of the Effect of Chain Length. T. Campbell, C.D. Vecitis, H. Park, J. Cheng, M.R. Hoffmann, Environmental Science & Technology, Caltech, Pasadena, CA; B.T. Mader, 3M Environmental Laboratory, 3M, Maplewood, MN. The perfluorinated surfactants, perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) are recognized as ubiquitous in the environment as well as bio-accumulative, persistent, and recalcitrant towards conventional water treatment technologies. Acoustic cavitation as driven by high-frequency ultrasound has been shown to mineralize dilute aqueous solutions of these perfluorinated chemicals. The PFOS and PFOA rate constants have been determined for the various sonochemical reactor configurations and it is observed for both PFOS and PFOA that the optimal acoustic frequency is 354 kHz and that rates increase linearly with increasing power density. Thus by increasing the applied acoustic power the degradation rate can be increased. These compounds were recently replaced by their more water soluble/non-bio-accumulative C4 analogs perfluorobutane sulfonate (PFBS) and perfluorobutanoic acid (PFBA). The sonochemical kinetics of the shorter chain perfluorochemicals PFHS, PFHA, PFBS and PFBA is also evaluated. 354 kHz was the most efficient ultrasound frequency for the C6 species and 618 kHz was the most efficient ultrasonic frequency for the C4 species. The degradation rates are also observed to increase with increasing power density.

359 Biological threats in the environment. S.M. Presley, TIEHH, Texas Tech University, Lubbock, TX. Biological threats in the environment are not limited to pathogens or toxins intentionally introduced through terrorism or criminal acts, but include an increasing number of disease-causing organisms that occur naturally or are unintentionally introduced. Emerging, resurgent and foreign animal diseases are clearly a growing concern for public health officials, veterinary medicine professionals, and various other governmental and private entities involved in the animal agriculture business. Recent highly publicized examples of emerging diseases of global concern have included anthrax, avian influenza (H5N1 and related strains), foot and mouth

disease, and porcine reproductive and respiratory syndrome (PRRS), as well as the resurgence or new appearance of many vector-borne diseases such as dengue fever, malaria, Rift Valley fever, Venezuelan equine encephalitis, and West Nile virus. Combining these growing concerns related to emerging and resurgent diseases with the real threat of biological terrorism highlights the critical necessity for an in-depth understanding of how naturally-occurring pathogens, particularly zoonoses, might be exploited to attack the citizenry and economic base of the U.S. Of specific concern is the fact that plague and tularemia are vector-borne zoonotic organisms that can be used as bioterrorism weapons. Arthropod-borne zoonoses pose a significantly complex challenge for human and animal health professionals regarding their potential for use as biological weapon agents. The intent of this presentation is to review the vulnerabilities and current state of preparedness relative to the potential intentional use of arthropod-vectored zoonoses as biological threats to human health and the food supply. An overview of history of bio-threat agents and a summary of zoonoses that are considered potential biological threat agents will be presented, as well as information on the establishment of the capabilities and resources necessary to conduct area-wide surveillance and ecological research targeting these diseases. This information will provide the audience with a greater understanding of biological threats in the environment, where they may be encountered, how they could be exploited, and what measures can be utilized to limit exposure.

360 History and Potential Use of Salivary Diagnostics in the Early Detection of Bio-Threat Exposures. M.E. Cullum, K.H. O'Connor, Applied Laboratory Sciences, Naval Institute for Dental and Biomedical Research, Great Lakes, IL. The need for field-deployable diagnostic assays, that have laboratory quality accuracy, has been of longstanding interest to the Navy. The ability to test for a number of militarily relevant biological agents in a field environment will greatly improve force health protection. This laboratory has an ongoing program to develop fluorescence polarization (FP) methods as diagnostic tools to assay biomarkers in saliva and other oral fluids. FP and related methods provide homogeneous real-time quantitation of antigens or antibodies without prior wash or separation steps. Results can be obtained in seconds instead of hours or days. There is potential for widespread use of these homogeneous assays as non-invasive tests. FP tests can be extended beyond their current domain of small molecule measurement to protein, viral, and bacterial quantitation. Phage display technology, an emerging technique, has the ability to create small mimics of large molecules making it ideal for use with FP. The uniqueness of the phage display method lies in its ability to 3-dimensionally mimic antibody-binding regions on the surface of proteins/molecules and to create small peptide-based mimics. The use of phage display for mimic production eliminates the need for work with potentially hazardous materials (e.g., organophosphates, botulinum toxins, hemorrhagic viruses, infectious agents) when producing competitive diagnostic assays. The combination of the FP assay system with phage-displayed mimics will create an inexpensive, simple test for monitoring exposure to multiple agents in the field.

361 Development of Advanced Proteomic Technologies as a Rapid Screening Method for Pathogen Exposure. M.D. Antoine, T.J. Cornish, N.A. Hagan, P.A. Demirev, RTDC, JHU-APL, Laurel, MD. Disease diagnostics has become another emerging area reaping the benefits of developmental advances in mass spectrometry (MS) technologies. Due to the "soft" ionization of MALDI and ESI, intact molecular ions of cellular components, such as proteins, are characterized and quantified at unsurpassed sensitivities while present in complex biological matrices. Proteins comprise over 60% of dry cellular and tissue mass. Monitoring protein expression by MS is thus extremely valuable in determining the physiological state of a particular cellular system or an entire organism. A greater understanding of disease pathogenesis and improving the methodology for biomarker characterization for noninvasive diagnosis can also be realized. Several research laboratories have reported the usefulness of MS analysis for monitoring the up and/or down regulation of specific proteins within a cell to aid diagnostic analysis of a particular disease. Many post-translational modifications of proteins within a cell have been specifically correlated to certain disease states, exposure to infectious organisms, as well as some traumas and injuries. Our laboratory is actively involved in using MS to screen various types of bodily fluids to detect and identify biomarkers indicative of healthy versus diseased states. MS-based proteomic strategies and rapid sample preparation protocols of biological fluids will be presented. The proposed technology will have application in the early pre-symptomatic diagnosis of disease caused by naturally occurring bacterial and viral infections or a biological attack and will be applicable for

rapid and high-throughput screening and triaging of a population after a suspected biological agent release.

362 Protection against chemical and biological threats. W.A. Bryden, Johns Hopkins University - Applied Physics Lab, Laurel, MD. Today there is heightened concern about our vulnerability to chemical or biological warfare agents. As the technologies to manufacture such weapons become increasingly available around the world, it is becoming increasingly clear that our buildings are potential targets for attack by chemical and biological agents. Most people, even those in the military, spend the majority of their time inside buildings, and as such buildings are natural targets for attack by chemical or biological warfare agents. Until recently, much of the Defense Department's funding in the area of Chemical and Biological Defense was concerned with protection of military personnel on the battlefield. Unfortunately, many of the technologies and techniques for dealing with the battlefield threat are unsuitable for building protection. As the former program manager responsible for the Immune Building program while at DARPA, I will discuss the expanded interest in chem/bio defense to include augmentation of existing and future buildings with passive and active responses to protect inhabitants, restore building function (following an attack), and preserve forensic evidence.

363 Facility wide catastrophic risk assessments. L. Tesch, Shaw Environmental, Inc., Bothell, WA; D. Huff, Shaw Environmental, Inc., Onalaska, WI. Environmental incidents, such as spills, releases or fires can be costly to companies, especially in terms of damage repairs, remedial action, regulatory enforcement and legal proceedings. Shaw along with some of its key customers has developed an approach to comprehensively identify, measure, and reduce environmental risks at industrial and commercial facilities. The approach is a decision making framework and associated tools and processes that is scalable and applicable to a broad range of enterprise risks. While organizations may focus their risk assessment on different areas, the risk analysis ultimately assesses internal controls with respect to the likelihood of an unacceptable event occurring and can be used to study a company's environmental risk profile. The definition of risk has evolved within the Environmental, Health and Safety practice. Initially, risk definitions were associated with injury – employee work place safety and injury to public and environmental health associated with the exposure to contaminants. Later, environmental compliance risk was highlighted. Today, risk definitions are evolving to include the identification of business risks that affect delivery of products and services as well as those that affect community, consumer, regulator and shareholder trust, with potential costs related to incident or non-compliance that can have significant negative impacts on the value of a company. Now, there are the added concerns of natural disasters and Homeland Security. The authors will use case studies to discuss these risk issues. The project examples include a RCRA Part B permit application risk assessment that was prepared for a hazardous waste classification, packaging, and transportation facility located in California and a electric power generating facility in the Northeastern US. The risk assessments evaluate potential releases and impacts due to waste handling, accidental chemical release during normal operations, traffic accidents involving transportation of wastes to or from the facility, and a fire at the facility.

364 Modeling Atmospheric Dispersion of Hazardous Chemical and Biological Species. J. Leggoe, Chemical Engineering, Texas Tech University, Lubbock, TX. Rapid computational prediction of the dispersion of aerosol species is essential to the informed direction of response operations in the event of releases of hazardous chemical and biological (CB) species. For weaponized aerosol species, the optimal size range for inhalation and alveolar deposition is 1-10 μm . The transport of aerosol species in this size range is predominantly an advective process, in which the aerosols move affinely with the local wind field. Given the turbulent nature of atmospheric air flows, released species can be expected to disperse into clouds, with a Gaussian concentration profile being expected in the case of homogeneous turbulence (based on the Central Limit Theorem). This has led to the development of a variety of dispersion models based on the transport and evolution of Gaussian 'Puffs', in which the parameters of the concentration profile depend on the local atmospheric conditions and the nature of the species being transported. The accuracy of the meteorological data used in the models is accordingly critical to the success of the models, especially in the near-surface region where the majority of the consequences of interest (such as exposure and deposition) occur. A variety of approaches are currently used in the resolution of the features of the local wind field, ranging from large scale meteorological models to fine scale computational fluid dynamics models. This presentation

will provide an overview of the evolution and current state of atmospheric transport modeling, and address the challenges currently being addressed in the continuing development of these models. Particular emphasis will be placed on approaches to characterizing the effects of surface features such as buildings and vegetation on ground level dispersion patterns. The effect of the characteristics of the species on the transport process and phenomena such as deposition will also be addressed. Specific examples, such as dispersion from ground level and elevated sources, will be provided to illustrate the information incorporated in and provided by current models.

365 On-line Toxicity Monitors and physical/chemical probe responses to Sodium Fluoroacetate, Potassium Cyanide, and Malathion. J. Allen, J. Hall, U.S. EPA, Cincinnati, OH; D. Macke, N. Muhammed, G. Meiners, Shaw E&I, Cincinnati, OH. Utilities are familiar with common physical/chemical parameters such as free chlorine, total organic carbon, turbidity, specific conductivity, pH, and oxidation-reduction potential. However, it is likely that these parameters are not sensitive to all potential distribution system contaminants. On-line toxicity monitors rely on physiological or behavioral changes of living organisms and are considered broad spectrum monitors for detection of changes in water quality. In order to understand the relative sensitivities of the two approaches, U.S. EPA Office of Research and Development Scientists have performed side by side exposures of the above physical/chemical endpoints and on-line toxicity monitors using fathead minnow (*Pimephales promelas*) swimming behavior and luminescent bacteria (*Vibrio fischeri*). The Monitors were exposed at the Test and Evaluation Facility in Cincinnati, OH using a once-through distribution pipe simulator. Flow was set at 5 gallons per minute and slip streams were distributed to the various systems at the 80 foot mark. Experiments were performed in duplicate at 2 concentrations for the contaminants Sodium Fluoroacetate, Potassium Cyanide, and Malathion. Results of these experiments will be presented.

366 Development of a Cell-based Toxicity Sensor for Drinking Water Protection. M. Widder, L. Brennan, T. Shedd, W. van der Schalie, US Army Center for Environmental Health Research, Fort Detrick, MD; T. Curtis, L. Romeo, Agave Biosystems, Ithaca, NY. As part of an effort to develop an Environmental Sentinel Biomonitor (ESB) system platform to rapidly identify toxicity associated with a broad range of industrial and agricultural chemicals in drinking water, an intensive down selection of 38 candidate toxicity sensors was performed. Based upon toxicant response sensitivity and other factors, the best performing sensor measured changes in electric impedance across live cell monolayers. Several modifications have improved the utility of the impedance sensor for the ESB system platform. A closed-system fluidic biochip increases long-term storage potential and portability while reducing maintenance requirements. Evaluation and selection of optimized cell types for use with the technology have further enhanced sensitivity to toxicants. Additional advancements to the fluidic biochip technology include the development of a cell maintenance system for improved field portability, ease of use, and automated long-term storage. The system, as designed, has minimal sample preparation requirements and can provide toxicity results within an hour of exposure initiation. An ESB system platform that includes the fluidic biochip technology can provide a rapid and effective tool to help identify both accidental and malicious contamination events in source and finished drinking waters.

367 Application of Aquatic Biomonitor Systems with Water Chemistry for Source Water and Distribution System Monitoring In the Washington, DC Area. J.W. Shell, S.A. Freudberg, S. Bieber, Metropolitan Washington Council of Governments, Washington DC; T.R. Shedd, D.E. Trader, M.W. Widder, W.H. van der Schalie, United States Army Center For Environmental Health Research, Fort Detrick, MD. Shortly after September 11, 2001, water utilities, local governments, state, federal and regional public agencies convened a special Water Security Workgroup under the umbrella of the Metropolitan Washington Council of Governments and its ad hoc Task Force on Homeland Security for the National Capital Region (NCR). The goal of the Workgroup is to ensure the security, safety, and reliability of drinking water supplies and distribution systems in the NCR. One component of a comprehensive water security program for the NCR is the development and implementation of a regional contaminant warning monitoring system using state-of-the-art technologies. The drinking water supply is obtained from rivers, lakes, streams, and ground water sources in the Potomac River basin. As a result, implementation of a monitoring system that can provide reliable and timely data regarding the quality of the water supply is an essential

element in helping ensure that the region has sufficient warning time for local action in the event of an accidental release of contaminants into the water source. A companion monitoring system for the various distribution systems is also of critical importance to water supply security. Currently, source and distribution water monitoring systems are deployed at multiple sites in the NCR. Component technologies include both water chemistry monitors (Hach Company Water Distribution Monitoring Panel and Event Monitor™ Trigger System) and biomonitors (Intelligent Automation Corporation iABS fish system). Experience with these technologies has provided insight into the response capabilities, operational and maintenance issues, and the overall response event framework necessary to apply real-time water monitoring technology. The presentation will address the issues and challenges faced in applying these state-of-the-art technologies.

368 Development of Thyroid Gland Specific Markers of Hypothalamic-Pituitary-Thyroid Axis Disruption in The Amphibian Model Species *Xenopus laevis*. S.J. Degitz, M.W. Hornung, J.J. Korte, G.W. Holcombe, P.A. Kosian, J.E. Tietge, MED, USEPA, Duluth, MN; J. Olson, L.M. Korte, Student Contractor Services, Duluth, MN. An amphibian-based hypothalamic-pituitary-thyroid (HPT) axis model is being developed for understanding thyroid toxicity. In developing this model it is important to differentiate changes due to compensatory responses and those which are direct effect of the chemical. Using *Xenopus laevis*, responses in the whole organism and thyroid gland culture were compared to separate compensatory mechanisms from direct chemical effects. The two chemicals used in this study, methimazole (MMZ) and perchlorate (PERC), inhibit T4 synthesis by unique mechanisms, TPO inhibition and NIS inhibition, respectively, although both result in decreased circulating T4. NF stage 54 tadpoles were treated with MMZ, PERC, or dilution water and thyroid glands were removed at 24, 48, 96, or 144 hours. Glands were processed for histopathology or gene array analysis using Affymetric gene chips. For in vitro experiments thyroid glands were dissected from stage 55 tadpoles and cultured for 24h in media alone (controls) or 500 ng TSH/ml (0.9 mU activity/ml), and processed for gene array analysis. Treatment with MMZ and PERC resulted in time dependent changes in thyroid gland morphology. Three patterns of gene expression changes were observed; those which were similar between chemical exposure and in vitro TSH stimulation, those unique to MMZ, and those unique to PERC. Of the genes observed to have altered expression levels about half were well-characterized genes while the others represent ESTs. Of the well-characterized genes identified as changing, a number of these have previously been shown to be involved in or correlated to cancer. This is not surprising given the high level of follicular cell hyperplasia which was observed. Follicular cell hyperplasia is a well established compensatory response. Surprisingly, there were very few chemical specific gene changes which were consistent across the time course evaluated. From these experiments we identified a number of genes that show promise as markers within the thyroid gland for thyroid axis inhibition/TSH elevation. We have also identified candidate markers for TPO and NIS inhibition, although additional testing is necessary to establish their utility. This abstract does not necessarily reflect EPA policy.

369 Aryl hydrocarbon receptor-mediated transcriptional response reveals pathways for neuroendocrine disruption in rainbow trout. M. Vijayan, Biology, University of Waterloo, Waterloo, Ontario, Canada; N. Aluru, Biomedical Sciences, University of Guelph, Guelph, Ontario, Canada. In teleost fishes, polychlorinated biphenyls (PCBs) disrupt the stress and reproductive axes, leading to an overall decrease in fish performance. While arylhydrocarbon receptor (AhR) activation is thought to be a key mediator of PCBs impact, little is known about the target tissues impacted and the molecular mechanisms involved. We tested the hypothesis that AhR activation alters gene expression in the brain, especially those critical for the functioning of the hypothalamus-pituitary-interrenal and -gonadal axes in rainbow trout. Using an in vivo pharmacological approach, feeding AhR agonist (β -naphthoflavone; BNF) and antagonist (resveratrol; RVT), we investigated the selective transcriptional response to AhR activation in trout brain. The gene expression pattern was analysed using a low density custom targeted trout cDNA array followed by quantitative real-time PCR of candidate genes. Upregulation of CYP1A1 gene expression with BNF and the blockade of this response by RVT confirmed AhR-dependent signaling. RVT by itself significantly impacted only a few select genes, while BNF treatment significantly modulated the transcript level of several genes, including those involved in the neuroendocrine control of stress and reproduction. Of these, only 27% of the BNF-mediated transcriptional changes were blocked by RVT suggesting multiple pathways, in addition to AhR signaling, involved in the molecular regulation. Overall, the selective transcriptomics approach reveals for the first time that AhR activation disrupts multiple pathways critical for the neuroendocrine control of stress and reproduction in fish.

370 A comparative genomics approach to investigate estrogen signaling and its susceptibility to modulation by environmental estrogens. E.M. Santos, T. Carroll, R. Yang, R. van Aerle, C. Tyler, School of Biosciences, University of Exeter, Exeter, United Kingdom; P. Kille, Cardiff School of Biosciences, Cardiff University, Cardiff, United Kingdom. The biological effects of estrogens are mainly mediated through binding to specific nuclear receptors, activation of estrogen responsive elements (ERs) and modulation of gene transcription. Environmental estrogens have the potential to modify estrogen homeostasis resulting in disruption of extensive gene networks. We

aimed at generating a comprehensive (genome-wide) understanding of the likely biological functions of estrogens and their potential for disruption by estrogen exposure using a comparative genomic approach. A bioinformatics system (using a neural network trained on 93 known ERE sites) was developed to identify the presence of functional ERs in the promoter regions of all available genes in the zebrafish genome (*Danio rerio*). The likely functionality of the ERs identified was further assessed by determining their evolutionary conservancy in two other fish species (*Takifugu rubripes* and *Tetraodon nigroviridis*). The bioinformatics predictions were validated by comparison with a list of genes differentially expressed in zebrafish following exposure to a model oestrogen (17 α -ethinylestradiol). In addition, a similar approach was used for human and mouse genes. We identified 1,398 genes containing conserved ERs in their regulatory region, suggesting that they are potentially regulated by estrogens in fish. Gene ontology analysis identified a number of biological processes over-represented in this gene list, including metabolism and daughter terms. This was similarly found in the list of putative estrogen responsive genes in humans. There was a significant overlap between the list of genes predicted to be responsive to estrogens using our bioinformatics approach and an experimentally (microarray) derived gene list of differentially expressed genes following exposure to estrogen in zebrafish ($P < 0.00001$). This study provides novel insights into the biological processes regulated by estrogens at the level of the whole-genome, and their susceptibility to modulation by exposure to environmental estrogens.

371 The Androgen Trenbolone and the Anti-Androgen Flutamide Regulate Distinct Biological Processes in Fathead Minnow. N.D. Denslow, N. Garcia-Reyero, K.J. Kroll, Physiological Sciences, University of Florida, Gainesville, FL; M.S. Sepulveda, Purdue University, Lafayette, IN; K. Watanabe, Oregon Health & Science University, Beaverton, OR; E.F. Orlando, Florida Atlantic University, Boca Raton, FL; D.L. Villeneuve, D. Martinovic, G.T. Ankley, 5. U.S. EPA, ORD, NHEERL, MED, Duluth, MN. Androgenic and antiandrogenic chemicals are present in the environment at concentrations that could impact reproduction in fish and wildlife. Yet, little is known about the underlying molecular pathways that are impacted by such chemicals. We exposed female fathead minnows (*Pimephales promelas*) to a prototypical androgen (17 β -trenbolone) and antiandrogen (flutamide) singly and in combination, and also exposed male fathead minnows to 17 β -trenbolone to determine changes in gene expression elicited by the chemicals. Livers and gonads from fish exposed to the chemicals for 48 hr were extracted and gene expression was analyzed using 21,000 gene microarrays. We had hypothesized that there would be significant overlap among the biological processes impacted by androgenic and antiandrogenic chemicals, but instead found distinct gene expression fingerprints for trenbolone and flutamide. The two compounds reciprocally regulated only a relatively small set of genes, which are involved in functional activities such as mRNA splicing, cell adhesion, DNA replication, immune response to pathogens, apoptosis, reproduction, angiogenesis, signal transduction and energy production. The concentrations of trenbolone and flutamide tested in the 48 hr exposure have previously been shown to cause phenotypic changes in female fathead minnows exposed in 21-day reproduction assays including reduction of egg production and masculinization. We are incorporating phenotypic endpoints and transcriptional changes into a physiologically based computational model to understand how endocrine active compounds cause adverse reproductive effects in fish.

372 A systems-based approach to assess the risks of mercury and other environmental neurotoxicants. N. Basu, Department of Environmental Health Sciences, University of Michigan, Ann Arbor, MI. Mercury is a heavy metal of global environmental health concern. By studying fish-eating organisms that bioaccumulate mercury (mink, river otters, common loons, bald eagles, humans, rats), we have shown that prior to the onset of overt neurotoxicity and changes in animal behaviour, mercury disrupts brain chemistry. Using high-throughput, in vitro assays we found that mercury impairs many receptors, enzymes, and transporters involved in the neurotransmission of acetylcholine, dopamine, GABA and glutamate. Many of these in vitro effects were verified in vivo by studying wild animals that naturally accumulate mercury and captive animals that were experimentally dosed. Here I synthesize results from the literature and our laboratory, and model the data into systematic flow diagrams. By use of graphical flowcharts, it is evident that mercury affects neurochemical systems at ecologically relevant exposure levels, and that patterns exist across organisms, brain regions, and signaling pathways. This systems-based analysis is being extended to

characterize the effects of other environmental neurotoxicants, including PCBs and PBDEs. Pollutant-specific, biochemical patterns are emerging from this work. The findings are leading to a better understanding of toxic mechanisms and to discoveries of novel biomarkers.

373 Transcriptional olfactory responses and swimming behavior in adult zebrafish exposed to copper and chlorpyrifos as single compounds or binary mixtures. E. Tilton, S.C. Tilton, P. Stapleton, T. Bammler, R. Beyer, F. Farin, E.P. Gallagher, DEOHS, University of Washington, Seattle, WA. Transcriptional olfactory responses and swimming behavior in adult zebrafish exposed to copper and chlorpyrifos as single compounds or binary mixtures. F. Tilton, S. Tilton, P. Stapleton, T. Bammler, R. Beyer, F. Farin, E. Gallagher The trace metal copper (Cu) and the organophosphate chlorpyrifos (CPF) have been shown to cause olfactory and neurobehavioral impairment in Pacific salmonids and several other fish species. In the current study, we have begun to utilize the superior genetic and experimental tractability of zebrafish to establish it as a molecular model to study neurobehavioral impairment and the mechanisms of olfactory injury. The overall goal is to elucidate relevant biomarkers of toxicant-induced neurobehavioral and olfactory injury in fish. Adult zebrafish (5 fish/replicate, N=3) were exposed for 24 hrs to Cu (10, 25, 50 ppb), CPF (35, 88, 220 ppb), or three binary mixtures containing 25 ppb Cu with 35, 88, or 220 ppb CPF. In order to assess neurobehavioral impairment, the horizontal swimming rates of each animal both pre- and post-exposure were by monitored and recorded. Fish exposed to Cu exhibited no statistical differences in swimming rates, although at 40 ppb Cu there were noticeable changes in swimming behavior in a number of fish. In contrast, an inverse relationship between increasing CPF concentrations and swimming rates was observed ($P < 0.05$). Interestingly, co-exposure to 25 ppb Cu and 220 ppb CPF protected against the decrease in swimming rates observed in the presence of 220 CPF alone. We analyzed the gene expression in the olfactory tissues (olfactory rosettes, olfactory bulb, and telecephalon) from these same animals using the Affymetrix zebrafish array platform in an effort to explore the mechanisms underlying olfactory injury. Relative to the control, all treatments had between 30-70 elements differentially regulated ≥ 3 -fold. No treatment had more than 800 elements differentially regulated ≥ 1.5 -fold and the majority of these were down-regulated. The relationships of transcriptional signatures to treatment, dose and biomarker development will be discussed. Supported by NIH grants ES04696 and ES07033.

374 Global proteomics and meta-proteomics and environmental peptide fingerprints. S.E. Baker, E.A. Panisko, D.S. Daly, K. Anderson, M. Monroe, Pacific Northwest National Laboratory, Richland, WA. Uncovering biological changes in an ecosystem using a global proteomics strategy offers great promise. Current global proteomic strategies, however, are critically dependent on the existence of a genome annotation database for each organism under study. This currently limits uncovering changes in ecosystem proteins by high-throughput peptide identifications and potential biomarker discovery to systems where the organisms have compiled genome annotations. In addition, many global proteomic analysis methods are not quantitative. We are developing relative quantitative proteomics in the absence metabolic labeling using statistical methods. We have successfully applied this method to a complex fungal sample. We are adapting our method to cope with proteomic data generated from a complex environmental sample for which there is little to no genomic sequence.

375 Microbial Community Responses to Perturbation: Subtractive Hybridization as a Starting Tool for Developing Environmental Biomarkers based on Microbial Communities. V. Bailey, S. Fansler, Microbiology, Pacific Northwest National Laboratory, Richland, WA; B. Webb-Robertson, Computational Biology and Bioinformatics, Pacific Northwest National Laboratory, Richland, WA. Subtractive hybridization is a tool for comparing two similar genomes under paired conditions. It is a well-recognized approach, however it has been largely restricted to single-genome applications (e.g., tissues, plants). We have modified the approach for detection of gene expression and inhibition in microbial communities presented with environmental perturbation (contamination). We present here a demonstration of subtractive hybridization in two types of microbial communities: (1) soil microorganisms exposed to chromium, and (2) periphyton exposed over time to uranium. Furthermore, we use computational bioinformatics to analyze the genes expressed and inhibited to speculate on the ecosystem processes that are initiated or disrupted by the perturbation.

376 Biosignature Integration for Evaluating Environmental Stressors. B. Webb-Robertson, J.E. McDermott, L. McCue, Computational Biology & Bioinformatics, Pacific Northwest National Laboratory, Richland, WA; N. Beagley, Statistical Sciences, Pacific Northwest National Laboratory, Richland, WA; K. Jarman, Decision & Sensor Analytics, Pacific Northwest National Laboratory, Richland, WA. Ecological media samples may represent a mélange of microbial communities of unknown structure with unknown levels of interactions. Thus, the evaluation of environmental stressors based on single technological platforms only offers a narrow view of a complex system of dynamically changing species and community functions. To approach evaluation of environmental samples from a "systems ecology" perspective requires the ability to interrogate a single environmental sample with multiple technologies. However, such data result in a data integration challenge. We demonstrate a statistical biosignature integration approach to aid in the determination of diagnostic marker of environmental stressors. In addition, this approach allows targeted questions that can be framed as probability distributions to be evaluated, leading to a greater understanding of the biological shifts in ecosystems under stressed or changing conditions.

377 Persistent Organic Pollutants in Korean Coastal Sediments: Distribution, Sources, and Potential for Biological Effects. J. Khim, Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; C. Koh, School of Earth and Environmental Sciences, College of Natural Sciences, Seoul National University, Seoul, South Korea; J.P. Giesy, Department of Biomedical Veterinary Sciences and Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; J.P. Giesy, Zoology Department, Center for Integrative Toxicology, National Food Safety and Toxicology Center, Michigan State University, East Lansing, MI. Here we summarize major findings from a study begun in 1996 that determined the contamination of persistent organic pollutants (POPs) in Korean coastal sediments. Out of 685 sites surveyed, 154 sites (covering inland and bay locations) were selected and scrutinized to determine the sources of various POPs and associated potential biological effects. Various POPs including PCDDs/DFs, PCBs, organochlorine (OC) pesticides, PAHs, alkylphenols (APs), and bisphenol A (BPA) were analyzed by instruments (GC and HPLC) and in vitro bioassays (H4IIE-luc and MVLN). TIE and Mass Balance Analysis (MBA) were performed to determine whether the chemical composition and concentrations identified could account for the biological responses observed. Varying concentrations of POPs were detected in both inland ($n=49$) and bay sediments ($n=105$) and their abundance was in the order of APs (380 ng/g, dw), PAHs (280 ng/g, dw), OC pesticides (32 ng/g, dw), and PCBs (16 ng/g, dw), on average ($n=154$). APs and PAHs were predominant and have been closely associated with point sources in stream and river sediments, while PCBs and OC pesticides concentrations were rather small and uniform, except for some hot spots, indicating their general sources along the coasts. Most of the dioxin-like activities were observed in the fractions containing PCDDs/DFs and certain dioxin-like PAHs and about half of the samples showed significant estrogenic activity caused by the fraction containing PAHs fraction. A qualitative MBA suggested the presence of unidentified dioxin-like and/or estrogenic compounds in F2 and F3, thus more elaborate characterization of compounds associated with polar fractions should improve further understanding of dioxin-like and/or estrogenic contamination associated with Korean coastal sediments.

378 A Multi-phase battery approach to the ecotoxicological assessment and Toxicity Identification Evaluation (TIE) of Irish marine sediments. A.L. Macken, M. Giltrap, M. Davoren, Radiation and Environmental Science Centre, Focas Institute, Dublin Institute of Technology, Dublin 8, Ireland; B. Foley, School of Chemical and Pharmaceutical Sciences, Dublin Institute of Technology, Dublin 8, Ireland; M. Giltrap, E. McGovern, B. McHugh, The Marine Institute, Rinnville, Oranmore, Co Galway, Ireland. Sediments have been recognised as both a source and a sink for persistent contaminants in the aquatic environment. Contaminants accumulated in the sediment have the potential to cause adverse effects to indigenous biota and aquatic organisms, should they become bioavailable or remobilised following chemical, physical or biological processes. The monitoring of contaminants in sediments should therefore form an integral part of any water quality management plan. This paper describes the ecotoxicological evaluation of a series of marine and estuarine sediment sites from around Ireland. A comprehensive assessment of potential sediment toxicity requires the consideration of multiple exposure phases. In addition to the evaluation of multi-exposure phases, the use of a battery of multi-

trophic test species has been advocated by a number of researchers as testing of single or few organisms may not detect toxicants with a specific mode of action. The Microtox® solid phase test and the 10-d acute amphipod test with *Corophium volutator* were used to assess whole sediment toxicity. Porewater and elutriates were assessed with the Microtox® acute test, the marine prasinophyte *Tetraselmis suecica*, the marine macroalgae *Ceramium tenuicorne* and the marine copepod *Tisbe battagliai*. It was not possible to correlate the observed ecotoxicological effects with a specific and/or class of contaminants. Therefore porewaters found to elicit significant toxicity with the test battery were assessed using Toxicity Identification Evaluation (TIE) techniques. Previous research conducted by us demonstrated *T. battagliai* and Microtox® to be the most appropriate tests to employ for TIE. The results of this study have important implications for risk assessment in estuarine and coastal waters in Ireland, where, at present the monitoring of sediment and water quality is predominantly reliant on chemical analysis alone.

379 The tetrad approach: incorporating ecosystem function assessment into the sediment quality triad approach for contaminated site assessment in rivers. A. Gazeas, D.J. Baird, Environment Canada @ Canadian Rivers Institute, Department of Biology, University of New Brunswick, Fredericton, New Brunswick, Canada; S. Lambert, Parks Canada @ Cape Breton Highlands National Park of Canada, Ingonish Beach, Nova Scotia, Canada. The Marrach is a small watershed draining the Cape Breton Highlands area of Nova Scotia. Over the past 15 years, a landfill has undergone major slumping of material into the adjacent Marrach Stream. Our study utilized a modified triad approach, integrating knowledge attained through study of (1) chemical analysis of water, sediment, and biota; (2) macroinvertebrate community structure; and (3) ecotoxicological testing with (4) the addition of measures of ecosystem function. This additional line of investigation involved the use of traditional leaf-litter bags to assess decomposition rates with in the stream. Chemical analysis has identified a variety of contaminants in both stream sediments and groundwater. Stream sediment analysis found levels of lead, naphthalene and DDT exceeding guidelines by 71, 506 and 672 % respectively. Groundwater analysis found the following metals exceeded guidelines in upwards of 2300 %, including aluminum (1000%), copper (0.3%), iron (2366%), lead (100%) and zinc (366%). Surface water analysis found aluminum, copper and iron exceeded guidelines by 607%, 12.5% and 163% respectively. Benthic community surveys found evidence of impairment downstream of the landfill with a 79% decrease in sensitive EPT taxa abundance and a 63% reduction in total species diversity compared with the upstream sites. Sediment toxicity was evaluated via a 96 hr in situ feeding inhibition bioassay with the freshwater oligochaete worm: *Lumbriculus variegatus*. Significant feeding inhibition ($P < 0.05$) was seen in the toxicity tests at two of three impacted sites with a 63 % reduction in feeding. Leaf litter breakdown rates by the microbial community (aperture size of 350 μm) were similar between reference streams and declined significantly ($P < 0.05$) at one of the impacted sites indicating some level of microbial impairment. The application of the modified triad demonstrated that the observed contamination had an adverse effect on aquatic life in Marrach Stream, at the community level with reduced diversity, at the level of individuals with feeding inhibition, and at the ecosystem function level with impairment of microbial detritus processing.

380 Soil Characterization, Contamination Modelling and Ecological Risk Assessment for Uranium in Soil near an Industrial Facility. E. Cooper, N.C. Garisto, Z. Eslami, SENES Consultants Limited, Richmond Hill, Ontario, Canada. In August 2006, a soil and vegetation sampling program was carried out in areas surrounding an industrial facility in order to measure current uranium concentration and soil-water distribution coefficient (Kd) for use in ecological risk assessment. Kd's were derived assuming a linear relationship between soil concentration (which was "spiked" with a uranium solution) and equilibrium solute concentration. A soil model, sensitive to variability in soil-water Kd, soil bulk density, moisture content and uranium concentration in air, was used to predict long-term accumulation of uranium in soil. In addition to measuring the parameters used in the soil model, the collected data provided a detailed characterization of uranium and other contaminants in the soil and vegetation surrounding the facility. The association of uranium with other metals in various soil depths indicated historical waste emplacement (not associated with historic activities of the facility) as the likely cause of elevated levels. The uranium concentration in soil samples collected from different depths (2.5 cm to 45 cm) varied between 0.24 and 98.3 mg/kg, while the typical range in North America is 0.9 to 9 mg/kg.

These levels can likely be attributed to historical waste emplacement based on the presence of high concentrations of associated contaminants such as arsenic, lead and copper in the samples with high uranium levels. The highest uranium concentrations occurred in soil types that include silty sand. The Kd range for the soil types with a significant number of data points was 35-82 L/kg. The full range of measured Kds was 31-109 L/kg. Based on the measured base uranium soil concentrations and site-specific model parameters, the model estimated that the 2031 maximum soil uranium concentrations would be 39.5 mg/kg at a depth of 2.5 cm and 21.3 mg/kg at a depth of 15 cm. The calculated Screening Indices (SIs) for the ecological risk assessment were less than one for all of the terrestrial receptors, based on the site-specific data. The results from the study can be used to focus the long-term monitoring of uranium in soil carried out by the facility to determine the actual long term accumulation rate of uranium in soil as affected by the facility's current operations and to verify the predictions of the soil model.

381 Use of BSAF approach in setting up sediment quality guidelines that are protective of human health. S.P. Bhavsar, University of Toronto, Toronto, Ontario, Canada; S.P. Bhavsar, S.B. Gewurtz, R. Fletcher, A. Hayton, E.J. Reiner, P.A. Helm, Ontario Ministry of the Environment, Toronto, Ontario, Canada; S.B. Gewurtz, Brock University, St. Catharines, Ontario, Canada; C.H. Marvin, Environment Canada, Burlington, Ontario, Canada. Sediments can be a repository of hydrophobic contaminants, and a source of these contaminants to the organisms having direct contact with sediments as well as to organisms such as top predator fish that are not in direct contact with sediment. Sediment quality guidelines are generally developed to protect only aquatic benthic invertebrates or all aquatic biota. However, in order to minimize human exposure to sediment derived contaminants through the benthic food web, sediment guidelines also need to keep the accumulation of contaminants in fish below the fish consumption advisory levels. To illustrate how this need can be addressed, we first calculate Biota Sediment Accumulation Factors (BSAFs) for total PCB and dioxins/furans in the Canadian Great Lakes using measured lake- and fish-species-specific concentrations in the sediments and fish. Using these BSAFs and tissue residue values for fish consumption advisory guidelines used by the Ontario Ministry of the Environment (MOE), we derive sediment levels that are likely to result in fish levels safe to eat without restriction. New lake-specific sediment quality guideline values for the protection of human health are suggested if the BSAF based sediment concentrations are below the current guidelines. Using this revised set of proposed sediment guidelines, the extent of sediment over-contamination in the Canadian Great Lakes is estimated.

382 Overview of Michigan's Guidance Regarding Groundwater/Surface Water Interface and Sediment Quality Characterization/Corrective Action. J.H. Barkach, D. McCauley, M. Garton, Great Lakes Environmental Center, Farmington Hills, MI. The Michigan Department of Environmental Quality considers contaminated sediments and impacted groundwater venting to surface water a significant threat to the State's surface water quality. Approximately 20% of the world's freshwater resides in the Great Lakes and connecting waterways. In addition, the State of Michigan has over 14,000 inland lakes and a large number of streams that receive between 50-90% of their base flow from groundwater. For these reasons, the MDEQ has promulgated rules and developed extensive guidance to address the impact of contaminated groundwater venting to surface water bodies. This work culminated in new rules that were promulgated on December 21, 2002 and with the release of extensive new guidance on September 30, 2004. Lessons learned while evaluating groundwater discharges to surface water have been applied, in part, to the evaluation of potential sediment quality impacts. For this reason, this paper provides a brief overview of MDEQ (2004) guidance regarding groundwater discharge to surface water bodies. On April 2, 2007, the MDEQ released an interim final guidance document (OM-4, Att. 3) regarding sediment characterization, site specific sediment criteria development, and a presumptive remedy approach. With respect to sediment characterization, the MDEQ utilizes a phased approach. The first phase involves presence or absence sampling utilizing USEPA sampling guidance. Sediment samples are collected and tested as totals, and the data compared to USEPA sediment quality guidelines. If the sediment data exceeds these USEPA sediment quality guidelines, then the second phase involves sediment toxicity testing and an evaluation of the horizontal and vertical extent of sediment quality impacts. Sediment toxicity testing is required when the MDEQ determines that the concentrations of compounds in sediment indicate the potential for toxicity to aquatic life, bioaccumulation, and/or

exceedances of water quality standards. If the toxicity testing reveals potential exceedances of water quality criteria, the third phase involves the development of site specific sediment quality criteria. The MDEQ requires that site-specific quality criteria be protective of aquatic life and potential use impairments (e.g. aesthetics). The MDEQ allows for a presumptive remedy that can be used in lieu of toxicity testing and the development of site specific sediment criteria.

383 Borrowing Tools From Gold Diggers: The Role Of Geostatistics and GIS In Sediment Assessment And Remediation. J. Schofield, R. Downing, R. Bryan, Water Programs Group, Computer Sciences Corporation, Alexandria, VA; L. Blume, Great Lakes National Program Office, US EPA, Chicago, IL. Geostatistics and Geographic Information Systems (GIS) are being used to plan and implement several sediment assessment and remediation projects in the Great Lakes. Geostatistics evolved with mineral exploration and mining of minerals, ores, and coals. This class of statistical techniques, applied in GIS, assists in analyzing and predicting values of a variable distributed in space. The mining industry, guided by profits, allocates significant resources to sampling and geostatistical interpretation of analytical data. Several sediment assessment and remediation case studies illustrate the benefits of these tools in more effectively addressing contaminated sediments. US EPA used these tools effectively for the sediment remediation project of the Ruddiman Creek in Michigan. The objective was to remove as much as possible of the contaminated sediments at the lowest possible cost, while achieving clean up goals for the contaminants of concern. Once the area was dredged, sampling and residuals analyses were conducted to verify that clean up goals were met. The statistical sampling design provided a 90% probability of detecting an exceedance of the clean up criteria. Based on the residuals data, project coordinators used geostatistical tools, including kriging, to interpolate complex patterns of contamination and develop the most economical approach to remove any remaining contaminated sediments. The resultant concentration contour map identified areas which exceeded the target levels for the contaminants of concern and focused the final remedial activities. This technique allowed the project to achieve the best sediment removal results at the lowest cost, reducing the anticipated dredge volume by 800 cubic yards and saving approximately \$100,000 in dredging costs. Geostatistics and GIS also are being used for a large sediment assessment project in the St. Louis River and for a remedial investigation and focused feasibility study in Wayne County Michigan. Geostatistics and GIS tools will be used to evaluate site conditions and subsequently determine the need, or lack thereof, for remedial action. Digging for gold and searching for contaminants in sediment are similar exercises. The tools developed to find valuable minerals also can be used to more effectively assess and remediate contaminated sediments.

384 Determination of Piperonyl Butoxide and Permethrin Residues in Sediments of Lubbock County Playa Lakes. R. McNew, S. Presley, Environmental Toxicology, Texas Tech University, Lubbock, TX. The use of permethrin with a synergist piperonyl butoxide (PBO) is employed as a means of vector control in urban, suburban, and rural areas. The primary target vector that is controlled by permethrin and PBO are adult mosquitoes. Mosquitoes are known to vector a variety of diseases and are also considered a nuisance. In Lubbock County last year alone, 1000 gallons of permethrin with PBO were employed for vector control. Along with all practical applications of pesticides, there can be unwanted environmental effects. In an area like Lubbock County where most of the runoff is due to rainfall events, and most of these end up in our natural ecosystems called playa lakes, there is a potential for harming unintentional species. Other studies have shown that permethrin along with PBO can cause sediment toxicity at concentrations as low as 2.3ppb. Therefore, I am proposing to sample sediments at selected playas. The sediments will be extracted with an accelerated solvent extractor (ASE), analyzed by high performance liquid chromatography (HPLC), and scanned for permethrin and PBO residues. We can then determine the sediment concentrations of permethrin and PBO in Lubbock County playa sediments to better characterize the fate and transport of these chemicals specific to our landscape, and thus provide a more applicable ecological risk assessment for native non-target species in our urban playas.

385 A New Look at the History of Contamination in the Passaic River. A. Accardi-Dey, C. Amato, C. Zeiner, C. Prabhu, Malcolm Pirnie, Inc., White Plains, NY; E.A. Garvey, J. Atmadja, S. Gbondo-Tugbawa, Malcolm Pirnie, Inc., Fair Lawn, NJ; S. McDonald, Malcolm Pirnie, Inc., King of Prussia, PA. The Lower Passaic River was one of the major centers of the American industrial revolution, with early manufacturing developing in the area around Great Falls in Paterson, New Jersey. In subsequent years, industrial

operations sprang up along the banks of the Passaic River, as the New Jersey cities of Newark and Paterson grew. These industrial developments included, but were not limited to, manufactured gas plants, paper manufacturing and recycling facilities, and chemical manufacturing facilities. These plants used the river for wastewater disposal. Moreover, the Lower Passaic River has been used as a means of conveyance for municipal discharges. Together, these waste streams (industrial and municipal) have delivered a number of contaminants, including but not limited to 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), DDT, mercury, and lead. By the twentieth century, contamination has resulted in poor water quality, contaminated sediments, bans on fish consumption, and degraded habitats. To understand historical contaminant loads to the river, sediment cores were collected along the length of the lower Passaic River. These cores were finely segmented and dated using ¹³⁷Cs to resolve concentration trends over time. Data from the cores documented the scale, duration and extent of contamination in the river. Among the major observations: - Sediment concentrations are consistent throughout the Lower Passaic at any given time horizon, indicating that tidal mixing is sufficient to carry transport contamination throughout the lower 12 miles of the river, regardless of its original source location. - Contaminant loads to the river have varied over time with peak mercury loads occurring between the 1950s and 1960s while peak 2,3,7,8-TCDD and Total PCB loads occurred in the 1960s and 1970s. - PAH contaminant loads have been relatively constant over the past 25 years with concentration levels similar to upriver samples, indicating an on-going upriver source. - The rate of concentration decline, estimated as a "half-life," ranged from <20 years for PCB, DDT, and 2,3,7,8-TCDD and >20 years for metals and PAH.

386 Florida Bay: A Risk Assessment for Salinity to Make Management Decisions. P.M. Bachman, G.M. Rand, Ecotoxicology & Risk Assessment Laboratory, Florida International University, North Miami, FL. Florida Bay presents a unique opportunity to apply the probabilistic ecological risk assessment approach to an abiotic stressor. Current salinity patterns and proposed water delivery changes related to the Comprehensive Everglades Restoration Plan (CERP) are ultimately controlled by water management activities upstream in the greater Everglades system. In this context, salinity regimes of the Bay can be considered anthropogenic in nature. Salinity is considered to be one of the primary environmental factors affecting the growth and survival of aquatic organisms as it can influence both the physiological and ecological processes of a given organism. To assess the risk of salinity to organisms in northeastern Florida Bay, we selected the U.S. EPA's Ecological Risk Assessment Framework. This framework, widely used for assessing the risk of chemical contaminants, uses the following approach: problem formulation, risk analysis, and risk characterization. The goal of the risk assessment was to estimate the likelihood and the extent of adverse effects towards various species as a result of exposure(s) to localized salinity regimes. Upper and lower tolerance limits for salinity were also taken into consideration. To gather effects data, a detailed and systematic literature review was conducted to create effects distributions (SSDs) for different species groups. Data was screened for suitability (qualitative vs. quantitative) and separated into effects for taxonomic groups (e.g. fish, crustaceans, vascular plants etc.) and ranked. For the exposure distribution, actual surface salinity data were collected for various monitoring stations in Florida Bay and ranked by concentration. Sources for salinity data were published literature, report documents and available local salinity databases (DBHYDRO, USGS). The overlap of the exposure and effects distributions were used as a measure of risk of salinity changes for different taxonomic groups in Florida Bay.

387 The State of San Francisco Bay: Water Quality. J. Davis, M. Connor, San Francisco Estuary Institute, Oakland, CA; R. Flegal, University of California Santa Cruz, Santa Cruz, CA. The mission of the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) is to provide the information needed by policy makers, water quality managers, and the public to make decisions about stewardship of this magnificent ecosystem. The RMP and other programs collect a wealth of information on the soup of chemicals that pervades the waters of the Bay, their sources and transport pathways, their cycling within the ecosystem, and the health threats they pose to wildlife and humans. To be useful to policy makers and the public, this complex mass of data must be boiled down to simple and clear statements about the condition of the Bay. Drawing on information summarized in a recent series of synthesis articles on contamination in the Bay, a concise and simple summary has been developed that retains enough

detail to be an accurate reflection of reality, yet is intended to be readily understood by all through a visual representation. Methylmercury, PCBs, dioxins, and exotic species are the currently regulated pollutants that pose the most severe problems in the Bay. Recovery in a 20-year timeframe is possible for methylmercury (though further deterioration is also possible), slight recovery is anticipated for PCBs, and recovery for dioxins and exotic species is not expected in this timeframe. Significant concerns also exist for selenium, PAHs, and legacy pesticides (dieldrin, DDT), though the degree of present impairment is not clear. Nickel, copper, and nutrients are below thresholds, but merit continued tracking. Emerging concerns that are currently not specifically regulated but appear to pose significant risks include PBDEs, pyrethroids, and sediment toxicity. The combined effect of pollutant mixtures is also a continuing concern. Urban runoff is an important pathway for many of the pollutants of concern. River inflow, remobilization from sediment, and wastewater discharges are also important for multiple pollutants. The Lower South Bay is particularly impacted by many pollutants. Important information gaps include sources of methylmercury, selenium fate and transport, and sources of sediment toxicity.

388 Risk Assessment in an Emerging Regulatory Process. B.D. McGaughey, Compliance Services International, Lakewood, WA; A.T. Hall, Bayer CropScience, Research Triangle Park, NC; D. Staats, CropLife America, Washington, DC. The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and the Endangered Species Act (ESA) both require an assessment of the impact of pesticide use on threatened and endangered species. Even though the agencies and statutory language of the Acts differ, the species risk assessment conducted under FIFRA is essentially equivalent and compatible to the effects determination made under ESA. While certain definitions vary in the underlying regulations, these language differences do not equate to a difference in scientific principles. In conducting evaluations of potential risk, both EPA, in operating under FIFRA, and the Services, in operating under ESA, are required to use best available methods and data to characterize the presumed risk. This presentation will examine how these methods address the statutory demands of both FIFRA and ESA with respect to the protection of endangered species from potential risks related to pesticide use. Of interest is the examination of where the two Acts intersect and how efficiency might be brought to the evaluation process through a common and transparent approach to risk assessment (the process described by FIFRA) and effects determinations (the process described by ESA). A process for identification and selection of the best available science will be examined as well as the manner in which uncertainties can be addressed. Experience with and an understanding of pesticide use parameters, labeling and agronomic or other application practices are all important to apply when initiating the FIFRA risk assessment process. While the FIFRA risk assessment general process is described in EPA's Overview Document and accompanying instructive guidance documents, and the effects determination process is described in ESA's Consultation Handbook and other supportive materials, the approach to and order of assessment steps may not be clear to the evaluator who is inexperienced in one or both of the Acts. This presentation outlines suggestions for conducting the FIFRA species and risk assessment in a manner that is equivalent to the ESA effects determination. Examined here are the state of the science of risk evaluation and the best methodologies that can now be applied to it, recognizing the challenges brought by emerging policy as well as emerging science.

389 Overcoming the technical challenges of an international human and ecological health risk project in Western Africa. G. Sower, A. Ackerman, W. Hillwalker, L. Quarles, K. Anderson, Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR; M. Sarr, C. Toure, CERES/Locustox, Dakar, Senegal. A multi-year, multinational project to field sample bioavailable pesticides in an effort to assess human and ecological health risks in western Africa has been initiated. The project aims to transfer passive sampling technology and expertise from Oregon State University to several West African laboratories beginning with the CERES/Locustox lab in Dakar, Senegal. From the beginning, the importance of developing conceptual site models and adequate terminology in cooperation with local scientists was understood, yet more basic issues became apparent. In its first year the project presented significant challenges regarding development of a quality assurance plan and methods applicable to multiple laboratories with varying equipment and skills, determining the most important analytes on which to focus, and then strategically sampling 6000 km of rivers. In an effort to help others

overcome similar challenges and promote continued international projects, we relate strategies, technologies, and techniques that proved effective.

390 Joining aquatic toxicity and treatability: a complete environmental profile of consumer products. M. Gausman, S. Belanger, J. Brill, K. Casteel, T. Federle, B. Nuck, B. Price, J. Rawlings, Procter and Gamble, Cincinnati, OH. Aquatic toxicity testing of chemicals for risk assessments is done one chemical at a time. However, products and consumer use result in complex mixtures discharged to wastewater treatment containing chemicals with various physical-chemical profiles. Here we report on a testing strategy for simultaneous evaluation of numerous components in consumer products that can be used to confirm the validity of single chemical assessments. Lab-scale wastewater treatability of consumer products or individual chemicals is coupled with toxicity testing of resulting effluents using multiple trophic levels (aquatic plants, invertebrates, and fish). The test system increases realism by accommodating different fate profiles (biodegradation, sorption) of chemical components and exposure to test organisms. Chemical removal by the system is environmentally representative and produced effluents still allow for identification of toxicity via sensitive species. The system and test results are discussed.

391 Framework for Application of the Toxicity Equivalence Methodology for PCDDs, PCDFs and PCBs in Ecological Risk Assessment. T.R. Henry, Office of Prevention, Pesticides & Toxic Substances, U.S. Environmental Protection Agency, Washington, DC; P. Cook, Office of Research & Development, U.S. Environmental Protection Agency, Duluth, MN; P. Cirone, Retired, U.S. Environmental Protection Agency, Seattle, WA; M. DeVito, Office of Research & Development, U.S. Environmental Protection Agency, RTP, NC; B. Duncan, Region 10, U.S. Environmental Protection Agency, Seattle, WA; R. Pepin, Region 5, U.S. Environmental Protection Agency, Chicago, IL; S. Schappelle, Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC; S. Wharton, Region 8, U.S. Environmental Protection Agency, Denver, CO. Polychlorinated dibenzo-p-dioxins (PCDDs), dibenzofurans (PCDFs) and biphenyls (PCBs) commonly occur as complex mixtures in environmental media and in animal tissues. For more than a decade, the U.S. Environmental Protection Agency (EPA) and other organizations have estimated the combined risks that such mixtures pose to human health using a method known as the toxicity equivalence methodology. Application of this methodology in ecological risk assessments has proceeded more slowly, in part because of the variety of species from different taxonomic classes that need to be considered. As both data and experience with the methodology have accumulated, experts have reached consensus that the toxicity equivalence methodology can strengthen ecological risk assessments. To advance the application of this methodology to ecological risk assessments, EPA's Risk Assessment Forum has developed the "Framework for Application of the Toxicity Equivalence Methodology for Polychlorinated Dioxins, Furans and Biphenyls in Ecological Risk Assessment". The draft framework originated from recommendations from a 1998 workshop sponsored by EPA and the U.S. Department of the Interior. It is intended to assist EPA scientists and decision makers in effectively using the toxicity equivalence methodology. The draft framework provides an introduction to the toxicity equivalence methodology, offers considerations for how and when to apply it and presents practical examples of use of the methodology. It presents a scientifically sound method for use in conducting risk assessments involving dioxin-like chemicals and serves to enhance the application of the best available science. In addition, the draft framework highlights uncertainties that may be reduced through the incorporation of future research results. This is an abstract and does not necessarily reflect EPA policy.

392 The Influence of Land-use on Riverine Delivery of Contaminants to Estuaries. R.J. Fauver, N. Nibbelink, J.T. Peterson, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA; A.T. Fisk, Great Lakes Institute for Environmental Research, University of Windsor, Windsor, Ontario, Canada; K. Pleskach, G. Tomy, Freshwater Institute, Dept. of Fisheries and Oceans, Winnipeg, Manitoba, Canada. Trace amounts of organic chemical contamination in natural waters is an inadvertent consequence of human activity. General land-uses (urban or agriculture) produce unique contaminants that may be delivered to streams and rivers by run-off, municipal and industrial discharges, or atmospheric deposition. Our objectives are to quantify organic contaminants in river water associated with general land-uses and model their transport downriver. The study Rivers, the Altamaha and Ogeechee, in Georgia have been impacted by population growth, which has resulted in land transformation from forest

land to urban and agriculture areas. Sampling sites were chosen by dividing the river into land-use classes (urban, agricultural, and mixed) and distance from the estuaries (near and far) as well as one site at the estuary of each river. Water samples were analyzed for perfluorinated compounds (PFCs), and two PFCs, perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA), were detected in the study Rivers. The Altamaha River is comprised of three rivers, the Ocmulgee, Oconee, and Oohoopee Rivers. PFOA was detected in the Ocmulgee River (6.36 ng/L) and Oconee River (5.00 ng/L) but not in the Oohoopee River. Upstream of the Altamaha River estuary PFOA was found in higher concentrations (15.83 ng/L) indicating a source for PFOA or accumulation of PFOA throughout the river system. PFOS was found in the Ocmulgee River (21.26 ng/L), Oconee River (5.41 ng/L) but not detected in the Oohoopee River. PFOS concentrations in the Altamaha River (5.66 ng/L) were similar to the Oconee River and lower than the Ocmulgee River. The Oohoopee is relatively unimpacted by urbanization, which may explain the absence of PFCs in this water. The Ogeechee River, which is in the same geographic area but completely separate from the Altamaha watershed, had the highest detected level of PFOA (23.52 ng/L) and a comparable level of PFOS (7.86 ng/L). Sources of PFCs in these rivers are unknown, and the impact to the estuary must be examined further.

392.5 A Screening-Level Risk Assessment Program for Golf Course Superintendents: Enabling Site-Based Risk/Benefit Considerations. S.Z. Cohen, J. Lam, Q. Ma, Environmental & Turf Services, Inc., Wheaton, MD; B. Branham, T. Fermanian, T. Voigt, University of Illinois, Urbana-Champaign, IL; J. Grant, M. Petrovic, Cornell University, Ithaca, NY. EPA registration decisions are based on a national perspective and considerations of regional crop/soil/climate scenarios in the context of risk/benefit analyses. There are over 18,000 golf courses in the US, and most are managed by superintendents. Some superintendents have expressed a need for risk assessment capabilities due to concerns for the local environment and/or specific land use permit requirements relevant to turf management and/or water quality monitoring. The Env'l Inst. for Golf (Golf Course Supt's Assoc. America) has joined with the US Golf Assoc. to fund the development of a user-friendly risk assessment scheme for superintendents. The goal is to develop comparative screening-level risk assessments to permit superintendents to consider environmental risk as another factor in deciding which pesticides to use. Data for approximately 100 pesticides have been/are being tabulated in the following categories: mammalian (human) toxicity; eco tox (aquatic, terrestrial invertebrates, and avian); and environmental fate. The appropriate toxicology endpoints are being integrated into a risk assessment program with EPA's SCI-GROW model for ground water and the Pfleeger et al. (1996) modification to the Kenaga nomogram for avian risks. We are evaluating the use of TurfPQ as well as EPA's PRZM runoff model for runoff coupled with simple surface water dilution scenarios or EXAMS. Two approaches are being investigated to assess non-target terrestrial invertebrates. When feasible, we intend to incorporate some regional or site-specific considerations i.e., temperature, rainfall, turfgrass variety, and soil texture variability. There will be a graphical user interface, and the output will be simple depictions of varying level of potential risk and/or occurrence concerns for the pesticides of interest and for different endpoints – human risk via drinking water (surface and ground water), avian risk, and terrestrial invertebrates. We are also examining the feasibility of integrating these modeling results with monitoring results. This would be used by the individual superintendents as part of their comprehensive IPM programs, and it is not intended to become a quasi-regulatory tool. We invite comments on the proposed modeling methods, the structure of the database, and the output. Completion is expected in 2008.

394 Chiral and isomer-specific chlordane signatures in stormwater runoff from different urban landscapes. K. Maruya, W. Lao, K. Schiff, SCCWRP, Costa Mesa, CA; J. Gan, University of California, Riverside, CA. Although it is well known that urban stormwater runoff can be a major contributor of particle reactive contaminants to receiving waters, little is known about specific land use contributions to wet weather contaminant loads. To determine if isomer- and chiral signatures can be used to help identify/apportion sources, we measured the enantiomer fraction (EF) and simple concentration ratios of trans- and cis-chlordane (TC/CC) in stormwater particulate material and bedded sediments from the Newport Bay (California, USA) watershed by enantiomer-specific GC-ECD. Differences in TC/CC for stormwater particles among sites representing active construction (i.e. land conversion), residential, industrial/commercial and agricultural land use were observed, with TC being depleted for all but the residential site and

receiving water sediments. For all samples, the (+) TC and (-) CC enantiomers were enriched relative to their antipodes. Moreover, chlordane EFs were most similar among agricultural and construction land use sites, which also contained the highest total chlordane concentrations for the events sampled. In the end, values of TC/CC and EFs measured in stormwater from integrative sites at the bottom of the watershed were consistent with a simple weighted average of those representing the land use categories sampled in this study. These results suggest that chlordane isomeric and enantiomeric signatures maybe useful in distinguishing among land use specific contributions to wet weather loads.

395 Chiral Organochlorine Contaminants and Maternal Transfer to Eggs of Glaucous Gulls From the Norwegian Arctic. M.S. Ross, C.S. Wong, Department of Chemistry, University of Alberta, Edmonton, Alberta, Canada; J. Verreault, R.J. Letcher, National Wildlife Research Centre, Science and Technology Branch, Environment Canada, Carleton University, Ottawa, Ontario, Canada; G.W. Gabrielsen, Norwegian Polar Institute, Tromsø, Norway. The glaucous gull (*Larus hyperboreus*) from Svalbard, in the Norwegian Arctic, has been used as biomonitoring species of the Arctic marine environment. Svalbard glaucous gulls have been shown to accumulate some of the highest concentrations of organochlorine (OC), brominated, and fluorinated contaminants among arctic seabird species. Furthermore, eggs have been commonly used to assess the degree of contamination in glaucous gulls. However, to date, the enantiomer distribution of chiral pollutants in glaucous gulls from this region is unknown. While non-racemic enantiomeric fractions (EFs) of some OC pollutants have previously been found in raptor and seabird eggs, the reason for these non-racemic EFs has not yet been investigated. In this study, blood (plasma) was collected from male and female glaucous gulls from Svalbard, Arctic Norway, and eggs were collected concurrently from within the same nesting colonies. Using chiral gas chromatography/mass spectrometry, the EFs of several legacy OC pollutants, including PCBs, α -HCH, heptachlor, and oxychlordane, were measured in both plasma and egg yolk samples. Non-racemic EFs were found in these samples, and a comparison of female plasma EFs to those measured in the egg yolk provides insight into the enantiomeric composition of OC pollutants in adults, as well as into the stereoselective nature of the subsequent maternal transfer. In addition, these results shed light on the feasibility of using eggs as a non-invasive technique to measure the EFs of OC pollutants within a population, and have implications for further biomonitoring studies using this species.

396 Using chirality to inform the metabolism of triadimefon to triadimenol: a cross-species examination. J.P. Overmyer, Department of Entomology, University of Georgia, Athens, GA; J. Kenneke, C. Mazur, A. Garrison, U.S. Environmental Protection Agency, National Exposure Research Laboratory, Athens, GA; J. Avants, Senior Service America Inc., U.S. Environmental Protection Agency, National Exposure Research Laboratory, Athens, GA; M. DeLorenzo, P. Key, NOAA, National Ocean Service, Center for Coastal Environmental Health and Biomolecular Research, Charleston, SC. Triadimefon is a systemic agricultural fungicide of the conazole class whose metabolite, triadimenol, provides the majority of the actual fungicidal activity; i.e. inhibition of steroid demethylation. Triadimenol is also registered and used as a fungicide. Both chemicals are chiral: triadimefon has one chiral center with two enantiomers while its enzymatic reduction to triadimenol produces a second chiral center and four enantiomers (two diastereomers). Our research involves treatment of microsomes prepared from a variety of mammalian, fish and invertebrate species with triadimefon, followed by analysis of the triadimenol metabolites using a chiral BGB-172 column in a GC-MS system. The two triadimefon enantiomers and the four triadimenol enantiomers are separated from each other so that the stereoselectivity of loss of the parent and formation of the metabolite can be observed. In vitro exposure of microsomes from seven species with subsequent chiral analysis shows that the (+)-enantiomer of triadimefon is transformed to triadimenol faster than the (-)-enantiomer in all these microsomes, but that the pattern of stereoselectivity of formation of the latter differs for all species. Since it is known that the diastereomers of triadimenol differ in their toxicities, the resulting biological activity of this metabolite most likely depends on the pattern of stereoisomers formed. Interspecies comparison by chiral analysis may be useful in probing the metabolism of pesticide-exposed organisms as well as improving cross-species extrapolation for risk assessment. Disclaimer: Although this work was reviewed by EPA and NOAA and approved for publication, it may not necessarily reflect official Agency policies. Mention

of trade names or commercial products does not constitute endorsement or recommendation for use.

397 Chiral Source Apportionment of Polychlorinated Biphenyls to the Hudson River Estuary Atmosphere and Food Web. L.A. Rodenburg, Environmental Sciences, Rutgers University, New Brunswick, NJ; B.J. Asher, C.S. Wong, Department of Chemistry, University of Alberta, Edmonton, Alberta, Canada. The New York/New Jersey Harbor Estuary is subject to significant contamination of polychlorinated biphenyls (PCBs) from numerous sources, including the historically contaminated Upper Hudson River, storm water runoff and sewer overflows, and atmospheric deposition from PCBs originating from the surrounding urban area. However, the relative importance of these sources to the estuary's food web is not fully understood. Sources of PCBs to the estuary were apportioned using chiral signatures of PCBs in air, water, total suspended matter, phytoplankton, and sediment. PCBs 91, 95, 136, and 149 were racemic in the atmosphere of the estuary. However, the other phases contained nonracemic PCB 95 and to a lesser extent PCB 149. Thus, the predominant atmospheric source of these congeners is likely unweathered local pollution and not volatilization from the estuary. The similarity in chiral signatures in the other phases is consistent with dynamic contaminant exchange among them. Chiral signatures in the dissolved phase and total suspended matter were correlated with Upper Hudson discharge, suggesting that the delivery of nonracemic contaminated sediment from the Upper Hudson, not the atmosphere, controls phytoplankton uptake of some PCBs. Thus, measures to control PCB contamination in the Upper Hudson should be effective in reducing loadings to the estuary's aquatic ecosystem.

398 Apportionment of Asian, Pacific Northwestern, and Pacific Ocean Air Masses using Chiral Signatures. S. Genualdi, T. Primbs, S. Simonich, Department of Chemistry, Oregon State University, Corvallis, OR; T. Bidleman, L. Jantunen, Centre for Atmospheric Research Experiments, Egbert, Ontario, Canada; S. Simonich, Department of Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR. The goal of this research is to use the enantiomer fractions of chiral pesticides measured in soils to apportion the relative contributions of these source regions to air masses in the Western United States. Because the re-volatilization of pesticides from agricultural soil is thought to be a major source of organochlorine pesticides to the environment, soil samples were collected from agricultural areas in four Chinese cities, and also from agricultural areas in the Pacific Northwest. During the spring of 2004, hi-volume air samples were collected during an intensive air sampling campaign on Okinawa Japan. Hi-volume air samples were also collected at three different air sampling locations in the Pacific Northwest from 2003 to 2006: Cheeka Peak, a coastal site on the Olympic Peninsula of Washington at 500m, Mary's Peak, a 1250m site in Oregon's Coastal range, and Mt. Bachelor, a 2300m site located in the Oregon Cascades. The enantiomer fractions of α -Hexachlorocyclohexane, cis and trans chlordane, and o,p'-DDT were determined in both the soil and the hi-volume air samples using GC-MS in ECNI mode. The enantiomers were separated using a 15m DB-5 column in tandem with a 15m BGB Analytik chiral column. The enantiomer fractions were calculated in the air and soil samples and a source apportionment model was used to determine the relative contribution of source regions.

399 Environmental Fate of Chiral Pesticides Used in Canada. P.B. Kurt-Karakus, T.F. Bidleman, L. Jantunen, Center for Atmospheric Research Experiments, Environment Canada, Egbert, Ontario, Canada; D. Muir, J. Struger, S. Cagampan, J. Small, National Water Research Institute, Environment Canada, Burlington, Ontario, Canada. Approximately 25% of modern pesticides are chiral molecules consisting two or more enantiomers. Knowledge of the toxicology and environmental fate of the individual enantiomers is important for several reasons. It is quite common that one enantiomer of a pesticide is effective while the other one is not. Toxic responses of nontarget organisms differ for the enantiomers. Enantiomers are degraded at different rates and sometimes can be interconverted in the environment. The objectives of this study were to: 1. Determine which chiral currently used pesticides (CUPs) in Canada are amenable to separation of enantiomers by GC-MS and HPLC-MS methods, 2. Determine selected chiral CUPs in water, precipitation and soil. Method development for separating enantiomers of 10 CUPs by GC-MS and one CUP by LC-MS has so far been achieved successfully. Water sample extracts from the 2004 Ontario Region Pesticide Science Fund sampling campaign were analyzed for mecoprop and dichlorprop after derivatization using chiral capillary GC-MS and metolachlor

was analyzed for all four stereoisomers by chiral LC-MS. Results for 19 water samples showed that (+) mecoprop was preferentially depleted in 21% of the samples, (–) mecoprop in 63% and racemic mecoprop occurred in 16%. For dichlorprop, enantiomer profiles favored depletion of the (+) enantiomer in all samples. Racemic mecoprop was last used in Canada in 2004 and replaced by single-enantiomer (+) mecoprop. Results for the water samples are consistent with a mixture of racemic and single-enantiomer products being used during this transition year, selective degradation of (+) mecoprop, or its conversion to the opposite enantiomer (–) mecoprop, as has been reported in some soils from Switzerland. Metolachlor stereoisomers were detected in 81 surface water samples. The isomer distribution patterns of metolachlor in all surface water samples were similar; enrichment of C^{*}S_aR and C^{*}S_aS diastereomers which are the components of enantioenriched S-metolachlor. However, at this point, we do not know whether the observed isomer profiles are due solely to S-metolachlor, or if some selective degradation has taken place.

400 Fate of chiral organic pollutants in the environment. M. Koblizkova, D. Nemethova, J. Jarkovsky, J. Klanova, RECETOX Research Centre for Environmental Chemistry and Ecotoxicology, Brno, Czech Republic; T.D. Bucheli, Forschungsanstalt Agroscope Reckenholz-Tänikon ART, Zürich, Switzerland. Two-dimensional gas chromatography was used for analysis of chiral compounds, which were extracted from soil and air samples. Enantiomeric fraction (EF) values were used to describe enantiomeric signatures. EF values in soil ranged from 0.408 to 0.524 for PCB 95, from 0.458 to 0.597 for PCB 132, from 0.494 to 0.547 for PCB 149 and from 0.478 to 0.535 for PCB 174. In some soil samples were also measured EF values of selected OCPs. EF values for α -HCH ranged from 0.475 to 0.517, for o,p'-DDD from 0.368 to 0.570 and for o,p'-DDT from 0.365 to 0.513. Relationship between EF values and organic carbon content and other physical and microbiological properties was also studied using multidimensional statistical analysis (PCA). The same analysis was performed with deviations from racemic mixture. Principal component analysis resulted in three latent factors explaining 75.7% of the total variance. The first principal component accounted for 53.6% of total variance in data. The most important soil variable highly correlated with the first principal component was organic carbon content, fulvic acids contents, humic acids content, total nitrogen amount and basal respiration; these correlations allow as to interpret the first factorial axis as related to microbial activity in the soil. pH was highly correlated with second principal component, which explained 12.7% of variability in data. PCB 149 (deviation from racemic mixture) correlated negatively with first principal component and pH. PCB 132 correlated positively with the first principal component, although the correlation was not significant. Significant negative correlations between PCB 132 and extractable carbon, humic acids content and Q4/6 were found. PCB 95 did not correlate significantly with any soil variable as well as with first principal component. Air samples were collected at the soil sampling stations in the Czech Republic, former Yugoslavia and Oman using the passive air samplers, and analyzed for PCBs. Irrespective of the samples origin, their EF values did not differ significantly from the value of a racemic mixture, and they ranged from 0.48 to 0.51. Volatilization of chiral compounds was studied using hat-sampler, which sampled the air over the soil surface. EF values are approaching values found in corresponding soils.

401 Enantiomerization of Pyrethroids in Solvents. J. Gan, S. Qin, Environmental Sciences, University of California Riverside, Riverside, CA. All pyrethroids are chiral compounds and isomerization has been frequently observed from exposure to heat, sunlight or certain solvents. However, so far isomerization of pyrethroids has not been characterized at the enantiomer level. In this study, we evaluated the occurrence of enantiomerization of permethrin and cypermethrin in various organic solvents and solvent-water systems. The four stereoisomers of permethrin were stable under all test conditions. Rapid enantiomerization of cypermethrin was observed in some alcohols, but the rate of enantiomerization varied greatly among different alcohols. Extreme rapid conversion occurred in ethanol, which was followed by methanol, 2-methyl-1-propanol and then 1-propanol. Enantiomerization invariably took place at the α carbon position. The rate of enantiomerization was temperature dependent, and was also influenced by water as a co-solvent. The presence of water in methanol greatly enhanced enantiomerization of cypermethrin, especially at water lower than 10%. Results from this study suggest that exposure to certain solvents and water may cause artifacts in chiral analysis and that for enantiomer-enriched pyrethroid products, such as abiotic enantiomerization may render the products less effective. Therefore,

enantiomerization induced by solvents should be carefully considered for rigorous analysis or proper handling of enantiomer-enriched products.

402 Stereospecific analysis of wastewater-derived chiral beta-blockers and selective serotonin re-uptake inhibitors by high performance liquid chromatography-tandem mass spectrometry. C.S. Wong, S.L. MacLeod, S. Priya, Chemistry, University of Alberta, Edmonton, Alberta, Canada. Enantiomer fractions (EF) and concentrations of pharmaceuticals were measured in wastewater using chiral liquid chromatography-tandem mass spectrometry (HPLC-MS-MS). Enantiomer resolution of six β -blockers (atenolol, metoprolol, nadolol, pindolol, propranolol, and sotalol) along with two selective serotonin re-uptake inhibitors (citalopram, fluoxetine) and one β_2 -agonist (salbutamol) was achieved with the Chirobiotic V chiral HPLC column using a 90:10 methanol:water eluent with 20 mM ammonium acetate, 0.1% formic acid run isocratically. Analyte recovery averaged 86% in influent and 78% in effluent with limits of detection ranging from 0.2 to 7.5 ng/L. These results represent an significant improvement over previous chiral HPLC-based wastewater EF measurement for atenolol, metoprolol and propranolol, and are similar to achiral HPLC measurements providing less information about pharmaceuticals in aquatic solution. Matrix effects, common in electrospray ionization, were negligible between enantiomers except for sotalol, based on enantiomer-specific standard addition. Nonracemic influent values for a number of analytes indicate input of biologically-degraded drugs to waste systems. Changes in EF within the Edmonton Gold Bar tertiary wastewater treatment plant was likely from biologically-mediated stereoselective processes occurring during wastewater treatment. To our knowledge, this work represents first EF measurements of citalopram, fluoxetine, nadolol, pindolol, salbutamol and sotalol in wastewaters.

403 Effects of single-walled carbon nanotubes on hydrophobic organic contaminant bioaccumulation by estuarine invertebrates. L. Ferguson, B. Englehart, A. DeMarco, W.A. Scrivens, Dept. of Chemistry & Biochemistry, University of South Carolina, Columbia, SC; T. Chandler, W.W. Klauber, K. Washburn, Dept. of Environmental Health Sciences, University of South Carolina, Columbia, SC; L. Ferguson, T. Chandler, R.C. Templeton, Marine Science Program, University of South Carolina, Columbia, SC. Single-walled carbon nanotubes (SWNT) have extremely high affinity for hydrophobic organic contaminants – considerably higher than natural or refractory (e.g., soot and detrital) carbon found in sediments. To evaluate the effect of sediment-associated SWNT on contaminant uptake from sediments by infaunal deposit feeders, we have conducted a comparative bioaccumulation study using two infaunal estuarine invertebrates – the deposit-feeding meiobenthic copepod *Amphiascus tenuiremis*, and the deposit/suspension-feeding polychaete *Streblospio benedicti* – exposed to hydrophobic organic contaminants (HOCs) including PAHs, PCBs and PBDEs for 14 days in the presence of sediment amended with (1) (SWNTs), (2) NIST diesel soot, or (3) no carbon amendment. Comparative BSAFs were determined for each analyte and taxon. Results indicate that the co-addition of SWNT to sediments significantly reduced bioaccumulation of HOCs in *S. benedicti*; however, soot addition to sediment tended to increase the bioaccumulation of these same compounds in the polychaete worm. Bioaccumulation of HOCs from sediments by copepods (*A. tenuiremis*) was less dependent on black carbon addition to sediment, as neither SWNT nor soot significantly impacted bioaccumulation of PAHs from sediment by this organism. To assess the potential mechanisms by which SWNT modulate contaminant uptake in exposed benthic organisms, we have initiated experiments to track accumulation of radiolabeled (^{14}C) SWNT from amended sediments by the polychaete *S. benedicti*. These experiments will be interpreted in the context of active sequestration of SWNT by these organisms and the implication for co-transport and uptake of adsorbed hydrophobic organic contaminants.

404 Bioaccumulation of Quantum Dots in a Simplified Food Web. D. Holbrook, Surface and Microanalysis Science Division, NIST, Gaithersburg, MD; K. Murphy, Analytical Chemistry, NIST, Gaithersburg, MD; J. Morrow, K. Cole, Biochemical Science Division, NIST, Gaithersburg, MD. Trophic transfer is a potential means for engineered nanomaterials to enter the food web after environmental release. Many engineered nanomaterials possess one or more characteristics that make them ideal candidates for trophic accumulation via biomagnification and bioaccumulation: biologically and environmentally stable material; small size; soluble in aqueous solutions; and non-lethal to whole organisms at environmentally relevant concentrations. We have investigated dietary accumulation, toxicity, and depuration of two

surface functionalized quantum dots (carboxylated and biotinylated QDs) using a simplified laboratory-based food web consisting of soil, the ciliate *Tetrahymena pyriformis*, and rotifer *Brachionus calyciflorus* to investigate the potential and extent of QD trophic biomagnification. Grazing experiments between the ciliates and soil-associated QDs indicate both types of QDs are readily accumulated by *T. pyriformis*. Similarly, predation experiments between the ciliate-associated QDs and rotifers indicate QD uptake and transfer to *B. calyciflorus*. Bioconcentration factors for *T. pyriformis* ranged between 300 and 1500 while biomagnification factors for *B. calyciflorus* varied between 5 and 20. Growth kinetic studies indicated no QD toxicity to either *T. pyriformis* or *B. calyciflorus* after 200 hours of contact. Our results demonstrate that QDs can enter and remain in a simplified food web. This presentation will focus on the trophodynamics of COOH and biotinylated QDs in a simplified freshwater food web. Quantified bioaccumulation and depuration rates will be presented along with confocal laser scanning microscopy (CLSM) and high-resolution structured illumination microscopy images detailing the spatial distribution of QDs within the biological organisms. Implications to aquatic ecosystem and human health will be discussed.

405 A product stewardship evaluation of potential environmental effects of titanium dioxide (TiO₂) nanoparticles. D.J. Caldwell, Worldwide Environment, Health, and Safety, Johnson & Johnson, New Brunswick, NJ. Titanium dioxide nanoparticles are increasing used in sunscreen applications because of the benefits they provide (e.g., increased UV-A and UV-B protection and cosmetic transparency). A significant mammalian toxicology database on TiO₂ exists, and many years of use have indicated no safety concerns. Under our product stewardship program, we decided to investigate the potential effects of acute exposure of fish (fathead minnow, *Pimephales promelas*) to insoluble nanoparticles of TiO₂ because of the lack of data on potential aquatic toxicity. However, prior to initiating the study, the first report on aquatic toxicity of insoluble nano-TiO₂ was published that showed *Daphnia magna* had >100 times more toxicity after exposure to a filtrate of solvent suspended nano-TiO₂ solution than a sonicated solution, and the authors' further concluded micro-TiO₂ was less acutely toxic than nano-TiO₂ [1]. The differential toxicity reported for nano- and micro-TiO₂ signaled that there may be a potential aquatic hazard; however, information presented at the SETAC Europe meeting in May 2006 showed no significant toxicity in four studies on daphnids and earthworms exposed to nano-TiO₂ at levels below 100 mg/L (100 ppm) and none of these studies used a solvent [2,3]. To address the effects of carrier solvent on aquatic toxicity potential, we modified the fish study and solvation of nano-TiO₂ and stability of the resulting suspension was determined in six solvents, with ethanol selected as the carrier solvent. Standard aquatic toxicity testing protocols were used, and fish exposed (static-renewal) for 96-hr to nano-TiO₂ up to 10.0 mg/L (nominal) exhibited no toxicity. When the aquatic toxicity data are evaluated together, nano-TiO₂ has little potential for aquatic hazard. 1. Lovern, SB and Klaper, R (2006). *Daphnia magna* mortality when exposed to titanium dioxide and fullerene (C₆₀) nanoparticles. *Environ Toxicol Chem* 25:1132-1137. 2. Hund-Rinke, K and Simon, M. (2006). Ecotoxicity of photoactive nanoparticles (TiO₂), SETAC Europe 16th Annual Meeting Abstracts, The Hague, Netherlands, p. 48. 3. Fernandes, MT, et al. (2006) The effects on nanoparticles in aquatic invertebrates, op cit, p. 48.

406 Nanoparticles in soil and sludges: implications to microbial processes. R. Turco, M. Bischoff, Z. Tong, L. Nies, B. Applegate, L. Nyberg, Purdue University, West Lafayette, IN; R. Turco, Laboratory for Soil Microbiology, Purdue University, West Lafayette, IN. The impact of fullerene, as either C₆₀ or C₆₀ in aqueous suspension (nC₆₀), on key biological processes and the structure of the microbial community in soil and other systems was evaluated in microcosm studies. Clearly, the impact of manufactured nanomaterials on key biological systems and processes must be addressed so that an unbiased discussion concerning the environmental consequences of nanotechnology can take place. In this set of studies, soils were treated with a variety of materials including 1 $\mu\text{g g}^{-1}$ of nC₆₀, or 1000 $\mu\text{g g}^{-1}$ of granular C₆₀, or tetrahydrofuran residues equivalent to that generated during nC₆₀ formation process or water (control). Treated soils were incubated under both normal and dry soil. The effects on basal respiration, glucose-induced respiration, and soil enzymatic activities, β -glucosidase, acid-phosphatase, dehydrogenase and urease, were evaluated for the soils system. Effects of nanomaterial application on community structure were evaluated following direct extraction of genomic DNA from samples and

PCR amplification using universal primers for the bacterial variable V3 region followed by DGGE. Changes in the population structure were also evaluated by monitoring the amount of total phospholipid phosphate and phospholipid fatty acid profiles for the soils. Sludge systems were also treated with C60 in aqueous suspension, with C60 dissolved in biodegradable solvent (methanol/ethanol) and high concentrations of C60 plated on dried biosolids. Methanogenic gas production was measured in the sludge system relative to unexposed controls. In the sludge system bacterial, fungal and archaea primers were used to simultaneously evaluate community shifts of three kingdoms. Our observations show that the introduction of fullerene, as either C60 or nC60, has little impact on the structure and function of the soil microbial community and microbial processes in either soil or sludge systems.

407 Effect of Oxidative Processes on the Colloidal Stability and Sorption Properties of Carbon Nanotubes in Aquatic Environments. H. Fairbrother, B.A. Smith, F.K. Bangash, K. Wepasnick, Chemistry, Johns Hopkins University, Baltimore, MD; H. Cho, W.P. Ball, Geography and Environmental Engineering, Johns Hopkins University, Baltimore, MD. Oxidation is the most important chemical transformation that can occur to either multi-walled or single walled carbon nanotubes (MWCNTs and SWCNTs). For example, many purification and functionalization strategies involve refluxing CNTs with strong oxidizing agents, such as nitric acid. Oxidation can also occur after CNTs are released into the environment through exposure to oxidizing agents, such as ozone and hydroxyl radicals. In this presentation I will describe the relationships that exist among CNT oxidants (e.g. HNO_3 , O_3 and OH), the nature and extent of surface oxidation and CNT behavior in aquatic environments. Our results indicate that the introduction of oxygen-containing functional groups (surface oxides), that occurs when CNTs are exposed to oxidizing conditions, exert a pronounced influence on the properties of CNTs in aquatic environments. Specifically, more highly oxidized CNTs remain stable over a wider range of aquatic conditions (defined by pH, ionic strength and the concentration of Ca^{2+} and Natural Organic Matter (NOM)). Furthermore, UV-vis spectroscopy and dynamic light scattering show that well-defined relationships exist between the level of CNT surface oxidation and their colloidal stability and aggregation rates, respectively. The sorption properties of CNTs also display systematic variations as the level of surface oxidation increases: adsorption of ^{14}C labeled-naphthalene, a hydrophobic organic chemical, decreased linearly while divalent heavy metal contaminants like Zn^{2+} showed an increasing affinity towards more highly oxidized CNTs. In general, our studies highlight the fact that even comparatively small changes in surface oxygen concentration are responsible for pronounced changes in the behavior of CNTs. The implications of these results on the fate and transport of CNTs in aquatic environments will also be discussed.

408 Comparative analysis of the effects of sublethal nanoparticulate metal exposure to zebrafish gills. J. Grifflitt, N.D. Denslow, D.S. Barber, Center for Environmental and Human Toxicology, University of Florida, Gainesville, FL; K. Hyndman, Department of Zoology, University of Florida, Gainesville, FL. We currently have little knowledge about the potential for environmental and ecological effects of nanometals. Because many of the metals being used as particles are toxic to aquatic life in soluble forms, it seems likely that nanometallic particles may also pose a toxic threat to aquatic organisms. We have previously shown that nanocopper exposure causes primarily gill toxicity that is not explained by particle dissolution. To further investigate the toxic responses elicited by nanometals, zebrafish were exposed to sublethal concentrations of nanocopper, nanosilver, and nanTiO_2 , as well as separate exposures to soluble copper or silver at the concentrations released by particles over 48 hours. Gill samples were taken at 24 and 48 hours, and were analyzed for metal content, gene and protein expression levels, and histopathology. Initial microarray results indicate that both nanocopper and nanosilver cause strong transcriptional alterations at 24 hours. Nanocopper strongly induced expression of major histocompatibility complex class I, cyclophilin G, and CCR4-NOT transcription complex, among others. Nanosilver exposure resulted in strong responses from protein phosphatase 1, Solute carrier organic anion transporter, and WNT1 inducible signaling pathway, among others. The transcriptome profiles elicited by nanocopper and nanosilver exposures were fairly distinct. Histological examination of sagittal sections through the gill filaments from these fish revealed that 24 hour exposure to copper nanoparticles caused a 3.8 fold increase in filament width compared to control and silver particle treatments. Silver particle and control treatments were not statistically different from each other. After 48 hours of

exposure, filament width was still increased by nanocopper, while soluble copper had only increased filament width by 1.9 fold. These results suggest that copper nanoparticles selectively lead to a hypertrophy of the interlamellar cells following exposure. Collectively, these data show that the effects of metallic nanoparticles on the gills differ by the identity and form of the metal.

409 The Influence of Natural Organic Matter on the Fate and Effects of Carbon Nanomaterials. A.J. Edgington, S.J. Klaine, ENTOX, Clemson Institute of Environmental Toxicology, Pendleton, SC. The potential use of carbon-based nanomaterials continues to grow exponentially. From biomedical to material science applications the use of these materials will result in significant quantities of nanoparticles entering the aquatic environment. The solubility and bioavailability of these compounds may be influenced by the water quality of the receiving stream. Natural organic matter (NOM), for example, has been shown to increase the solubility of sparingly soluble organics. Recently, the stability of multi-walled carbon nanotube suspensions was increased in the presence of NOM. The goal of this study was to characterize the influence of NOM on the fate and bioavailability of multi-walled nanotubes, coiled nanotubes, coiled nanowires, and C-60 and C-70 fullerenes. The stability of each carbon nanoparticle suspension was assessed as a function of NOM concentrations. The data suggests that these hydrophobic materials can be stabilized in suspensions as nanoparticle-NOM complexes. The bioavailability and toxicity of these stable nanoparticle suspensions were then characterized using standard acute and chronic *Daphnia magna* bioassays. Furthermore, toxicity was quantitatively related to nanoparticle concentration within the stable suspension. Finally, confocal and fluorescence microscopy revealed the presence of nanoparticle aggregates outside of the intestinal tract within the daphnids.

410 Zebrafish as an in vivo model to assess nanomaterial/biological interactions. R.L. Tanguay, S.L. Harper, C.Y. Usenko, Environmental and Molecular Toxicology and the Environmental Health Sciences Center, Oregon State University, Corvallis, OR; R.L. Tanguay, S.L. Harper, C.Y. Usenko, Oregon Nanoscience and Microtechnologies Institute, Safer Nanomaterial and Nanomanufacturing Initiative, Corvallis, OR. The rapid growth of the nanotechnology industry will undoubtedly lead to increased environmental release of nanomaterials. An important step in determining whether there is a risk from these exposures is to define the structural properties of nanomaterials that lead to specific biological responses. It is expected that the biological activity of nanomaterials will depend on inherent physicochemical properties not routinely considered in toxicity studies such as particle size, particle charge, size distribution, and agglomeration status. The nanomaterial structural properties and resulting biological response for most classes of nanomaterials remain largely undefined. There is a pressing need to develop rapid, relevant and efficient testing strategies to fill this information gap. Early vertebrate developmental life stages are uniquely sensitive to environmental insult, due in part to the enormous changes in cellular differentiation, proliferation and migration that are required to form a complex animal. Thus, developmental life stage assessments have the highest probability to detect adverse nanomaterial/biological interactions. We are exploiting the advantages of embryonic zebrafish as an in vivo system to rapidly assess the morphological, behavioral, cellular, and genomic responses to nanomaterials. The data derived from embryonic exposures to several classes of nanomaterials including carbon fullerenes, carbon nanotubes, a series of metal oxides and a number of diverse gold nanomaterials will be presented. In addition, we are developing a collaborative knowledgebase of Nanomaterial-Biological Interactions (NBI). The NBI will serve as a repository for annotated data and will house computational and analytic tools to perform data integration over multiple structured and semi-structured data sources; thus providing the framework within the NBI to conduct species, route, dose and scenario extrapolations. Collectively, although it is currently not possible to predict toxic responses to nanomaterials, we have developed platforms that will help to move the nanotoxicology field in that direction. Supported by NSF grant RD-833320, NIEHS grants P30-ES03850, and T32-ES07060.

411 Nanoparticle toxicity studies with oyster cells, embryos, and adults. A. Ringwood, T. Changela, Biology, UNC-Charlotte, Charlotte, NC; N. Levi, D. Carroll, Physics, Wake Forest University, Winston-Salem, NC. There are numerous potential environmental risks of engineered nanoparticles that are not yet well-characterized or understood. Nanoparticles may be introduced into aquatic environments during production processes and also as a result of release following their use in electronic and biological applications. Filter-feeding bivalve mollusks spend their lives removing particles so they

are potentially very valuable as model species for characterizing nanoparticle bioavailability and interactions with basic cellular processes. The overall purpose of this ongoing program is to characterize the potential toxicity of various nanoparticle preparations (e.g. quantum dots, fullerenes, metal nanoparticles) to marine organisms using oysters, *Crassostrea virginica*. Nanoparticle exposure regimes were conducted with whole animals, isolated hepatopancreas cells, and embryos of oysters to characterize the relative toxicity based on different types of assays, and to determine if early developmental stages are more sensitive than adults. Generally, the lowest concentration at which significant toxicity was observed was similar between all assays, and between embryo assays and adult responses. Fluorescent confocal microscopy and electron microscopy were used to verify the accumulation of the nanoparticles inside hepatopancreas cells and embryos. These kinds of basic studies are essential for addressing the potential impacts of nanoengineered particles on fundamental cellular processes as well as aquatic organisms.

412 Using the UN Transformation/Dissolution Protocol in the Hazard Classification of Alloys. J. Skeaff, D. Hardy, Natural Resources Canada, CANMET-MMSL, Ottawa, Ontario, Canada. The UN Globally Harmonized System of Classification and Labelling of Chemicals (GHS) is intended to provide information to users on the identities and environmental hazards of chemicals in commerce, including metals, metal compounds and alloys. The data requirements for UN GHS application, which is underway within the EU, are considerable. For the hazard classification of metals, metal compounds and alloys, data from the UN GHS Transformation/Dissolution Protocol (T/DP), which measures the rate and extent of the release of metal ions to aqueous media under conditions representative of the environment, can be compared to ecotoxicity reference values. In this paper, we show how T/D data for Inconel, Monel, nickel-silver and ferronickel alloys could be used to derive their GHS hazard classification levels, and how a new Critical Surface Area-Toxic Units (CSA-TU) approach can be applied to some of the alloys. The data indicate that the proposed approach is precise and flexible, and accounts for the multi-component nature of alloys in their classification.

413 Physiological Interactions between Mercury and Selenium Determine Their Environmental Interactions. C.R. Ralston, N.V. Ralston, Energy & Environmental Research Center, University of North Dakota, Grand Forks, ND. To understand mercury (Hg) bioaccumulation and toxicity it is necessary to understand selenium (Se) metabolism. The molecular mechanisms of Se-dependent Hg-accumulation in plants and animals, Se-dependent Hg-retention from ecosystems, Hg toxicity, and Se-protective effects against Hg-toxicity all depend on the extraordinarily high binding affinity between Hg and Se (10⁴⁵). Although survival of plant life does not appear to depend on Se-dependent physiology, Hg-hyperaccumulator plant species accumulate more Hg in the presence of richer soil Se. Although the molecular form of Hg that accumulates has not been characterized, it may occur in the highly insoluble HgSe form known to accumulate in animal tissues. All forms of animal life that possess nervous systems require Se in order to form the rare but essential amino acid selenocysteine, the bioactive form of Se. Selenocysteine is required for the functions of Se-dependent enzymes, many of which are known to detoxify reactive oxygen metabolites formed as a natural consequence of aerobic metabolism. Se-dependent physiology is vulnerable to Hg toxicity because Hg can sequester the Se that is required for selenocysteine synthesis. Supplying supplemental Se has been shown to protect against Hg toxicity in all animal species studied. The concentrations of Hg in lake fish appear to be inversely related to environmental Se availability. Se additions to Se-deficient lakes have been found to decrease Hg bioaccumulation in fish, perhaps because the HgSe that is formed in organisms is biologically unavailable. Formation of HgSe in prey insects results in less Hg accumulation in the predatory insects and small fish that consume them and eventually results in less Hg bioaccumulation in larger predatory fish. It is important to note that although selenium's geological distribution follows regional trends, Se availability can vary over even short distances and is highly dependent on pH.

414 Cobalt: Application of an International Approach for Developing Environmental Criteria/Guidelines/Standards for Metals. W. Stubblefield, E. Van Genderen, Parametrix, Albany, OR; T. Brock, The Cobalt Development Institute (consultant), located at: Division of Occupational and Environmental Medicine, Dept of Community and Family Medicine, Duke Medical Center, Durham, NC; K. De Schampelaere, C. Janssen, Laboratory of Environmental Toxicology and Aquatic Ecology, Ghent University, Ghent,

Belgium; D. Heijerick, P. Van Sprang, Euras, Ghent, Belgium; R. Welton, The Cobalt Development Institute, Guildford, Surrey, United Kingdom. Water quality standards for cobalt have yet to be developed for the European Union, Canada, or the United States. As such, efforts have been made towards characterizing the toxicity and influence of various water quality parameters on the toxicity of cobalt to several freshwater species. *Ceriodaphnia dubia* and rainbow trout were among the species most sensitive to cobalt. Acute median-lethal concentrations (LC50s) for the species tested ranged from 0.7 to 140 mg Co/L for *C. dubia* and *Chironomus tentans*, respectively. Chronic test results indicate that invertebrate and plant species are substantially more sensitive to cobalt chronic exposure than are fish. Acute-chronic ratios were low for fish species (typically <5), moderate for plants (6-18), but were substantially greater for invertebrates (>100). Tests using a range of water-quality parameters were conducted and initial results suggest an important protective effect of Ca on acute and chronic toxicity of Co. The results of these tests will contribute to the development of Biotic Ligand Models (BLMs) for site-specific criteria derivation. Calculations of water quality standards/guidelines/criteria derived using procedures for the European Union, Canada, and the United States will be presented, compared, and contrasted.

415 Accumulation and Toxicity of Waterborne Copper in the Euryhaline Copepod *Acartia tonsa*: Protective Role of Dissolved Organic Carbon. S.C. Rodrigues, Pós-Graduação em Oceanografia Biológica, Fundação Universidade Federal do Rio Grande, Rio Grande, RS, Brazil; A. Bianchini, Departamento de Ciências Fisiológicas, Fundação Universidade Federal do Rio Grande, Rio Grande, RS, Brazil. There are few information about how natural organic matter (NOM), measured as dissolved organic carbon (DOC), from different sources influences accumulation and copper toxicity in marine invertebrates. Therefore, our main goal was to analyze possible NOM protective effects against whole body copper accumulation and waterborne copper toxicity (48-h EC50) in the euryhaline copepod *Acartia tonsa*. Three sources of NOM were used: Suwannee river commercial fulvic acid (SRFA), sewage treatment plant (STP)- and freshwater-derived NOM. The last two NOMs were extracted by reverse osmosis. Different combinations of copper and DOC concentrations were tested at salinities 5, 15 and 30 ppt. Salinity by itself was protective against copper accumulation and toxicity. In all salinities tested, copper accumulation and toxicity were generally lower in the presence than in the absence of DOC. However, the protective effect was dependent on the concentration and source of DOC. Higher protective effects were observed at the highest DOC concentration. Overall, freshwater- and STP-derived DOC were more protective than SRFA. These findings clearly indicate that both salinity and DOC (source and concentration) should be taken into account for regulatory purposes. Financial support: International Copper Association.

416 Tier 1 'Unit World' Model for Metals in Lakes. K.J. Farley, R.F. Carbonaro, Civil & Environmental Engr, Manhattan College, Riverdale, NY; K.J. Rader, D.M. Di Toro, Civil & Environmental Engr, University of Delaware, Newark, DE; K.J. Farley, R.F. Carbonaro, D.M. Di Toro, HydrQual, Inc., Mahwah, NJ. A "Unit World" Model for Metals (UWMM) has been developed to assess the ecological risks posed by metal inputs to aquatic systems. The Tier 1 version of the UWMM has been applied to an idealized lake with a vertically well-mixed water column overlying a sediment layer. Processes specifically considered in the model include dissolved and particulate phase transport, a simplified description of the biogeochemical cycling of organic carbon and sulfur, the complexation to organic carbon and inorganic ligands (as described by WHAM), metal hydroxide, carbonate and sulfide precipitation, and competitive interactions of metals and major cations to the biological site of action for water column and sediment-dwelling organisms (as described by the BLM). A user-friendly version of the UWMM has been developed using Microsoft Visual Basic and is used to develop a relative hazard ranking for metals (Al, Cd, Co, Cu, Ni, Pb, Zn) and several organic contaminants. The effects of organic carbon production, sediment AVS, metal dissolution kinetics, and toxic endpoint are highlighted as part of the ranking evaluation.

417 Update and evaluation of the freshwater copper BLM. R.C. Santore, A.C. Ryan, HydroQual, Inc., East Syracuse, NY; P.R. Paquin, HydroQual, Inc., Mahwah, NJ. The freshwater biotic ligand model (BLM) for copper has recently been updated with all relevant available toxicity data. Since the original BLM was developed, several toxicity experiments encompassing a wide range of exposure conditions have been conducted to evaluate BLM performance and applicability. The goal of this analysis was to

evaluate BLM performance with as much relevant toxicity data as possible. Nearly 900 median effect concentrations (EC50s) for copper were collected from twenty-three different individual datasets for a variety of freshwater organisms, including *Ceriodaphnia dubia*, *Daphnia magna*, *Daphnia pulex*, *Hyalella azteca*, *Oncorhynchus mykiss*, and *Pimephales promelas*. Experiments conducted with daphnids were especially useful in this work because those experiments contributed the majority of the data, and they covered the widest range of experimental conditions. The composition of exposure media varied widely, with calcium, magnesium, sodium, and potassium varying by approximately three orders of magnitude. Dissolved inorganic carbon concentration, and dissolved organic carbon concentration varied by slightly less than three orders of magnitude, and pH ranged from 5.5 to 8.7. With this range in exposure conditions it was possible to investigate bias in model predictions across the various water chemistry characteristics tested. In general, application of the BLM to this large dataset shows that the BLM is an effective tool for predicting the effect of wide ranges of bioavailability factors on copper toxicity.

418 Prediction of Chemical Speciation, Toxicity and estimated site-specific Water Quality Criteria for Copper in San Diego Bay. I. Rivera-Duarte, D.B. Chadwick, P. Wang, G. Rosen, Code 2375, SPAWAR Systems Center San Diego, San Diego, CA; W. Choi, SPAWAR Computer Sciences Corporation, San Diego, CA; R.C. Santore, A.C. Ryan, HydroQual, Inc, East Syracuse, NY; P.R. Paquin, HydroQual, Inc, Mahwah, NJ. Copper is present in San Diego Bay at dissolved concentrations that approach or exceed USEPA water quality criteria (WQC; 3.1 µg/L) for marine aquatic life. Natural waters in the bay, however, are not toxic to larvae of the blue mussel (*Mytilus galloprovincialis*), which is considered to be the most sensitive organism to copper. For San Diego Bay, dissolved copper concentrations as much as seven times higher than the USEPA WQC are required to reach the median effective concentration (EC50). This lack of toxicity is attributed to the natural complexation capacity controlling the bioavailability of copper in these marine waters. The USEPA has recently promoted the use of the Biotic Ligand Model (BLM) for the development of WQC in freshwaters (USEPA, 2007). A seawater-BLM was developed and integrated with a fate and transport model (i.e., CH3D) for the prediction of site-specific WQC in the Bay at high-resolution (100 m). The integrated model was calibrated with the data sets from four sampling cruises, and validated with data from two independent cruises. The calibration proceeded by adjusting model parameters until the concentration distributions of the different environmental parameters were reproduced. For the validation, the calibrated model was used, and only the input data required by the seawater-BLM (i.e., DOC, TSS, salinity and pH) were provided. The concentration distributions predicted by the model were compared to the measured distributions. Finally, distributions of EC50 and estimated WQC were predicted for both the calibration and validation scenarios (following the same approach as mentioned above for each set of data) and were compared with measured data. The integrated model predicted EC50s and estimated WQC that are within the range of a factor of two accepted by the USEPA for freshwater. The predicted distributions have a resolution only attainable by the analysis of an excessive number of samples, with geographic variation comparable to the measured data. However, copper speciation and EC50s predicted for the mouth of the Bay (i.e., two stations out of twenty five) does not correspond to the measured ones. These results attest to the applicability of the integrated model to bays and harbors with elevated concentrations of dissolved copper.

419 The Linked Transport Model (CH3D) and the Biotic Ligand Model (BLM) for Copper in San Diego Bay. P. Wang, I. Rivera-Duarte, D.B. Chadwick, G. Rosen, Code 2375, SPAWAR Systems Center San Diego, San Diego, CA; W. Choi, Computer Sciences Corporation, San Diego, CA; R.C. Santore, A.C. Ryan, HydroQual, East Syracuse, NY; P.R. Paquin, HydroQual, Mahwah, NJ. Elevated copper concentrations are found in most U.S. estuaries and harbors. These excessive concentrations approach or exceed the USEPA marine Water Quality Criterion (WQC) of 3.1 ppb derived from published median lethal concentrations (EC50s) for marine aquatic organisms. Since toxicity is modified by environmental factors including complexation capacity, site specific WQC tend to deviate from the current USEPA marine WQC. These site-specific effects are being addressed by the regulatory community with the application of the Biotic Ligand Model (BLM) for freshwater. In order to address marine harbor situations a seawater-BLM was developed for San Diego Bay. In this study, we present the integration of the seawater-BLM with the fate and transport CH3D model, for the prediction of an estimated

site-specific WQC at high resolutions in both time and space. The input parameters required by the seawater-BLM include total copper, salinity, DOC, TSS, and pH. CH3D simulates the transport of copper in the Bay, taking into consideration the inputs of copper, transport by tide-induced circulation and mass loss to the bottom sediment via settling. From these inputs and effects, the concentration distributions of total copper and salinity are predicted by CH3D. The other parameters required by the seawater-BLM are from field measurements. The seawater-BLM is embedded as dynamic link library in the integrated CH3D/seawater-BLM model, allowing for control of the time of prediction of toxicity thresholds, and optimization of overall running time. For a simulation, the CH3D model first predicts the hydrodynamics, including water surface elevations, currents, and the transport of total copper for 419 days (1 year + 54 days), to ensure that the transport of copper reaches steady state. Once this is accomplished, the seawater-BLM is called every hour for 14 days, with the output parameters being stored at every CH3D grid cell (dimension 100 m). The integrated model was calibrated with the data sets from four sampling cruises to the Bay, and validated by prediction of the distribution of copper species for two independent sampling cruises. The parameterization of the integrated model for the prediction of copper species, toxicity and estimated WQC will be explained.

420 Development of a terrestrial BLM for copper: parameterization of biotic ligand reactions. A.C. Ryan, R. Santore, HydroQual, Inc., East Syracuse, NY; P. Antunes, Stantec Consulting Ltd., Guelph, Ontario, Canada; S. McGrath, Rothamsted Research, Harpenden, Hertfordshire, United Kingdom; H.E. Allen, University of Delaware, Newark, DE; M. McLaughlin, CSIRO CECR/Univ. Adelaide, Glen Osmond, South Australia, Australia; E. Smolders, Katholieke Universiteit Leuven, Heverlee, Belgium; C. Janssen, Ghent University, Ghent, Belgium; R. Dwyer, International Copper Association, New York, NY; I. Schoeters, European Copper Institute, Brussels, Belgium. A terrestrial biotic ligand model (tBLM) was developed for wheat and barley seedlings to describe copper (Cu) accumulation and consequent toxicity. Data from independent studies were used to estimate parameters of the biotic ligand (BL), including the strength of Cu binding, BL site density, and the binding strength of competing cations. Copper accumulation studies using simple media suggested that two distinct sites are necessary to describe Cu accumulation in seedling roots. Based on these observations, a two-site tBLM (with high- and low-affinity sites) was developed. From related work, it was demonstrated that accumulation of Cu at the low affinity site was a good predictor of toxicity, and this response was used in the current tBLM. As with other BLMs, several cations, including Ca^{2+} , Mg^{2+} , H^{+} , and Al^{3+} , were shown to effectively decrease copper toxicity, so they were included as competing cations. Competing cations can reduce Cu toxicity, but it is also known that both H^{+} and Al^{3+} can be toxic to plants. Consideration of the accumulation and potential toxicity of these cations within the Cu exposures will also be briefly discussed. The calibrated model was applied to a dataset encompassing 19 European soils (18 of which were used for barley toxicity tests). Using soil solution concentrations for necessary inputs, the model accurately predicted median effective concentrations (EC50s) expressed as soil solution Cu. This work is an important step toward the development of a terrestrial tBLM for Cu. *Due to the author limit of ten, some contributing authors were not included during the abstract submission process.

421 Bioaccessibility of arsenic adsorbed onto or incorporated within freshly synthesized iron oxide minerals using the Simulator of the Human Intestinal Microbial Ecosystem. B. Laird, D. Peak, S.D. Siciliano, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; T. Van De Wiele, W. Verstraete, University of Ghent, Ghent, Belgium; C. Le, University of Alberta, Edmonton, Alberta, Canada. It is now accepted that the use of the total arsenic concentration of contaminated minerals may lead to the overestimation of arsenic exposure and risk. Therefore, in vitro gastrointestinal models were developed to measure the extent to which arsenic may be released from minerals into gastrointestinal fluids. However, before it is possible to develop a predictive model for arsenic bioaccessibility, i.e., the fraction of arsenic solubilized into gastrointestinal fluids, the determinants of arsenic bioaccessibility must be identified. Recent work demonstrated that both arsenic concentration and gastrointestinal microbes may increase arsenic bioaccessibility. Since it is likely that these observations are mineralogy specific, it is critical to investigate the mechanisms by which these relationships are controlled. The bioaccessibility of arsenic adsorbed to amorphous ferrihydrite or incorporated within amorphous scorodite was measured in the stomach, small intestine, and colon stages of the Simulator of the Human

Intestinal Microbial Ecosystem (SHIME), an in vitro gastrointestinal model that incorporates the microbial community found in the human colon. The SHIME digests of these arsenic-bearing minerals were used to construct arsenic dissolution isotherms for the stomach, small intestine, and colon SHIME; thereby investigating the mechanism by which arsenic concentration may determine arsenic bioaccessibility. Subsequently, the Kd of arsenic in gastrointestinal fluids and the mechanism of concentration-dependent constraints on arsenic bioaccessibility was evaluated. Also, the colon digest was repeated with sterilized colon SHIME suspension to investigate the role gastrointestinal microorganisms in determining the bioaccessibility of arsenic adsorbed onto or incorporated into iron oxide minerals. Subsequently, the mechanism by which gastrointestinal microbes impact arsenic bioaccessibility (e.g., via iron and/or arsenic reduction) was evaluated by measuring the arsenic and iron speciation in the liquid and solid phases following digestion through the colon SHIME. Finally, to elucidate the role of gastrointestinal microbes on the toxicodynamics or arsenic ingestion, the capability of gastrointestinal microbes in the colon to produce genotoxic metabolites was evaluated.

422 Quantifying Pollutant Emission Factors for Electronic Office Equipment: Results of Chamber Studies. T.E. McKone, R.L. Maddalena, H. Destaillass, M.L. Russell, A.T. Hodgson, Indoor Environment Department, Lawrence Berkeley National Laboratory, Berkeley, CA; H. Destaillass, Arizona State University, Tempe, AZ; T.E. McKone, School of Public Health, University of California, Berkeley, CA. The last few decades have seen major changes in how people collect and process information at work and in their homes. More people are spending significant amounts of time in close proximity to computers, video display units, printers, fax machines and photocopiers. At the same time, efforts to improve energy efficiency in buildings by reducing leaks in building envelopes are resulting in tighter (less ventilated) indoor environments. Therefore, it is critical to understand pollutant emission rates for office equipment because even low emissions in areas that are under-ventilated or where individuals are in close proximity to the pollutant source can result in important indoor exposures. We present here the results of a project in which we measured emission factors for a range of chemical classes including volatile and semivolatile organic compounds (VOCs and SVOCs), ozone and particulates. The measured SVOCs include phthalate esters, brominated and organophosphate flame retardants and polycyclic aromatic hydrocarbons. We made these measurements in large and small exposure chambers for several different categories of office equipment. We started by operating a number of units simultaneously for each equipment category using specific duty cycles in a large test chamber and measured emissions for a range of pollutant. Results from the screening experiments identified pollutants and conditions that were relevant for each category of office equipment. In the second phase of the study, we used a smaller test chamber to measure pollutant specific emission factors for individual devices and explored the influence of a range of environmental and operational factors on emission rates. The measured emission factors provide a data set for estimating indoor pollutant concentrations and for exploring the importance of user proximity when estimating exposure concentrations.

424 An Exposure Assessment of Methylmercury from Seafood for Consumers in Japan. Y. Zhang, S. Masunaga, Yokohama National University, Yokohama, Japan. Seafood consumption is promoted due to its positive effects on health. But on the other hand, bio-accumulated chemical contaminants in seafood are consumed simultaneously, such as methyl mercury, PCB. Due to this dilemma, an exposure assessment of nutrients and contaminants via seafood is important to do to provide more detailed information. In addition, the average seafood consumption in Japan is about ten times than that in USA. Therefore it is necessary to know the statue of contaminants intake in current Japanese. An exposure assessment via seafood is conducted in this paper, considering methyl mercury as contaminant. Mercury exposure via seafood are quantified by determining the distribution of concentrations in seafood and fish consumption distribution for consumers. Deterministic and probabilistic exposure assessments are both conducted, especially for both women with child-bearing age and children (1-to-6-year old), who vulnerable to the exposure to methyl mercury. Three biomarkers simulations are conducted to predict population distribution for mercury in blood and hair. The estimated results are then compared with subtotal survey data of Japanese, which illustrated taht estimated hair mercury level is similar to survey data. In conclusion, the simulation method used in this paper is suitable for exposure assessment via seafood consumption.

425 Assessment of Human Exposure to Polybrominated Diphenyl Ethers in China via Fish Consumption and Inhalation. E.Y. Zeng, X. Meng, L. Yu, Y. Guo, State Key Laboratory of Organic Geochemistry, Guangzhou Institute of Geochemistry, Guangzhou, China; X. Meng, L. Yu, Y. Guo, Graduate School, Chinese Academy of Sciences, Beijing, China. This study examined human exposure to polybrominated diphenyl ethers (PBDEs) associated with fish consumption and inhalation in China. The median intake of S7 PBDEs via human milk was 48.2 ng/day for nursing infants (0-1 years old) (a range of 23.4-99.1 ng/day). For all other age groups, the median intake of S11 PBDEs via fish consumption was 1.7-12.9 ng/day with a range of 0.59-56.3 ng/g. Additionally, human exposure to PBDEs via inhalation was 2.7-9.2 ng/day (a range of 0.72-108 ng/day). The median total S10 PBDEs intakes for nursing infants (6,874 and 7,372 pg/kg b.w./day for males and females, respectively) were much higher than other age groups (215-608 pg/kg b.w./day). No significant difference in the total PBDEs intakes was found between males and females. Of the 11 PBDEs congeners, BDE-47 was predominant in the total intake for nursing infants with a mean contribution of 38%, whereas BDE-209 was the dominant congener of total intake for other age groups, varying from 44% to 61%. Currently, the PBDEs levels in Chinese consumer fish and the total intakes of PBDEs via fish consumption were at the lower end of the global range. Compared with similar studies in other countries, however, human exposure to PBDEs via inhalation in China was relatively high. Overall, estimated daily intake of total PBDEs in Chinese population was far below the lowest observed adverse effect level. However, studies are needed to further understand the fate and impact of PBDEs as PBDE-containing products are still used widely and in large quantity in China. Keywords: Human exposure; Polybrominated diphenyl ethers; Fish consumption; Inhalation; China

426 Assessing the risk in infants: PBDE, PCB, and organochlorines pesticide levels in human breast milk from Massachusetts, USA. B. Johnson-restrepo, K. Kannan, Environmental Health Science, School of Public Health - State University of New York at Albany, Albany, NY; R. Addink, K. Kannan, Wadsworth Center, New York State Department of Health, Albany, NY; C. Wong, K. Arcaro, Department of Veterinary & Animal Sciences, University of Massachusetts-Amherst, Amherst, MA; B. Johnson-restrepo, Environmental and Computational Chemistry Group - Department of Chemistry, Universidad de Cartagena, Cartagena, Bolivar, Colombia. Concentrations of polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs), and organochlorine pesticides (OCPs) were measured in human breast milk samples collected across Massachusetts, USA in 2004. Seventeen PBDE congeners were found in the samples, ranging in concentration from 0.06 to 1910 ng/g lipid wt. BDE-47 (2,2',4,4'-tetraBDE), BDE-99 (2,2',4,4',5-pentaBDE), and BDE-100 (2,2',4,4',5-pentaBDE) were the major congeners detected in breast milk samples. Overall mean concentrations (mean $\pm$ SD) of PCBs, DDTs, HCHs, CHLs, and HCB were 305 $\pm$ 262, 64.5 $\pm$ 75, 18.9 $\pm$ 19, 32.4 $\pm$ 36, and 2.3 $\pm$ 2.2 ng/g lipid wt, respectively. Concentrations of PBDEs were strongly correlated with concentrations of PCBs and OCPs in the samples. Based on the concentrations of organohalogenes and the intake rates of breast milk by infants in the United States, daily ingestion rates of contaminants were calculated. The median ingestion rates for PBDEs, PCBs, DDTs, HCHs, CHLs, and HCB were 5.7, 60.7, 18, 3.1, 3.5, and 0.5 μ g/kg body wt/day, respectively. The estimated daily intake of organohalogenes by infants was compared with the minimum risk level (MRL) suggested by the Agency for Toxic Substances and Disease Registry (ATSDR), for calculation of hazard quotients (HQs). HQs for individual organohalogenes and the sum of HQ for all organohalogenes were calculated as HQ indices (SHQi). The results suggest that the HQ values for PCBs and DDTs exceeded one, for 76% and 42% for the breast milk samples, respectively; thus, these two legacy contaminants continue to be a concern.

427 Biomonitoring of Perfluorinated Compounds in Human Breast Milk from Massachusetts, USA. L. Tao, K. Kannan, Department of Environmental Health Sciences, State University of New York at Albany, Albany, NY; L. Tao, K. Kannan, New York State Department of Health, Wadsworth Center, Albany, NY; C. Wong, K. Arcaro, Department of Veterinary & Animal Sciences, University of Massachusetts-Amherst, Amherst, MA. Perfluorinated compounds (PFCs), especially perfluorooctanesulfonate (PFOS) and perfluorooctanoic acid (PFOA) are contaminants of concern due to their prevalence in the environment, bioaccumulation in humans and wildlife, and toxicity. Although PFCs have been detected in human blood from several countries, occurrence in

human breast milk and potential for exposure of infants to PFCs through breastfeeding were not studied in detail, so far. In this study, 11 PFCs were measured in 45 human milk samples collected from Massachusetts, USA, in 2006. A method to measure trace levels of PFCs in breast milk was developed and validated; 5 to 10 mL of breast milk was used to enable low levels of detection. PFOS and PFOA were the two predominant PFCs found at mean concentrations of 121 pg/mL and 40 pg/mL (wet wt), respectively. Perfluorohexanesulfonate (PFHS) and perfluorononanoic acid (PFNA) were detected in 45% and 60%, respectively, of the samples analyzed at concentrations lower than that of PFOA. PFOS concentrations determined in our study were similar to or lower than those previously reported from other countries. The concentration pattern of PFCs in breast milk was similar to the pattern found in blood. Significant correlation between concentrations of PFOS and PFOA was found. Correlation between PFC concentrations in mother's milk and the age of infants was examined. Daily intake of PFCs by infants through the ingestion of breast milk was calculated.

428 Uptake of Perfluorochemical Surfactants in the Human Intestinal Caco-2 Cell Model. C.P. Higgins, J.P. Bressler, R.U. Halden, Environmental Health Sciences, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD. The widespread detection of perfluorochemical (PFC) surfactants in humans and aquatic organisms has led to concerns over their potential impact on the environment and human health. Previous work indicated PFCs such as perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) are much more bioaccumulative than would be predicted from traditional models. Studies examining the toxicokinetics of PFCs in rodents have implicated specific interactions with organic anion transporters in the kidney. In addition, many questions remain with respect to human exposure routes to PFCs. Indeed, exposure through food and subsequent intestinal absorption of PFCs or PFC precursors is one exposure route that is increasingly receiving attention. To evaluate the bioaccumulation mechanisms of PFCs in the human intestine, uptake and transport of PFOS and perfluorocarboxylates of various chain-lengths was evaluated using Caco-2 cells. This *in vitro* model has been used extensively to evaluate human intestinal absorption of pharmacologically-active chemicals. Specifically, we sought to evaluate whether PFCs interact with specific intestinal transporters or whether absorption was due to passive uptake only. PFC uptake kinetics in Caco-2 cells were temperature, chain-length, and head-group dependent, with significantly more PFOS accumulating than perfluorononanoate (PFNA). However, uptake of PFCs in the Caco-2 model was non-saturable and not affected by probenecid, an inhibitor of organic anion transporters, which suggests that transport of PFCs across the human intestinal epithelium is different from transport in the kidney. These data should prove useful in developing accurate toxicokinetic models of PFCs in humans.

429 Estrogen receptor (ER) interaction as an alternative mechanism of toxicity of perfluoroalkyl acids (PFAAs). A.D. Benninghoff, D.E. Williams, Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR; A.D. Benninghoff, D.E. Williams, Environmental Health Sciences Center, Oregon State University, Corvallis, OR. Perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS) and other PFAAs are by-products formed during the synthesis of perfluorinated chemicals or intermediates in the manufacture of some nonstick and stain-resistant coatings. Recent evidence suggests that PFOA acts via an estrogenic mechanism to promote hepatocellular carcinoma in rainbow trout, an animal model that, like humans, is insensitive to peroxisome proliferation. Moreover, *in vivo* bioassays measuring induction of the estrogen-responsive liver protein vitellogenin in trout have shown that C8 to C11 perfluoroalkyl carboxylic acids are estrogenic. The present study was conducted to determine whether these PFAAs interact directly with the hepatic estrogen receptor (ER). Perfluorocarboxylic acids (C7 to C12), PFOS, perfluorodecane sulfonate (PFDS), 8:2 fluorotelomer alcohol (8:2 FtOH), 10:2 FtOH, 8:2 fluorotelomer acrylate (8:2 FtOAc) and N-methyl perfluorooctane sulfonamido ethyl acrylate (MeFOSEA) were tested for their ability to bind the rainbow trout hepatic ER using a standard steroid receptor competitive binding assay. All PFAAs tested displaced [³H]-estradiol from the ER by more than 75% with relative binding affinity values ranging from 0.0007 to 0.0092%. PFDA, PFOS and PFDS had the highest affinities for the hepatic ER, although PFOS and PFDS were not found to be estrogenic *in vivo* in our previous studies. Alternatively, 8:2 FtOH, 10:2 FtOH, 8:2 FtOAc and MeFOSEA did not bind the hepatic ER. Additional experiments were conducted to assess the estrogenicity of PFOA, PFDA, PFOS and PFDS in human ovarian

carcinoma (BG-1) cells using the LUMI-CELL™ ER recombinant bioassay. PFOA and PFDA moderately increased luciferase activity in this human ER transactivation assay at the highest concentrations tested, though PFOS and PFDS were ineffective. Overall, these observations show that multiple perfluoroalkyl carboxylic acids are weakly estrogenic in trout and humans and that this effect is likely mediated via interaction with the estrogen receptor. Additional *in vitro* studies are in progress to examine PFAA-induced changes in gene expression and the potential involvement of other receptor-mediated pathways in the toxic response to PFAAs. Supported by NIH grants ES07060, ES03850 and ES014777.

430 Precipitation and aggregation of HgS and ZnS nanoparticles and colloids in the presence of dissolved natural organics. H. Hsu-Kim, A. Deonarine, Civil & Environmental Engineering, Duke University, Durham, NC. Hg, Zn, and other pollutant metals tend to persist as sulfide mineral phases in anaerobic soils and sediments. These minerals are generally insoluble and do not readily dissolve in porewater. The formation of metal-sulfide colloids and nanoparticles, however, can facilitate leaching to adjacent aquatic systems and can even resist degradation by oxygen in aerobic surface waters. Dissolved Hg will also strongly adsorb to the surfaces of ZnS and other metal-sulfide colloids, thus altering the bioavailability and mobility of mercury in sediments and the water column. In this study we investigated the role of dissolved natural organics for facilitating the stability of HgS and ZnS colloids in aqueous solution. Sodium sulfide was dissolved with either Hg(NO₃)₂ or Zn(NO₃)₂ under conditions of supersaturation in simulated surface water containing low-molecular-weight organics (e.g., oxalate, cysteine, serine) and dissolved humic acid. The formation and aggregation of particles was monitored by measuring average particle size over time using dynamic light scattering. The results indicated that the precipitation and aggregation rates of HgS and ZnS particles varied by orders of magnitude, depending on the type and concentration of organic ligands in solution. Aggregate growth rates were slowest in the presence of thiol-containing ligands and humic acid. In the presence of equimolar concentrations of cysteine, ZnS nanoparticles (diameter less than 100 nm) were stable for at least several hours. In contrast, HgS and ZnS aggregates grew to larger than 400 nm within 20-60 min in the absence of other ligands. Aggregation rates were generally not affected by oxalate and serine, compounds that contain O- and N-functional groups. Hg²⁺ and Zn²⁺ have a greater affinity for thiols compared to ligands with other functional groups. Thus, slow aggregation of HgS and ZnS nanoparticles is likely caused by coordination of thiols to the particle surface, which would hinder further growth (i.e., precipitation) of the particle. Surface attachment of thiols would also induce surface charge on the particles and decrease aggregation rates. These results demonstrate a possible pathway for the formation and stabilization of colloidal metal-sulfides in the aquatic environment.

431 Temporal variability of dissolved organic carbon and suspended solids as predictors for aqueous mercury in streams and rivers. M. Tsui, Water Resources Science Graduate Program, University of Minnesota, St. Paul, MN; M. Tsui, H.B. Grun, J.C. Finlay, Ecology, Evolution and Behavior, University of Minnesota, St. Paul, MN; E.A. Nater, Soil, Water and Climate, University of Minnesota, St. Paul, MN. Eight streams and rivers of different sizes (first to fourth) and under contrasting land use patterns (urban, forested and groundwater-fed) in Minneapolis/St. Paul Metro Area (Minnesota, USA) were chosen to understand the dynamics and levels of aqueous mercury in this region. Water samples were collected biweekly from March to October 2007 and analyzed for unfiltered and filtered (< 0.45-μm) total-mercury (THg), dissolved organic carbon (DOC) and total suspended solids (TSS). From samples analyzed so far (until May 2007), unfiltered THg varied ~ 2 orders of magnitude (0.2–38 ng/L) while filtered THg only varied from 0.14–3.6 ng/L. Analyses of the log-log relationships between THg concentrations and DOC or TSS across sites at the same sampling date show that the slopes of regressions of unfiltered THg and both DOC and TSS peaked at late March and decreased gradually after snowmelt, while the slope between filtered THg and DOC and TSS peaked in mid-April. In addition, the correlation coefficients (r²) were highly related to the slope. Thus DOC and TSS were both strong predictors of THg during and after snowmelt, but were weaker after this seasonal hydrologic event. Such temporal variability of predictors (DOC and TSS) suggests that the binding of Hg to organic carbon and sediment varies seasonally. Finally, this study also implies that Hg in different sites is possibly from the same source when the predictors are strong.

432 Analysis of spatial loading profiles of mercury and methylmercury and their relationship to seasonal and physical

characteristics of the South River, Virginia, USA. A. Redman, R. Santore, HydroQual, Inc., East Syracuse, NY; E. Garland, HydroQual, Inc, Mahwah, NJ; N. Grosso, DuPont, Wilmington, DE; J. Flanders, T. Morrison, URS, Fort Washington, PA; R. Turner, RT Geosciences, Squamish, British Columbia, Canada. Mercury and methylmercury in biota, water, soils and sediments increase from typical background concentrations to about 100 times greater concentrations along the South River, VA, USA due to historic releases of mercury from an industrial facility located 24 miles upstream of the confluence with the South Fork of the Shenandoah River. Incremental loading calculations were performed on unfiltered fractions of mercury and methylmercury to identify reaches of the River responsible for additional inputs to the river under different low- and high-flow regimes for a series of intensive sampling campaigns during 2006 and early 2007. Areas of variable methylation/demethylation activity were identified by examining differences in spatial and temporal loading profiles of total mercury and methylmercury. Spatial loading profiles were compared to transects of the river to identify specific features (e.g., islands, side channels, etc.) that explain, in part, the observed differences in loading profiles in the river under different flow conditions. There is also a strong seasonal influence on methylmercury where the concentrations increase by a factor of 4-5 between the cold and warm months. Peak methylmercury concentrations are observed in spring and early-Summer months then begin to decline in the mid- to late-Summer months even though water column temperatures were still elevated until early Fall. This pattern is not observed for total mercury and these observations are discussed in light of temperature and other factors that can affect mercury methylation in the River. In addition to the incremental loading analysis, integrated loadings of suspended solids, mercury and methylmercury were calculated for a number of well-characterized storms, to assess potential sources of mercury and methylmercury to the river. Areas of potential inputs of total mercury and potential methyl mercury production areas will be discussed.

433 Dissolved gaseous mercury concentrations and mercury volatilization in a frozen freshwater fluvial lake. N.J. O'Driscoll, Earth and Environmental Science, Acadia University, Wolfville, Nova Scotia, Canada; L. Poissant, Center St. Laurent, Environment Canada, Montreal, Quebec, Canada; J. Canario, National Institute for Fisheries and Sea Research, Lisboa, Portugal; D.R. Lean, Biology, University of Ottawa, Ottawa, Ontario, Canada. Dissolved gaseous mercury (DGM), or dissolved elemental mercury, is the volatile form of mercury in water. The formation and volatilization of DGM from freshwaters is a mechanism by which water bodies may naturally reduce their mercury burden. Recent work has highlighted the importance of understanding DGM vertical distribution in the water column. While there are a wealth of DGM data for unfrozen freshwaters, there are little published data for frozen freshwaters. Experiments were performed to assess the effects of sediment diffusion and horizontal advection on vertical mercury distribution in a frozen fluvial lake (Lake St. Louis, Beauharnois, QC). The natural system was compared a mesocosms with open bottom (no advection) and a closed bottom (no advection, no sediment diffusion). Low concentrations of dissolved gaseous mercury were observed in surface water under the ice (Mean 27.6 pg L^{-1} ; s.d. = 7.2 ; $n = 26$) with no discernable diurnal pattern. However DGM concentrations were found to be substantially higher in samples of surface ice (mean 73.6 pg L^{-1} ; s.d. = 18.9 ; $n = 6$) and snowfall (mean 368.2 pg L^{-1} ; s.d. = 115.8 ; $n = 4$). DGM depth profiles showed a small increase in DGM towards the surface in all treatments during the day, but no similar trend in the night. In addition, the open-bottom cylinder (no advection) found increases with depth (an increase of 30 to 70 pg L^{-1} over 1 meter). We propose that that DGM gradients resulting from sediment diffusion are affected by advection under the ice. Mercury volatilization over ice was low and unchanging (mean = $0.23 \text{ ng m}^{-2} \text{ h}^{-1}$; s.d. = 0.02 $n = 164$). Mercury volatilization over a small hole in the ice with no cylinder did not show a diurnal pattern and was low (mean = $0.08 \text{ ng m}^{-2} \text{ h}^{-1}$; s.d. = 0.09 $n = 227$). Mercury volatilization from water to air in the closed-bottom cylinder also did not show a diurnal pattern and was low (mean = $-0.02 \text{ ng m}^{-2} \text{ h}^{-1}$; s.d. = 0.28 $n = 71$). Mercury volatilization over the open-bottom cylinder was also observed to be low (mean = $0.24 \text{ ng m}^{-2} \text{ h}^{-1}$; s.d. = 0.08 $n = 96$) however a diurnal pattern was observed, suggesting that volatilization may be linked to the DGM gradients observed in the open-bottom cylinder.

434 Insights on the distribution of mercury in a Gulf of St. Lawrence food web from stable nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$) isotope analysis. R.A. Lavoie, L. Hill, E. Yumvihoze, D.S. Lean, Centre for Advanced Research in Environmental Genomics, Department of Biology, University of Ottawa,

Ottawa, Ontario, Canada; R.A. Lavoie, J. Rail, Canadian Wildlife Service, Environment Canada, Québec, Québec, Canada. Mercury (Hg) is a chemical of concern because of its persistence, toxicity and biomagnification potential in the environment. Details of its distribution and pathways in food chains are still poorly understood, especially in estuarine ecosystems. The general objective of this study is to determine the main variables of the feeding ecology that are driving the concentration of total mercury (THg) and methyl-mercury (MeHg) in a Gulf of St. Lawrence estuarine food web. THg as well as MeHg levels were measured in representative species from primary consumers to top-level predators (seabirds). Stable nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$) isotope analyses were used to provide information on the trophic level and the source of the organic matter (benthic vs. pelagic and fresh vs. marine water), respectively. We found that even though THg was biomagnified from primary consumers to seabirds, the source of the organic matter was the main contributor to higher concentrations. This suggests that elevated THg concentrations are more likely to be associated with species that feed in the benthic zone in opposition to the pelagic zone. This study will help to identify the mechanisms of Hg accumulation in the Gulf of St. Lawrence food web and to develop predictions on the influence of environmental perturbations.

435 Fate of dietary uptake of methylmercury in *Xenopus tropicalis* tadpoles: developmental alterations related to exposure levels. M.A. Davidson, C. Millar, D.R. Lean, V.L. Trudeau, Biology, University of Ottawa, Ottawa, Ontario, Canada. It is well known that human embryos accumulate more mercury than the exposed mother, however; the known effects of methylmercury (MeHg) on fetal development are incomplete. This is of concern due to its inherent toxicity and ability to bioaccumulate. Because early hormonally controlled developmental processes are common in amphibians and humans, frog tadpoles provide a free living model for investigation. We examined the effects of MeHg on the development of *Xenopus tropicalis* tadpoles as well as their capacity to bioaccumulate and eliminate MeHg when exposed to three experimental diets: a control, a low and a medium MeHg diet (0.42 , 44.2 and 268.5 ng/g wet weight respectively). Experimentation was initiated when the tadpoles began feeding (Nieuwkoop and Faber stage 45) and was terminated when the tadpoles reached metamorphic climax (stage 60). Percentage mortality and the percentage of tadpoles reaching metamorphosis were significantly higher for the medium treatment group than for the control or low treatment groups. Age at metamorphosis was not statistically different between any of the treatment groups however; the total number of days between each tadpole reaching metamorphosis was higher in the medium treatment group. Both weight and snout to vent length at metamorphosis were also higher for tadpoles in the medium treatment group which suggests a delay in tadpole development, presumably by disrupting the thyroid axis. Total mercury (THg) and MeHg body burdens for tadpoles in both the control and low treatment groups demonstrated that Hg levels increased initially but elimination of MeHg was significant. In the medium treatment group, body burden concentrations of THg and MeHg increased throughout the experiment without reaching a threshold or decreasing. These results show that at low dosages of MeHg, elimination of MeHg may prevent toxic exposure. In contrast, with high MeHg, demethylation and selective excretion mechanisms may be overwhelmed and disruption of development or death may occur in tadpoles.

436 Mercury bioaccessibility and speciation in Inuit country foods evaluated using the Simulator of the Human Intestinal Microbial Ecosystem. B. Laird, S.D. Siciliano, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; T. Van De Wiele, W. Verstraete, University of Ghent, Ghent, Belgium; L. Chan, University of Northern British Columbia, Prince George, British Columbia, Canada. Mercury contamination of northern country foods presents health risk to Inuit communities. However, assessing the risk due to this contamination may be confounded by differences in mercury bioaccessibility, which is defined to be the percentage of contaminant solubilized in the gastrointestinal tract, between country foods. Therefore, a variety of country foods, including flesh from caribou, lake trout, arctic char, seal, narwhal, and walrus, were digested in the Simulator of the Human Intestinal Microbial Ecosystem (SHIME), an in vitro gastrointestinal model that includes a microbial community representative of that found in the human colon. Subsequently, the bioaccessible mercury fractions from the stomach, small intestine, and colon were separated using ultrafiltration ($< 10 \text{ kDa}$) and measured using Cold Vapour Atomic Fluorescence Spectroscopy. Additionally, the potential for changes in mercury speciation in the gastrointestinal tract due to the activity of colon microorganisms will also

be assessed. We hypothesize that mercury bioaccessibility will vary with gastrointestinal stage, food type (e.g., fish, marine mammals, wild game, etc.), trophic level, mercury concentration, and mercury speciation. Results demonstrate that mercury bioaccessibility ranges between 5% and 100% and mercury bioaccessibility in fish is greater than that observed in other food types. Also, mercury bioaccessibility in the small intestine, an important site of mercury uptake, may be less than that of stomach and an inverse relationship between mercury concentration and bioaccessibility may exist; however, these trends are likely dependent upon food type.

437 Methyl mercury and total mercury distribution in water and accumulation in periphyton in High Arctic: a comparative study of a polar desert and a polar oasis. E. Garcia, Jacques Whitford Axys Ltd, Burnaby, British Columbia, Canada; A. Poulain, D. Belanger, M. Amyot, Biology, University of Montreal, Montreal, Quebec, Canada. We compared total mercury (THg) and methyl mercury (MeHg) levels in aquatic systems and in periphyton in a polar desert (Cornwallis Is.) and in a polar oasis (Fosheim Peninsula, Ellesmere Is.) in High Canadian Arctic. Arctic ecosystems are pointed as sink of mercury derived from southern regions through long range atmospheric transport, and have been the focus of a growing number of studies on mercury biogeochemistry and bioaccumulation. Although well known by its cold, dark and long winters, the Arctic region can present diverse microclimatic conditions during the growing season, which can explain the occurrence of biomes as distinct as polar deserts and oases. Polar deserts are characterized by a short growing season from July to mid August, with mean daily temperature slightly above 0°C. Polar oases have a significantly longer (~3 months) and warmer (mean July temperature ~8°C) growing season and support a greater abundance and diversity of wildlife and vegetation. It can be expected that such variations in weather and ecological features will affect differently mercury cycling in these regions during the growing season. Indeed our study on 37 streams and ponds showed significantly higher THg and MeHg levels in aquatic systems in the Fosheim Peninsula relative to concentrations observed in Cornwallis Island. THg levels ranged from 3.3 to 4.1 ng.L⁻¹ in the Fosheim Peninsula, and from 0.8 to 1.2 ng.L⁻¹ in Cornwallis, whereas MeHg varied from 0.17 to 0.22 ng.L⁻¹ in the polar oasis and from 0.14 to 0.16 ng.L⁻¹ in the polar desert. In both regions more than 80% of THg in the water was observed in the dissolved phase. Variations in THg and in MeHg in aquatic systems were mostly correlated to temperature (+), light intensity (+) and precipitation (-), as well as to variations in pH and dissolved organic carbon (DOC). THg and MeHg concentrations in periphyton did not differ significantly between the two regions, but significant differences were observed in terms of percent of Hg in the methylated form. In the Fosheim Peninsula it ranged from 0.7 to 16%, whereas in Cornwallis it varied from 16 to 23%. Variations in THg and MeHg in periphyton were related to taxonomic composition and to weather, as observed for water. Overall our results indicate that Hg in Arctic ecosystems is influenced by weather conditions and can be thus directly influenced by global warming trends.

438 Mercury and Mercury Species Mass Balance in Four North American Lakes. A. Qureshi, M. MacLeod, M. Scheringer, K. Hungerbühler, Institute of Chemical and BioEngineering, ETH Zurich, Zurich, Switzerland. We have applied a multimedia mercury mass balance model to four North American Lakes – Lake Superior, Lake Michigan, Onondaga Lake, and Little Rock Lake – to assess the cycling of mercury in these lakes and to identify the major mercury sinks and fate determining processes. We modeled atmospheric mercury deposition to the lakes from the reported ambient air concentrations of mercury and combined that with information on tributary loadings. From these estimates of total loading, we predicted concentrations and fluxes of total mercury and its species (elemental, divalent and methyl mercury) in water and sediment, and lower bounds on species interconversion rates. Modeled mercury concentrations and fluxes in the four lakes are in good agreement with the observed concentrations and fluxes reported in field studies. In all four lakes sediments are the major repository of mercury, containing 85% or more of total mercury. Methyl mercury is evenly distributed between the water and sediment compartments in Lake Superior, but in the other three lakes sediments contain more than 80% of the methyl mercury. Volatilization of elemental mercury is the main (total) mercury loss process from Lake Superior; for other lakes sediment burial is the dominant process removing total mercury from the modeled system. We have conducted Monte Carlo analyses to determine model input parameters that contribute most to variance in calculated mercury concentrations and fluxes. Parameters describing dynamics of elemental mercury were found to be important in determining

mercury fate in Lake Superior. In Lake Michigan and Onondaga Lake, parameters describing particle dynamics determine the mercury fate, while the mercury balance in Little Rock Lake is determined by parameters describing both particle and elemental mercury dynamics. From our uncertainty analyses, it is evident that sedimentation, resuspension and volatilization plays a major role in determining the fate and transport of mercury in the lake ecosystems studied. We conclude that measurements of elemental mercury concentrations in air and water, and accurate descriptions of sediment dynamics are very important for proper determination of mercury mass balances for lake ecosystems. In addition, the good performance of the model demonstrates its appropriateness as a management tool for setting loading reduction targets for mercury.

439 Representative Sampling for Energetic Compounds at Military Training Ranges. T.F. Jenkins, A.D. Hewitt, M.E. Walsh, US Army ERDC-CRREL, Hanover, NH; C.A. Ramsey, EnviroStat, Inc., Fort Collins, CO. The total error for characterization of surface soil contamination includes contributions from sampling error, subsampling error, and determinative error. Most of the QA/QC effort is currently directed at minimizing the determinative error, largely that in the final instrumental determination. Qualitatively, this makes sense because the identity of the contaminant is paramount in making a judgement on the necessity to engage in remedial activities at a site. Quantitatively, however, research has demonstrated that for energetic compounds in soil, the uncertainty in the determination is generally minor and often insignificant compared with that from sampling and subsampling. The largest source of uncertainty for this application and many others is the inability to collect truly representative samples from the areas of concern (sampling error). This error is due to two types of heterogeneity, compositional heterogeneity and distributional heterogeneity, both of which exist at different scales. Compositional heterogeneity is due to the fact that not all of the particles that make up the population within the exposure unit have the same concentration of target analytes. This heterogeneity is at a maximum when a portion of the target analytes is present as discrete particles, which is often the case for energetic compounds at training ranges. The error due to compositional heterogeneity is called the fundamental error and is inversely related to the sample mass. Distributional heterogeneity is due to the fact that contaminant particles are scattered across the site unevenly. The error associated with distributional heterogeneity is inversely related to the number of individual increments that are used to build the sample. This type of error is at a maximum when a single discrete sample is used to estimate the mean. In this presentation we will discuss results from a number of field experiments designed to minimize sampling error thereby improving the representativeness of soil samples.

440 Comparison of Four Sampling Techniques for Monitoring Hydrophobic Organic Compounds in Surface Waters. S. Gbondo-Tugbawa, J.W. Talley, E.A. Garvey, J. McCann, C. Purkiss, Malcolm Pirnie Inc, Fair Lawn, NJ; J.W. Talley, Department of Civil Engineering, University of Notre Dame, Notre Dame, IN; T. Su, Civil, Environmental & Ocean Engineering, Stevens Institute of Technology, Hoboken, NJ. Hydrophobic organic compounds (HOCs) are persistent contaminants found in soils, sediments, and surface waters. They tend to partition to organic carbon in suspended or bed sediments rather than be dissolved in the water column. Because of this behavior these compounds can be present in sediments in concentrations that are orders of magnitude higher than those in the water column. Nonetheless, depending on ambient conditions, their ultra-low levels in the water column can still represent a significant means of transport while presenting a sampling and analytical challenge for accurate measurement. To understand the complexities and potential biases associated with HOC measurement in water, an HOC sampling methodology study using four sampling techniques was conducted in the Lower Passaic River in New Jersey, examining levels of polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), and polychlorinated dibenzo-dioxins and furans (dioxins). The objectives of this study were to determine the uncertainties associated with each HOC sampling methodology and the effects of HOC phase shifts due to holding times and adsorption to the walls of the sampling containers. The sampling methodologies tested in the Lower Passaic River included: (1) Infiltrax 300 and (2) Trace Organics Platform Sampler (TOPS), both of which contained a filtering system and Amberlite XAD-2 resin beads to capture HOCs in the particulate and dissolved phase; (3) 20-Liter stainless steel “pop can” containers for collection of whole water samples for subsequent lab filtration and analysis; and (4) semi-permeable membrane devices (SPMDs)

for collecting time-weighted average dissolved HOC concentrations. A comparison of measurements of dioxin from the Infiltrax, TOPS and 20-L pop can techniques indicates that concentrations in the dissolved and particulate phases are consistent among these different methodologies. Furthermore, the chemical content of the particulate phase is comparable to recently deposited surface sediment concentrations in the Lower Passaic River. Estimates of dissolved phase concentrations derived from SPMD samples were slightly higher than the other measuring techniques. The results of the comparison for all three HOC classes will be presented.

441 Field Validation and Modified Methods for Lipid-Free Polyethylene Membrane Passive Sampler. L. Quarles, A. Ackerman, G. Sower, W. Hillwalker, K.A. Anderson, Department of Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR. The need for an inexpensive and simple time-integrative passive sampler for dissolved hydrophobic contaminants in water is growing. In response, we have further developed the lipid-free polyethylene membrane tubing (LFT) sampler. The LFT sampler works on the premise that dissolved hydrophobic target compounds diffuse through the aqueous boundary layer and into the polyethylene membrane, thus mimicking the uptake by organisms. We have demonstrated through laboratory and field validation studies that LFT proved reliable and have similar benefits as other PSDs without the analytical interference potential of lipid impurities. An alternative preparation and extraction method was developed to significantly reduce solvent by more than half with respect to other organic PSD methods as well as eliminating the use of all chlorinated solvents. The method still maintains sensitivities in the ng/ml range. Extraction time has also decreased by more than four times. The direct result of this method is reduced solvent waste, laboratory and labor costs, and use of less toxic solvents. Laboratory and field trials using this updated method were performed that incorporated modeling for over 45 target analytes, including PAHs, PCBs, and pesticides. The modeling is used in conjunction with ratios and in situ calibration to estimate LFT sampling rates. The effects of environmental conditions on the uptake rates of the device were indicated by an in situ calibration using a simple internal surrogate spiking method. Deuterium labeled compounds were investigated to further validate sampling rates. The LFT extracts also were paired in a series of pilot projects concerning bioassays; for example, zebrafish.

442 Sampling and Analytical Determinations of Nitroglycerine. J. Clausen, A. Hewitt, M. Walsh, D. Lambert, S. Bigl, Biogeochemical Sciences Branch, US Army ERDC-CRREL, Hanover, NH; J. Kaste, Earth Sciences, Dartmouth College, Hanover, NH. The distribution of propellant compounds at military firing points has recently been an area of focus for the Department of Defense due to the recognition that residues can build up on the soil surface as a result of normal training. One particular compound of interest is nitroglycerin (NG), which is used in propellant formulations for small arms as well larger munitions such as anti-tank rockets. Field studies were conducted at several military installations to assess the distribution of NG at small arms range firing points. Sampling consisted of the collection of surface and subsurface soil samples as well as water samples from tension lysimeters and monitoring wells. The field studies were augmented with laboratory experiments to evaluate the sorption/desorption characteristics of a soil from one military installation. Because NG is impregnated into the nitrocellulose (NC) polymeric matrix the behavior of NG with binding agents and as neat material was evaluated.

443 In-Situ Solid Phase Analysis of Environmental Samples using Synchrotron-Based X-ray Spectroscopies. M. Chappell, US Army Corps of Engineers, Vicksburg, MS. Solute chemical equilibrium in predominantly biphasic natural systems is overwhelmingly controlled by the solid phase. Institutional and analytical limitations to solid phase behavior fomented the implementation of various digestion/extraction techniques for transferring solutes to the simpler liquid phase. However, such techniques are offer so little information about the natural state of adsorbed metals that speciations are often relegated to purely arbitrary delineations. The advent of synchrotron-based x-ray spectroscopies offers new capabilities for providing direct, in-situ information about the distribution and solid phase speciation of heavy metals in soils and sediments. The purpose of this paper is to discuss the application of Synchrotron-based x-ray absorption spectroscopy for the in-situ mapping and speciation of heavy metals in soils. The Synchrotron-based technique micro-x-ray fluorescence (micro-XRF) mapping was used to determine the distribution of soil Cd relative to other detected heavy metals, Fe, Zn, As, Pb, and Mn. Coupling this technique with laboratory SEM/EDX analysis demonstrated

the distribution of the heavy metals to soil organic carbon and lead to a new hypothesis explaining heavy metal immobilization in a high-carbon solid. Also, we present studies using the Synchrotron-based technique extended x-ray absorption fine structure (XAFS) spectroscopy to determine Pb speciation and potential for immobilization in the presence of natural sorbents.

444 Improving Analytical Confidence in the Determination of PCBs in Complex Matrices by a Sequential GC-MS/MS Approach. D.T. Qadah, B.A. Ruddy, J.H. Aldstadt, Dept. of Chemistry & Biochemistry, Univ. of Wisconsin-Milwaukee, Milwaukee, WI. A method is described for achieving increased confidence in the selective determination of PCBs using capillary gas-liquid chromatography with electron impact ionization tandem mass spectrometry (GC-MS/MS). It is well known that quantitation of PCBs by MS is susceptible to a false positive interference that arises from the co-elution of a higher PCB homolog with a lower PCB homolog (i.e., M-Cl⁺ from a higher homolog is M+ for a lower homolog). Because the elution order of the PCB congeners is not exactly proportional to increasing Cl content, frequent switching from MS/MS windows for specific homologs must take place. This can yield significant errors when matrix-induced retention time shifts occur. We therefore explored an approach involving repetitive analyses of a single extract. We optimized a method that required three injections, with homolog classes sequentially monitored as: 1-4-7-10, 2-5-8, and 3-6-9, respectively. The sequential design of the method entails the use of separate, broad MS/MS windows for each homolog class, thereby minimizing adverse matrix effects on retention variability. However, a consequent tripling of overall analysis time is incurred for each sample. The homolog classes are determined with high confidence (99%) that overlapping higher homolog fragments do not interfere with the quantitation of lower homologs. The method was demonstrated for extracts in small samples (~750-1000 mg) from a variety of freshwater biota (n = 20). Application of the method resulted in more accurate quantitation, correcting an average 31% relative error (false positive bias) in observed concentration.

445 Ion Trap MS/MS - An Option for Eliminating False Positives & Elevated Detection Limits for Organochlorine Pesticides. C. Zhang, A.M. Niklas, Environmental Sciences, University of Houston-Clear Lake, Houston, TX; J. Gandhi, 12521 Gulf Freeway, Metrohm-Peak, LLC, Houston, TX. The analysis of organochlorine pesticides using traditional EPA methodologies that employ gas chromatography with electron capture detectors (GC/ECD) are often affected by a number of non-target matrix components causing false positive identification or high bias for certain compounds. A number of known co-elutions of PCB congeners with various O-C pesticides exist, but a plethora of other low-level matrix interferences can result in poor selectivity when using GC/ECD procedures. The interferences originate from other halogenated compounds, nitriles, nitro compounds, organometallics, and compounds containing conjugated carbon bonds. High biased results for organochlorine pesticides can lead to an overall lack of data confidence and unnecessary environmental actions. To eliminate the interference, an Ion Trap GC/MS/MS method was developed and evaluated. Using standard extraction procedures combined with large volume injection, the method was able to achieve detection levels typically observed by ECD detection. The method was applied to the analyses of effluents, sediment/soil, and tissue matrices. Ion Trap GC/MS/MS showed additional advantages in complex matrices by further reducing co-extractable interferences. The use of Ion Trap GC/MS/MS for chlorinated pesticide analysis provides superior analyte selectivity over traditional ECD procedures and as good or better sensitivity. Contact Author: Howard Boorse Columbia Analytical Services, Inc. 1317 South 13th Ave Kelso, WA 98626 360-430-7733 hboorse@caslab.com

446 Determination of Bromide and Bromate in Drinking Water and Surface Water Using LC/MS and IC/MS. C. Zhang, A.M. Niklas, Environmental Sciences, University of Houston-Clear Lake, Houston, TX; J. Gandhi, 12521 Gulf Freeway, Metrohm-Peak, LLC, Houston, TX. Bromate (BrO₃⁻) is a carcinogenic anion that can be found in drinking water. It is introduced into the drinking water primarily from the conversion of bromide (Br⁻) in bromide-containing source water during the ozonation disinfection process. Several U.S. Environmental Protection Agency (EPA) methods have been developed; however, these methods require extensive pre-concentration, expensive sample preparation, and/or specialized instrumentations that routine laboratories cannot afford. The objective of this work was to develop a simple mass spectrometric method to analyze bromate and bromide below 1 ppb levels in drinking water and surface water matrices. Two mass spectrometric methods developed to determine ppb levels of bromate and

bromide include liquid chromatography/mass spectrometer (LC/MS) for drinking water samples and ion chromatography/mass spectrometer (IC/MS) for surface water samples. A total of 21 water samples were collected, including 6 tap water samples, 10 bottle water samples of various brands, and 5 surface water samples from the Houston area (Canyon Lake, Brazos River, Colorado River, Lake Conroe, and Lake Livingston). Both methods employed ion chromatography anion column where the ions were separated, followed by a mass spectrometer equipped with atmospheric pressure ionization electrospray source (API-ES), which selectively detected bromide at 79 amu and bromate ion 127 and 129 amu. With LC/MS, the Method Detection Limit (MDL) was 0.61 ppb for bromide and 0.95 ppb for bromate in bottle waters and tap waters. For IC/MS, the calculated Lowest Concentration Minimum Reporting Limit (LCMRL) was 0.19 ppb for bromide and 0.15 ppb for bromate in surface water. Analytical results revealed that some tap waters in the Houston area did contain bromate levels close to the U.S. EPA's Maximum Contaminant Level (MCL) of 10 ppb. Most bottled water samples did not contain much bromate, but some did have higher than expected bromide levels. Surface waters tested did not contain bromate, but some bromide. These mass spectrometric methods do not require pre-concentration or special sample preparation, and can be used to measure bromate in water, below the MCL and close to the Maximum Contaminant Level Goal (MCLG) of 0 ppb. The IC/MS is better suited to monitor bromate below the U.S. EPA's MCL in surface waters.

447 What are the Fluorinated Precursors that Mother Nature Uses to Make PFCA/PFSAs? S.A. Mabury, Department of Chemistry, University of Toronto, Toronto, Ontario, Canada. Perfluorinated acids (PFCAs and PFSAs) are widely disseminated in the global environment and appear at high concentrations in humans and in Arctic mammals. Substantial evidence indicates that volatile polyfluorinated alcohols, the fluorotelomer alcohols or FTOHs and sulfamidoethanols or SMOHs, are significant contributors to this contamination. It is well established that FTOHs can yield PFCAs via atmospheric oxidation, biotic metabolism (microbial and mammalian), or through indirect photolysis in surface waters; analogous mechanisms are, or are expected to be, operative for the conversion of SMOHs into PFSAs. More recently an FTOH-based surfactant, the polyfluoroalkylphosphates (PAPs) used widely in food contact paper, were shown to rapidly undergo metabolic release of an FTOH which was subsequently oxidized to the corresponding PFCA. Similar observations were made for the biodegradation of an FTOH based acrylate monomer; studies continue to explore whether the fluorinated polymers themselves yield PFCAs through hydrolytic release of the FTOH. These experiments have primarily focused on the conversion of the free fluorinated alcohol or its initial hydrolytic release from an ester. Many other non-alcohol based polyfluorinated materials may also be sources of PFCA/PFSAs in the environment and thus should be explored as potential precursors. These would include the telomer-based sulfonates and phosphonates, which differ critically in having a C-S and C-P bond that would require oxidation, rather than hydrolysis, for the release of the FTOH. Potential precursors also include the perfluorinated ketones which have the potential to undergo photolytic conversion to PFCAs. This talk will explore the interplay between chemical architecture and mechanism for the conversion of fluorinated precursors to the persistent and widely disseminated PFCAs and PFSAs.

448 Novel atmospheric sources of perfluorocarboxylic acids. C.J. Young, S.A. Mabury, Department of Chemistry, University of Toronto, Toronto, Ontario, Canada; M.D. Hurley, T.J. Wallington, Ford Motor Company, Dearborn, MI. Perfluorocarboxylic acids (PFCAs) are present ubiquitously in the environment, including remote regions where local contamination is expected to be minimal. Studies from these regions suggest that atmospheric oxidation of volatile precursors are an important source of PFCAs. To date, fluorotelomer alcohols (FTOHs) and fluorosulfamido alcohols have been the suggested atmospheric precursors of PFCAs. However, any chemical which can form a $\text{CF}_3(\text{CF}_2)_n\text{C}\cdot(\text{O})$ radical has the potential to form PFCAs. The 4:2 fluorotelomer iodide (4:2 FTI) is the shortest member of the FTI family used as precursors for the production of FTOHs and can be used as a proxy to study the FTI family. These compounds are likely to behave in a manner similar to the FTOHs and produce PFCAs of all chain lengths. Additionally, perfluoro-2-methyl-3-pentanone (PFMP) is produced in large quantities as a fire protection fluid and can photolyze to give $\text{CF}_3\text{CF}_2\text{C}\cdot(\text{O})$. This could help to account for large quantities of perfluoropropionic acid (PFPrA) in precipitation that are currently unexplained. Smog chamber studies

were undertaken to determine the atmospheric fate of these two compounds and determine their potential to produce PFCAs. Photolysis was shown to limit the lifetimes of both compounds, with average atmospheric lifetimes on the order of 1-2 days for 4:2 FTI and a week for PFMP. Production of PFCAs from trifluoroacetic acid (TFA) up to perfluoropentanoic acid were observed from atmospheric degradation of 4:2 FTI. Photolysis of PFMP was demonstrated to yield TFA and PFPrA. Thus, FTIs and PFMP, if present in the atmosphere, could be sources of PFCAs to the environment.

449 Quantitative Determination of Fluorochemicals in Landfill Leachates. C.A. Huset, Chemistry and Biochemistry, University of South Carolina, Columbia, SC; M.A. Barlaz, Civil, Construction and Environmental Engineering, North Carolina State University, Raleigh, NC; D.F. Barofsky, Chemistry, Oregon State University, Corvallis, OR; J.A. Field, Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR. Paper and packaging products have recently been identified as potential routes of fluorochemical exposure to humans. The presence of fluorochemicals in these coatings highlights the fact that while the bulk of fluorochemical production has been for solid material applications, little is known regarding fluorochemicals in solid waste treatment. A method was developed to quantitatively determine fluorochemical concentrations in landfill leachates using solid phase extraction followed by EnviCarb cleanup. Standard addition experiments were performed to evaluate matrix effects during electrospray ionization tandem mass spectrometry analysis of leachate extracts. Recoveries for the most abundant fluorochemicals ranged from 70-130% and limits of detection were analyte dependent and ranged from 0.5-5.4 ng/L. Twelve leachate samples were analyzed including five samples of different ages from the same site and one sample from a laboratory scale reactor. Perfluoroalkyl carboxylates analytes ($\text{C}_4\text{-C}_{14}$) were all detected in leachate; shorter chained carboxylates were the dominant species (maximum concentration of perfluorobutanoate (PFBA) 1700 ng/L). Perfluorobutane sulfonate (PFBS) was the dominant perfluoroalkyl sulfonate detected, at a maximum concentration of 2300 ng/L. Other perfluoroalkyl sulfonates detected included the C_6 , C_8 and C_{10} perfluorosulfonates and 6:2 and 8:2 fluorotelomer sulfonates. Perfluoroalkyl sulfonamides were detected in all leachate samples; methyl perfluorobutane sulfonamido acetic acid (MeFBSAA) was the most abundant sulfonamide at 540 ng/L. The short chained analytes, PFBA, PFBS, and MeFBSAA, were present at in all leachate samples, including sites which closed in the 1980s. While the presence of longer chained (>8-carbon) analytes in recent leachate samples suggests continued input of these fluorochemicals.

450 Environmental Prevalence of Polyfluorinated Phosphates and Phosphonates. J.C. D'eon, V.I. Furdul, S.A. Mabury, Chemistry, University of Toronto, Toronto, Ontario, Canada; P. Crozier, E. Reiner, Laboratory Services Branch, Ontario Ministry of the Environment, Toronto, Ontario, Canada. Perfluorinated carboxylic (PFCAs) and sulfonic (PFSAs) acids are prevalent in the environment. Questions remain regarding the origin of this contamination, as the chemicals can be emitted directly into the environment or arise as degradation products of either fluorotelomer alcohols or perfluorinated sulfonamides via atmospheric or biological processes. Another class of fluorinated compounds that has recently received experimental attention is the polyfluoroalkyl phosphate surfactants (PAPS). PAPS are used in human food contact paper applications, and their ability to migrate into food from packaging has been demonstrated. Previous experiments in our lab have shown that although PAPS are stable towards abiotic hydrolysis the phosphate ester linkage is biologically labile, producing the corresponding PFCA from the biodegradation of the released fluorinated alcohol. This duality means that PAPS may themselves be present as a fluorinated contaminant while also being a source of perfluorinated acids to the environment. In addition to food-contact applications, PAPS and related fluorinated phosphonate chemistries are used as inert defoaming additives to pesticide formulations. Estimates of the total fluorine present in environmental samples, whether determined via incineration followed by fluoride measurements or using ^{19}F -NMR, yield values above the cumulative amounts of PFCAs and PFSAs present. To determine whether fluorinated phosphates and phosphonates account for some of the missing organo-fluorine mass balance we surveyed wastewater influent and effluent, as well as surface water samples from around southwestern Ontario, Canada. Samples were analyzed for one class of fluorinated phosphates and two classes of fluorinated phosphonates. Extraction and concentration was performed using Oasis WAX SPE cartridges, with quantification by HPLC-MS/MS.

451 Perfluoroalkyl contaminants in window film before and after a carpet installation. S. Gewurtz, Department of Chemistry, Brock University, Toronto, Ontario, Canada; S. Gewurtz, P. Crozier, S. Bhavsar, E. Reiner, P. Helm, Ontario Ministry of the Environment, Toronto, Ontario, Canada; M. Diamond, Department of Geography, University of Toronto, Toronto, Ontario, Canada; C. Marvin, Environment Canada, Burlington, Ontario, Canada. Although perfluoroalkyl contaminants (PFCs) have been detected in areas throughout the globe, ranging from the arctic to indoor air and human blood, confusion still exists on their sources to the environment and exposure routes to humans. Window film has been previously identified as an effective sampler of air concentrations of a variety of contaminants such as polychlorinated biphenyls and polybrominated diphenyl ethers. The purpose of this study was first, to determine if window film could be used to monitor PFCs, and second to evaluate if carpet installation was a source of PFCs to the film. The window film in a room where carpet was installed was sampled on a window just before and a window two months after carpet installation. The film was sampled by washing the windows with precleaned laboratory kimwipes using methanol as a solvent. Two windows in a nearby reference room where carpet was not installed were also sampled on the two sampling dates. Field blank samples were taken by waving precleaned laboratory kimwipes in the air for 2 minutes at both sampling dates. The samples were extracted with a modification of the Hansen et al. (2001, Environmental Science and Technology, 35:766) ion pairing method and analyzed by liquid chromatography tandem quadrupole mass spectrometry (HPLC-MS/MS). PFCs were detected in all of the film samples but in none of the field blanks, suggesting that window film can be used to monitor PFCs. Perfluorooctanoic acid (PFOA) was the dominant PFC in all window film samples, followed by perfluorooctane sulfonate (PFOS) and perfluorodecane sulfonate (PFDS). Total PFC concentrations in the carpeted room prior to carpet installation was 5.62 pg/cm² window and increased 2.4-fold to 13.4 pg/cm² two months after carpet installation. Total PFC concentrations in the reference room at both sampling dates were similar and low (3.85 and 3.32 pg/cm² window), compared to the carpeted room. Further studies are underway to evaluate if carpet installation results in a similar increase in window film concentrations at other sites using different carpet brands.

452 Mass Flow of Fluorochemicals in a Swiss River Valley. C.A. Huset, Chemistry and Biochemistry, University of South Carolina, Columbia, SC; A.C. Chiaia, D.F. Barofsky, Department of Chemistry, Oregon State University, Corvallis, OR; N. Jonkers, H. Kohler, W. Giger, J.A. Field, EAWAG, Dübendorf, Switzerland. Fluorochemicals are globally-distributed, persistent pollutants which are not removed during wastewater treatment and are therefore emitted to aqueous systems in wastewater effluent. The contribution of wastewater effluents to the load of fluorochemicals in a river system was assessed in the Glatt River in Switzerland. Daily, flow composite samples of influent and effluent were collected from seven wastewater treatment plants (WWTP) for one week. River water flow proportional composites were collected daily for one week at a point upstream of the wastewater outfalls, at a point after the discharge of four of the treatment plants, and just before the Glatt River empties into the Rhine. The most abundant analytes detected were perfluorooctane sulfonate (PFOS) > perfluorohexane sulfonate (PFHxS) > perfluorooctanoate (PFOA). Comparison of fluorochemical concentrations in influent and effluent wastewater at each of the seven WWTP did not reveal significant differences in concentration for most fluorochemical analytes indicating limited removal during treatment. From the aqueous concentrations of fluorochemicals in wastewater effluent and in river water samples, mass flows of fluorochemicals were calculated. Mass flows of PFOS, PFHxS, and PFOA in WWTP effluents were additive along the river and were conserved throughout the system; removal processes were not significant. Per capita discharges for fluorochemicals in WWTP effluents accurately estimated upstream fluorochemical contribution from Greifensee, the headwaters of the Glatt River.

453 In Vivo Isomer-Specific Tissue Distribution and Elimination of Perfluorinated Acids Part I: Single Dose Study. J.P. Benskin, J.W. Martin, Laboratory Medicine and Pathology, University of Alberta, Edmonton, Alberta, Canada; A.O. De Silva, S.A. Mabury, Chemistry, University of Toronto, Toronto, Ontario, Canada. Perfluorinated acids (PFAs) and their precursors (PFA-precursors) exist in the environment as multiple isomers which are hypothesized to have different biological properties. This study is the first in a 2-part project which examined perfluoroalkyl

acid isomer-specific uptake, tissue distribution and elimination in vivo. Seven male Sprague-Dawley rats were administered a single gavage dose of 500ug/kg perfluorooctane sulfonate (PFOS, 70% linear/30% branched), perfluorooctanoic acid (PFOA, 80% linear/20% branched), 500ug/kg linear perfluorononanoic acid (n-PFNA) and 500ug/kg isopropyl-PFNA (iso-PFNA). Two additional control rats were administered the vehicle (Milli-Q water). Animals were housed conventionally and were provided food and water ad libitum. PFA isomer elimination in urine and feces was monitored by placing the rats in individual metabolic cages for <24hrs at routine time points. Isomer elimination from blood was monitored by routine sampling of the lateral tail vein of each animal. On days 3 and 38, animals were euthanized with CO₂ and large blood volumes and tissues were collected. Analysis of urine, feces, blood, and tissues were conducted using a novel high performance liquid chromatography-tandem mass spectrometry (HPLC-MS/MS) method for PFA isomer separation. Results for PFOA and PFNA were confirmed by gas chromatography-negative chemical ionization-mass spectrometry (GC-NCI-MS). For both PFOA and PFNA, branching of the perfluoroalkyl chain resulted in a statistically significant decrease in blood elimination half life. For PFOS, the linear isomer was found to have the longest half life, but in this study was not found to be statistically different from the half life of branched isomers. In tissues collected on day 3, PFOS, PFOA and PFNA isomer profiles were similar to those in blood on day 3. The exception was for PFNA in brain, in which the linear isomer was found to preferentially cross the blood-brain barrier. These experiments demonstrate that branching of the perfluoroalkyl chain decreases the biological half-life of these chemicals in rodents. Environmental implications will be discussed.

454 In Vivo Isomer-Specific Tissue Distribution and Elimination of Perfluorinated Acids Part II: Subchronic Dose Study. A.O. De Silva, S.A. Mabury, Chemistry, University of Toronto, Toronto, Ontario, Canada; J.P. Benskin, J.W. Martin, Lab Medicine & Pathology, University of Alberta, Edmonton, Alberta, Canada. Industrial syntheses of perfluorooctanoate (PFOA, C₇F₁₅COO-) can be classified as either linear isomer or mixed isomer production. Ascribing perfluorocarboxylate (PFCA) contamination sources based on isomer analysis of biota depends upon biological behaviour of isomers. Another perfluoro acid (PFA), perfluorooctane sulfonate (PFOS, C₈F₁₇SO₃-) was manufactured only as a mixed isomer product. We sought to decipher whether chronic exposure to a defined PFA isomer mixture produces an identical isomer pattern in the body. To this end, male rats were fed a diet containing 2000 ng/g (0.00020%) PFAs for 12 wk, followed by a 12 wk clearance period. In the dose was 500ng/g each of the following: "mixed isomer" technical PFOA, "mixed isomer" technical PFOS, n-PFNA (n-isomer of C₈F₁₇COO-), and iso-PFNA ((CF₃)₂CF(CF₂)₅COO-). Technical PFOA and PFOS were characterized to contain an array of isomers, incl. the n-isomer (80 and 70%, respectively). Blood samples were acquired throughout to assess isomer uptake and clearance kinetics. PFOA reached steady-state blood concentration by day 26 and each isomer in the dose found in the blood. The n-isomer dominated and comprised ~90% of total PFOA. Uptake rates of the PFNA isomers were indistinguishable and their steady state concentrations were 1.8x greater than n-PFOA. Preferential elimin. of branched isomers was observed for PFCAs, leading to isomer signatures pronounced with the n-isomer. Of all the branched PFOA isomers, iso-PFOA was most persistent. Blood half lives using 1st order elimination kinetics were 9.4, 5.4, 50, and 33 d corresponding to n-PFOA, iso-PFOA, n-PFNA, and iso-PFNA. These results indicate that exposure to an isomer mix will result in preferential accumulation of n-isomer compared to branched isomers of that PFCA. This is due to favoured n-isomer uptake and enhanced branched isomer elimin. The findings suggest biol. handling of PFCA isomers may confound the ability to ascertain linear vs. mixed isomer PFCA exposure based on biota analysis. Isomer behaviour in other species should be investigated as n-isomer PFCA pharmacokinetics are species-dependent. In contrast to PFCA isomers, biological handling of PFOS isomers demonstrated only slight differences. The distinction between PFOS isomers vs. that of PFCAs may indicate varying affinity for specific organic anion transporters.

455 Environmental Characterization of 3M Electrochemical Fluorination Derived Perfluorooctanoate and Perfluorooctanesulfonate. W.K. Reagen, K.R. Lindstrom, C.B. Jacoby, R.G. Purcell, T.A. Kestner, R.M. Payfer, J.W. Miller, 3M Company, St. Paul, MN. Representative 3M electrochemical fluorination (ECF) production lots of perfluorooctanoate (PFOA) and perfluorooctanesulfonate (PFOS) were assessed to determine lot-to-lot variations in isomer distributions and to quantify the levels and

isomer distributions of higher chain homologue byproducts. Results from analyses of multiple ECF PFOA and PFOS production lots showed that the materials are highly branched and showed small variations in both the percentage and distribution of branched isomers of PFOA (~22%) and PFOS (~30%). The presence and isomer distribution profiles of differing chain length byproducts present in ECF PFOA were evaluated and compared to environmental media (soil, water) associated with ECF production facilities. Analyses of environmental samples associated with ECF production showed exclusively highly branched PFOA. Additionally, when trace levels of PFNA (perfluorononanoic acid) were detected (typically < ppb) in environmental samples the PFNA was highly branched. The environmental characterization of PFNA was consistent with the trace quantities of highly branched PFNA byproduct in ECF PFOA production lot material. The consistency in concentration and isomer distribution between production lot data and ECF manufacturing environmental samples provides a basis for interpretation of other environmental data.

456 Persistent organic chemicals pollution of pinnipeds living in the Sea of Okhotsk. H. Hoshino, S. Fujita, Veterinary Medicine, Hokkaido University, Sapporo, Hokkaido, Japan; B.N. Vladimir, National Marine Mammal Laboratory, National Marine Fisheries Service, Seattle, WA; Y. Goto, Hokkaido Kushiro Fisheries Experiment Station, Kushiro, Hokkaido, Japan; T. Isono, Hokkaido National Fisheries Research Institute, Kushiro, Hokkaido, Japan; T. Ishinazaka, Rausu Ranger Office, Shiretoko National Park, Rausu, Hokkaido, Japan; M. Kobayashi, Aqua Bioscience and Industry, Tokyou University of Agriculture, Abashiri, Hokkaido, Japan; Y. Sakurai, Fisheries Sciences, Hokkaido University, Hakodate, Hokkaido, Japan. The Sea of Okhotsk has the unique marine ecosystem and high biodiversity. However, this area is possibly polluted by persistent organic chemicals; e.g. PCBs, DDTs and PFOS. These chemicals are major pollutants of the marine ecosystem released from human activities. They tend to accumulate in higher trophic predators among marine species because of their high stability. Marine mammals; whales and pinniped, are higher trophic predator in the marine ecosystem and some of them are reported to suffer from pollution. Thus they are good indicators of pollution in the marine ecosystem where they dwell. To clarify the extent of organic chemicals pollution in the Sea of Okhotsk ecosystem, we examined levels of persistent organic chemicals in pinnipeds in the Sea of Okhotsk. We collected blubbers and fetuses of Steller sea lions *Eumetopias jubatus* in the Sea of Okhotsk. Blubbers were also collected in the western Bering Sea which faces lower human activity area than the Sea of Okhotsk. We measured levels of hexachlorocyclohexans, chlordanes, DDTs and PCBs in blubbers and fetal livers. To examine toxic effect of these chemicals, testosterone levels in the fetal livers were also measured. These studies showed levels of DDTs and PCBs in sea lions in the Sea of Okhotsk are higher than those in sea lions in the western Bering Sea. However, no relationships were observed between levels of these chemicals and testosterone in the fetal livers. In addition, we are examining the effect of DDT and PFOS exposure on gene expressions related to the adipogenesis and endocrine function of seal primary adipocyte now. Preliminary result showed short exposure of DDT to adipocyte during adipogenesis did not affect on the later expression of adiponectin gene.

457 Biovector Transport of Contaminants to Terrestrial Food Webs at Cape Vera, Devon Island, NU, Canada. E.S. Choy, J.M. Blais, L. Kimpe, Biology, University of Ottawa, Ottawa, Ontario, Canada; M. Mallory, Canadian Wildlife Service, Iqaluit, Nunavut, Canada; J. Smol, Biology, Queen's University, Kingston, Ontario, Canada. At Cape Vera, Devon Island, Nunavut, Canada, a colony of northern fulmars can surpass atmospheric sources of pollutants by heavily concentrating and releasing contaminants through guano to the terrestrial environment. Based on a survey of twelve ponds, concentrations of hexachlorobenzene (HCB), total mercury (THg) and dichlorodiphenyltrichloroethane (DDT) from the sediment of ponds closer to seabird colonies were 10 to 60-fold higher than ponds outside the area of seabird influence. At Cape Vera, fulmars serve as a keystone species, creating important habitats to emergent insect species, a snow bunting population that is higher than elsewhere in the Canadian High Arctic, and other species by depositing nutrients via guano. Since diet is the primary route of organochlorines (OCs) and methylmercury (MeHg) to Arctic biota, contaminant transfer from seabirds to the biota is of concern for ecosystem health. We examined contaminants from the seabirds to members of the terrestrial food web at Cape Vera. THg concentrations in lichens and flora strongly correlated with indicators of seabird-derived nutrients, such as $\delta^{15}N$

and $\delta^{13}C$ values. Our analysis of lichen, plant, and invertebrate species, as well as snow buntings and collared lemmings from twelve ponds support seabird guano as a major pathway of contaminants to the terrestrial food web of Cape Vera.

458 Bioaccumulation of chlorinated hydrocarbons in relation to productivity and dietary factors in ospreys breeding in alpine regions of western Canada. J. Elliott, C. Morrissey, S. Lee, L. Wilson, Pacific Wildlife Research Centre, Environment Canada, Delta, British Columbia, Canada; M. Wayland, Prairie Wildlife Research Centre, Environment Canada, Saskatoon, Saskatchewan, Canada; D. Muir, National Water Research Institute, Environment Canada, Burlington, Ontario, Canada. From 1999 to 2002 we studied ospreys (*Pandion haliaetus*) breeding in lakes and rivers varying in altitudes and drainage size across the alpine regions of western Canada. Eggs were collected, nest success determined and where possible blood and feathers were taken from nestlings and adults. Mean concentrations of organochlorine (OC) pesticides and polychlorinated biphenyls (PCBs) varied significantly across the spatial range of the study from the southern Yukon to southeastern British Columbia. There were no significant differences in contaminant concentrations in eggs in relation to altitude of nests; however, both DDE and PCB concentrations increased with size of the drainage basin. We also studied whether contaminants or other ecological factors such as variation in prey delivery rates and biomass were affecting Osprey productivity. In total, 68 Osprey nests from 5 different lake sites across southern British Columbia, Canada were surveyed for productivity in 2001, while 25 of those nests were intensively observed to identify prey deliveries. Prey biomass per nest increased with the number of young/active nest indicating Ospreys at some locations were capable of increasing their delivery effort to feed larger broods. Two sites, Lillooet and Nakusp, consistently had the lowest prey sizes, prey delivery rates and prey biomass per nest, and subsequently had lower overall productivity and nest success. In addition, Lillooet Ospreys also experienced the largest reduction in brood size (63%). Differences in productivity among sites could not be explained by contaminants. Concentrations of organochlorines, PCBs and mercury in eggs collected from the same five locations in 1999 or 2000 were below levels known to cause reproductive toxicity. This study highlights the importance of food availability to breeding Osprey that can confound the interpretation of contaminant related reproductive effects.

459 The relevance of ecological principles in explaining accumulation of contaminants in terrestrial food webs. N. van den Brink, H. Baveco, Alterra, Wageningen, Netherlands; F. Vermeulen, University of Antwerp, Antwerp, Belgium. Exposure to most environmental contaminants started only recently in evolutionary terms. There are examples of invertebrates that have shown adaptation to contaminant exposure. However, higher organisms have in general a longer lifespan, and there are no signs that they have adapted to exposure to environmental contaminants. Hence, the pattern of accumulation through food uptake is not only governed by characteristics of the contaminants, but should also be explained from an ecological perspective. This implies that in modeling bioaccumulation in food webs such factors need to be incorporated. In the presentation we will illustrate the relevance of feeding behavior, including foraging strategies and functional responses, and habitat preferences of predators and prey in predicting the accumulation of contaminants to higher organisms. This will be done based on virtual scenarios and on spatially explicit accumulation models developed in the BERISP project (see www.berisp.org).

460 Mass balance and transfer efficiency of BDE-99 and BDE-47 topically applied to snapping turtle and red-eared slider egg surfaces. K.M. Eisenreich, A.M. Sides, C.L. Rowe, University of Maryland Center for Environmental Sciences: Chesapeake Biological Lab, Solomons, MD. Embryonic development is highly sensitive to chemical insult resulting from maternal transfer of lipophilic contaminants. Maternal transfer of contaminants is difficult to study in turtles because, unlike avian eggs which can be injected with a contaminant thus ensuring accurate embryonic exposure, injecting turtle eggs results in very high embryonic mortality rates. Thus, reptilian studies typically deliver contaminants to embryos via topical exposures to the eggshell with the use of a solvent carrier. In this study, snapping turtle (*Chelydra serpentina*) and red-eared slider (*Trachemys scripta*) eggs were topically dosed with either BDE-47 or BDE-99 dissolved in dimethyl sulfoxide (DMSO) as the carrier to achieve a target dose of 40 ng/g in the embryo. Dosing solutions, adjusted for mean egg mass, were placed on each egg in 5 μ l volumes over six days to avoid acute lethality as well as to obtain maximum transfer across the eggshell. Based a pilot study, dosing

solutions were made assuming a 20% transfer rate. Eggs were frozen two weeks after dosing for subsequent chemical analyses. For both species, more BDE-47 was transferred across the eggshell than BDE-99. Mean concentrations of BDE-47 measured in egg contents were 73.29 ng/g ww (SE = 3.58) and 55.25 ng/g ww (SE = 3.77) for snapping turtles and sliders, respectively, whereas mean BDE-99 concentrations in egg contents were 40.71 ng/g ww (SE = 4.65) and 19.48 ng/g ww (SE = 4.95). Transfer efficiency is likely dependent upon the steric properties of the compound as BDE-99 contains an additional bromine atom compared to BDE-47. Analyses are underway to quantify transfer efficiency across the eggshell as well as transfer across the allantoic membrane to understand the partitioning of BDEs among egg components.

461 Assessment of Individual and Population-Level Endpoints in Red-Eared Slider Turtles (*Trachemys scripta*) from a Metal-Contaminated Superfund Site. K.A. Hays, K. McBee, Department of Zoology and Collection of Vertebrates, Oklahoma State University, Stillwater, OK. Many toxicological studies focus on only one endpoint to assess deleterious effects of contaminants; however, use of multiple endpoints provides a more complete understanding of detrimental effects of exposure to contaminants on wildlife populations. I investigated effects of exposure to environmental metals (Pb, Cd, and Zn) on: 1) population demography, 2) genetic structure, 3) neurobehavioral response and 4) tissue-metal content, in red-eared sliders, *Trachemys scripta*, inhabiting Tar Creek Superfund Site (TCSFS) and 2 reference sites, Lake Carl Blackwell (LCB) and Sequoyah National Wildlife Refuge (SNWR). Turtles (N = 331) were collected during 2003 and 2004 and basic measurements and mark-recapture data were used to evaluate demographic differences among the 3 sites. The TCSFS population had significantly more melanistic males ($\chi^2 = 7.09$, $P = 0.02$) and significantly different sex ratios ($\chi^2 = 11.24$, $P = 0.0036$) and size distributions ($\chi^2 = 57.71$, $P < 0.0001$) than reference sites. Flow cytometry was used to measure variation in DNA content of red blood cells from *T. scripta* collected from the 3 sites. There was a significant difference in the frequency of aneuploidy among the 3 sites ($\chi^2 = 20.94$, $P < 0.0001$). Neurobehavioral response was assessed by measuring righting time. Mass was significantly correlated with initiation and completion of righting ($P = 0.02$ and 0.03 , respectively); however, site was not significantly correlated with initiation or completion of righting. *T. scripta* from TCSFS had a significantly higher ($\chi^2 = 5.91$, $P = 0.015$) mean blood Cd level than animals from SNWR; however, there was no significant site ($\chi^2 = 1.52$, $P = 0.22$) effect on blood Pb concentrations. Combined evaluation of these endpoints indicate that *T. scripta* from TCSFS have been negatively impacted by the presence of heavy metals.

462 Small Mammals Inhabiting a Heavy Metal Contaminated Superfund Site: Community and Population Parameters. K. McBee, K.L. Phelps, Zoology, Oklahoma State University, Stillwater, OK; K. McBee, K.L. Phelps, Collection of Vertebrates, Oklahoma State University, Stillwater, OK. The overall goal of this study was to determine ecological characteristics of small mammal assemblages inhabiting a heavy metal contaminated site, Tar Creek Superfund Site, compared to reference sites located in northeastern Oklahoma. Primary hazardous materials present at Tar Creek Superfund Site include lead, zinc, and cadmium. Mark-recapture techniques were employed to determine ecological characteristics of small mammal assemblages, both at the population and community level. Small mammal assemblages inhabiting contaminated sites within Tar Creek Superfund Site had reduced species diversity, including richness and evenness, as well as fewer overall captures, compared to reference sites. Species composition was different between contaminated sites and reference sites as evidenced by detrended correspondence analysis. Basic demographic parameters such as population size, survival rate, recapture rate, mean minimum longevity, number of reproductively active females, reproductive success, prevalence of botfly (*Cuterebra fontinella*) infestation, and home range size, of a commonly captured species, *Peromyscus leucopus*, were not significantly different between contaminated and reference sites. However, average body mass of adult, non-reproductive *P. leucopus*, along with overall dental condition, were significantly different between populations inhabiting Tar Creek Superfund Site and reference populations. Unfortunately, no direct link between site contamination and alterations to community and some population characteristics could be established. Further study is needed to elucidate relationships between observed effects at the community level and apparent lack of effect on population parameters for the most common species within the small mammal community.

463 Toxicity of acid metalliferous tailing ponds to migrating waterfowl. C.B. Meyer, J.S. Meyer, A. Thatcher, ARCADIS BBL, Golden, CO; P.E. Goodrum, ARCADIS BBL of NEW YORK, Syracuse, NY. Toxicity experienced by migratory waterfowl that drink tailing-pond waters with high concentrations of metals is unknown. Birds may drink large amounts during stopover periods or be averse to the water and seek alternate sources. Using laboratory toxicity data available for mallard ducks (*Anas platyrhynchos*), we developed total dose-response curves for copper, cumulative water consumption curves, and exposure duration-mortality curves to predict mortality for waterfowl that consume water from acidic tailing ponds. In the laboratory, drinking rates varied greatly among individuals offered ad libitum access to synthetic acid metalliferous mining water (predominantly copper, pH = 2), but mean rates for treatment groups were lower than for controls by more than a factor of 10, which supports a hypothesis that birds are averse to the water. Predicted mortality for exposure periods ranging from 1 to 8 hours varied from 1 to 2% on ponds containing 600 mg/L to 75 to 100% on ponds containing 6000 mg/L copper.

464 Foraging behaviour in ecotoxicology: tool or endpoint? E. Vermeulen, H. D'Havé, V.K. Mubiana, L. Bervoets, R. Blust, W. De Coen, Biology, Universiteit Antwerpen, Antwerpen, Belgium; N. Van den brink, H. Baveco, Alterra, Wageningen, Netherlands. The health of residential wildlife is increasingly threatened by the accumulation of heavy metals through terrestrial food chains. An important determinant of contaminant uptake is the foraging behaviour. Nevertheless, it is rarely included in ecotoxicological risk assessments and often subject to unrealistic assumptions. In our study bioaccumulation of heavy metals was monitored in a three-step terrestrial food chain, and foraging behaviour of the predator was assessed using highly quantitative GPS mapping. As a model system we chose the soil – earthworm/ beetle – hedgehog food chain in two residential park areas in the region of Antwerp (Belgium). These parks are situated along a metal pollution gradient. Metal concentrations of prey items and soil were assessed in different habitat types. Cadmium and lead concentrations were significantly habitat dependent. For cadmium the difference between habitat types were consistent throughout the food chain. In contrast, lead concentrations in soil were higher in forest than in grassland, whereas the opposite was observed for hedgehogs. This was due the spatial heterogeneity in the abundance of earthworms which were about 300 times more contaminated with lead compared to beetles. Our observations clearly demonstrate that knowledge of foraging behaviour and prey identity and prey availability is indispensable for an accurate appraisal of the risk of soil pollution for resident wildlife. It remains to be explored to which extent the foraging behaviour is determined by the microspatial variation in pollutant concentrations, and as such it might be rather an endpoint in stead of a tool in ecotoxicology.

466 Molecular biomarkers of chlorpyrifos exposure identified in juvenile trout. M.L. Rise, M. Rise, Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, Newfoundland, Canada; S.L. Miller, G. Goetz, M.J. Carvan, Great Lakes WATER Institute, University of Wisconsin - Milwaukee, Milwaukee, WI. Organophosphate pesticides (OPs) are widely used in agriculture, and can cause adverse neurological effects by mechanisms that remain poorly understood. We used DNA microarray hybridization, suppression subtractive hybridization (SSH) cDNA library construction, and quantitative reverse transcription – polymerase chain reaction (QPCR) to identify and validate juvenile rainbow trout (*Oncorhynchus mykiss*) genes responsive to 48 hour sub-acute (1-100 ppb) waterborne chlorpyrifos exposure. A reference design microarray experiment identified candidate molecular biomarkers of chlorpyrifos exposure, including a gene encoding a novel small heat shock protein (sHSP). A different sHSP gene was identified in a SSH library designed to be enriched for *O. mykiss* genes induced by chlorpyrifos, and additional members of this family of molecular chaperone genes were identified in public DNA sequence repositories. We used QPCR with 48 hour chlorpyrifos-exposed (1, 3, 10, 30, and 100 ppb) and vehicle control whole juvenile templates to study biological variability of expression of several molecular biomarkers for chlorpyrifos exposure including four sHSP genes and CCAAT/enhancer binding protein delta. We consider how expansion of some gene families (e.g. molecular chaperones) through gene/genome duplication events may influence species' relative sensitivity to environmental stressors such as pesticides. Keyword(s): organophosphate pesticide, chlorpyrifos, gene expression, molecular chaperone

467 Biomarker Responses in Fathead Minnows (*Pimephales promelas*) During Exposure to Exceptional Quality Biosolids. C.A. Sullivan,

CANTEST, Ltd., Vancouver, British Columbia, Canada; C.A. Sullivan, R.C. Hale, P.A. Van Veld, Virginia Institute of Marine Science, Gloucester Point, VA; C.L. Mitchelmore, University of Maryland Chesapeake Biological Laboratory, Solomons, MD. Biosolids are stabilized sewage sludge known to contain a complex mixture chemicals known to impact aquatic organisms via genotoxic, endocrine disruption, and other pathways. Adult male fathead minnows (*Pimephales promelas*) were exposed to EQ (exceptional quality) biosolids for 28 days in static renewal aquaria. Treatments were clean water (control), low dose (0.5 g/L), and high dose (2.5 g/L). Hepatic cytochrome P4501A (CYP1A) was elevated approximately eight- to 21-fold in fish exposed to low and high dose biosolids exposures relative to controls. DNA damage measured in hepatocytes using the Comet assay was elevated in low- and high-dose exposed fish at all time points measured. Analytical chemistry revealed high levels of PAHs, PBDEs, nonylphenols, and personal care products. Our data suggest that biosolids-associated contaminants have the potential to impact aquatic organisms exposed to these contaminants.

468 Induction of the vitellogenin gene in early life stage fathead minnows as an effective exposure indicator for estrogenic compounds. J. Lazorchak, D. Lattier, T. Reddy, D. Bencic, A. Biales, ORD, U.S. EPA, Cincinnati, OH; M. Smith, The McConnell Group, c/o U.S. EPA, Cincinnati, OH. Vitellogenin (Vg) gene expression in adult male fathead minnows (FHM) has previously been used successfully to detect exposures to estrogenic compounds in aquatic systems; however, sample volume(s) required for >24h exposure durations and the logistics of sampling pose some limitations on the use of adult male fish. We have previously established that Vg is indeed expressed in larval FHM and responses were proportional to external concentration. In addition to the minimal experimental scale required to use larval fish, they are readily available, less labor intensive, economical and afford a greater number of experiments that can be performed. Early development is an exquisitely complex biologic sequence in which signaling interactions and changes in gene expression must be orchestrated in a precise spatial and temporal program to ensure that embryogenesis and pattern formation progress faithfully; therefore, a more advantageous rationale to using early developmental stages of teleosts is the would-be predictive biology arising from genomic analysis of ecological exposure. In an initial attempt to use developmental stages as a means to predict adverse outcome and develop consistent exposure biomarkers, we have developed a method for detecting exposure to estrogenic compounds in water samples using early life stage FHM. The objective set for the FHM early life stage estrogen exposure method was to establish an ideal age of larvae/juveniles that exhibited minimal variation in Vg gene expression, within groups exposed to estrogenic endocrine disrupting chemicals (EDCs) (EE2, E2, E1, and NP) and respond to the lowest levels at which adult male fathead minnows are induced to express Vg. To establish an ideal age, different stages of larvae (4,7,14,21,28, and 35 dph, in triplicate) were taken from the same larval pool. Exposures were carried out in 500 ml beakers and renewed daily. For controls, 500 ml beakers containing MHRW with the appropriate amount of DMSO (5 10 µl /L MHRW) were used. Fish were fed for 2 hours before initiation of exposure, with age adjusted amounts of newly hatched brine shrimp and exposed to test chemical(s) for 48 h. At 48 h, fish were fed again for 2 h and exposed to the respective test chemical for an additional 48h. Results will be presented on the various ages using nominal concentrations of EE2 2.5 ng/L, E2 40 ng/L, E1 60 ng/L and NP 50 µg/L.

469 Differential Expression of Vitellogenin Genes in Zebrafish Exposed to Environmental Estrogens. T.B. Henry, J. McPherson, T. Heah, E.D. Rogers, Center for Environmental Biotechnology, University of Tennessee, Knoxville, TN; T.B. Henry, E.D. Rogers, Department of Forestry Wildlife and Fisheries, The University of Tennessee, Knoxville, TN. The lipoprotein vitellogenin is produced in hepatocytes of female fish in response to estrogen and deposited in developing oocytes where it is cleaved to form yolk proteins. Although vitellogenin is not normally expressed in mature male fish or larvae, vitellogenin genes are present, and production of vitellogenin can be induced by exposure to exogenous estrogenic substances. In most fish investigated, there are at least three genes that code for vitellogenin proteins, and while the biological significance of the multiple genes is unknown, differential expression of the individual genes offers an opportunity to better interpret the exposure of fish to environmental estrogenic substances. In the present research we have developed a quantitative reverse transcriptase PCR (qRT-PCR) approach to evaluate the expression of seven vitellogenin genes in zebrafish. The primers and probe sets used were developed based on

sequences of the individual genes available online (i.e., GenBank) and through molecular biology techniques in the laboratory. Subsequently, we exposed zebrafish in the laboratory to various environmental estrogens, total RNA was extracted following exposure, and expression of individual vitellogenin genes was evaluated by qRT-PCR. We found that expression of individual genes varied according to exposure to estrogenic substances and that qRT-PCR of vitellogenin genes offers a unique tool for evaluation of endocrine disruption in fish.

470 Biochemical and Genotoxic Biomarkers in Crab *Ucides cordatus* as Tools to Monitor Oil in Mangroves. A.D. Wagener, A.H. Nudi, A.L. Scofield, C.B. Sette, Quimica, Pontificia Universidade Catolica do Rio de Janeiro, Rio de Janeiro, Brazil; E.L. Francioni, DTO/SMS-SUDESTE, TRANSPETRO, Rio de Janeiro, Brazil. The present study aimed at understanding the relation between development of biomarkers in urine as well as in haemocytes of *Ucides cordatus* and exposure to oil pollution in mangroves. To this end the following experiments were performed: (1) chemical analyses of 37 PAHs in hepatopancreas samples using gas chromatography coupled to a mass spectrometer detector (GC/MS); (2) bioassays including exposure of crabs to pyrene as a model PAH, and evaluation of biological responses through pyrene metabolites development in urine samples; (3) micronucleus assay in crab hemocytes to verify genotoxic response derived from exposure to PAHs. Animals were collected during the period of September 2003 to October 2004 in four mangrove areas of Guanabara Bay, Rio de Janeiro, a system subjected to chronic and acute oil contamination. Crab urine was sampled in the field and in the laboratory after exposure to pyrene. The urine collected in the field contained as major metabolite pyrene-1-glucoside while samples collected up to 72 hours after inoculation in the lab were enriched in pyrene-1-sulphate. Pyrene-1-glucoside increased steadily over the 120 hours of experiment. Concentration of pyrene metabolites in crab urine showed strong correlation ($r = 0.88$) with total PAH in hepatopancreas as well as with total PAH concentration in sediment samples obtained from each studied site. Micronucleus assay was applied to crabs exposed to pyrene in the lab and to field crabs. An increase in micronucleus frequency in haemocytes was observed during the 120 h of bioassay indicating genotoxic response. However, the micronucleus frequency in field crabs was not proportional to the contamination gradient in the mangroves and was not significantly correlated to PAHs levels in crab samples. As for the biochemical markers *Ucides cordatus* can be considered an excellent bioindicator of oil residues, suitable for monitoring the environmental quality in mangrove areas.

471 The Structure and Dynamics of Bottlenose Dolphin Blubber: Key Factors in Interpreting CYP1A1 Expression in the Skin-blubber Biopsy. E.W. Montic, V.R. Starczak, J.J. Stegeman, M.E. Hahn, Biology, Woods Hole Oceanographic Institution, Woods Hole, MA; P.A. Fair, G.B. Mitchum, W.E. McFee, NOAA, National Ocean Service, Charleston, SC; G.D. Bossart, Harbor Branch Oceanographic Institution, Ft. Pierce, FL; M. Houde, D.C. Muir, Department of Environmental Biology, University of Guelph, Guelph, Ontario, Canada; D.C. Muir, National Water Research Institute, Environment Canada, Guelph, Ontario, Canada; R.J. Letcher, National Wildlife Research Centre, Environment Canada, Ottawa, Ontario, Canada. Persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs) accumulate in blubber of marine mammals. Therefore, it is necessary to understand the structure and dynamics of blubber layers and how these factors affect biomarker responses to POPs. We used established histological and immunohistochemical methods to document the structure of bottlenose dolphin (*Tursiops truncatus*) blubber and to assess the expression of cytochrome P4501A1 (CYP1A1) in skin-blubber biopsies of dolphins sampled in the waters off Charleston, SC (n=38), and Indian River Lagoon, FL (IRL) (n=36). The goal of the present study was to integrate the histological analysis of the integument with measures of CYP1A1 expression in vascular endothelial cells of the different blubber layers, and the concentrations of non-ortho and mono-ortho PCB congeners and OH-PCBs. CYP1A1 expression was strongest and most frequent in capillary endothelial cells; the greatest CYP1A1 staining was in the deepest layer of the blubber. CYP1A1 expression in deep blubber and 2,3,7,8-TCDD Toxic Equivalents in total blubber were significantly higher in dolphins from CHS as compared to those from IRL. Blubber dynamics was an important factor in the degree of CYP1A1 expression. Male dolphins with smaller adipocytes from CHS and IRL had higher levels of CYP1A1 expression in deep blubber. In CHS females, reproductive status affected CYP1A1 expression in vascular endothelial cells.

CYP1A1 expression in the deep layer was highest in simultaneously pregnant-lactating dolphins, and these dolphins had the smallest adipocytes in deep blubber. In all dolphins, CYP1A1 expression in the deep blubber layer was positively correlated with hydroxylated PCB (OH-PCB) concentrations in plasma. Redistribution of AHR agonists from blubber into the circulatory system during blubber mobilization may enhance PCB metabolism and production of OH-PCBs by induction of CYP1A1. The OH-PCBs thus formed have the potential to interfere with thyroid hormone homeostasis.

472 Comparative Toxicokinetics of Organohalogen Contaminants in Top Arctic Carnivores in Greenland-Captive Sledge Dogs and Free-Ranging Polar Bears. R.J. Letcher, J. Verreault, S. Shahmiri, W.A. Gebbink, Science and Technology Branch, National Wildlife Research Centre, Ottawa, Ontario, Canada; R. Dietz, C. Sonne, Department of Arctic Environment, National Environmental Research Institute, Roskilde, Denmark. As phylogenetically surrogate species for the polar bear (*Ursus maritimus*) in East Greenland, captive sledge dogs (*Canis familiaris*) were used to investigate the fate, toxicokinetics and effects of exposure to an array of organohalogen contaminants (OHCs). In a community in West Greenland, a cohort of adult female sledge dogs was fed a control diet consisting of pork fat (for human commercial consumption), and another cohort was fed a naturally OHC contaminated diet comprised of blubber of a minke whale (*Balaenoptera acutorostrata*) harvested in the waters off West Greenland. In the present study, we examined the compositional patterns of selected OHCs (e.g., various organochlorines and brominated flame retardants) and their known or suspected metabolic products (i.e., hydroxylated- and methylsulfonyl-substituted compounds) in adipose tissue and blood (plasma) of control and exposed sledge dogs in relation to their diet (i.e., pork fat or minke whale blubber). Further, we compared these OHC and associated metabolite patterns with those in adipose tissue and blood (plasma) of adult female polar bears, and blubber of their main prey species, the ringed seal (*Phoca hispida*) from East Greenland. We found notable differences in the accumulation profiles of major OHC classes and their metabolically-derived products between control and OHC-exposed sledge dogs, and between OHC-exposed sledge dogs and polar bears. Differences were also found within major classes of OHCs (e.g., PCBs and PBDEs). In addition to factors such as historical exposure (age) and sources of exposure (diet and background environmental levels), present findings suggest that for these two top Arctic carnivores in Greenland, the biotransformation of OHCs is species-dependent and influenced by the occurrence, induction and activity of specific xenobiotic-metabolizing enzymes (i.e., phase I and II enzymes).

473 Xenobiotic-Metabolizing Enzyme Activity and Organohalogen Metabolite Formation in Comparative Cohorts of a Captive Top Arctic Carnivore in Greenland, the Sledge Dog. J. Verreault, F. Maisonneuve, R.J. Letcher, Science and Technology Branch, National Wildlife Research Centre, Ottawa, Ontario, Canada; C. Sonne, R. Dietz, Department of Arctic Environment, National Environmental Research Institute, Roskilde, Denmark. As phylogenetically surrogate species for the polar bear (*Ursus maritimus*) in East Greenland, captive sledge dogs (*Canis familiaris*) were used in a larger, overall study to investigate the fate, toxicokinetics and effects of exposure to organohalogen contaminants (OHCs). In a community in West Greenland, adult female sledge dogs (P cohort) and their first-generation pups (F1 cohort) were fed a control diet consisting of pork fat (for human commercial consumption), and separate P and F1 cohorts were fed a naturally OHC contaminated diet comprised of blubber of a minke whale (*Balaenoptera acutorostrata*) harvested in the waters off West Greenland. In the present study, we examined, using catalytic enzyme assays, the comparative responsiveness of enzyme activity of major xenobiotic-metabolizing phase I and II enzymes (e.g., cytochrome P450 (CYP) 1A, 2B and 3A, epoxide hydrolase and uridine diphosphoglucuronosyl transferase) in liver microsomes of exposed and control P and F1 sledge dog cohorts. Further, we investigated the associations between the activity of these catalytic assays and the concentrations and patterns of known or suspected metabolic products of OHCs in blood (plasma), with particular focus on the hydroxylated (OH)-PCBs and -PBDEs and methylsulfonyl (MeSO₂)-PCBs. Initial results showed CYP 1A-mediated activity (measured as 7-ethoxyresorufin-O-deethylase activity) in sledge dog liver microsomes differed between the exposed and control P and F1 dogs, which was reflected by distinct retention profiles of OH-PCBs/-PBDEs and MeSO₂-PCBs in blood. A more complete and detailed result overview will be presented at the meeting.

474 Conservation Toxicology: DNA damage and oxidative stress in Gopher Tortoises on a Military Reservation. C. Theodorakis, Biological Sciences, Southern Illinois University Edwardsville, Edwardsville, IL; C. Theodorakis, Environmental Sciences Program, Southern Illinois University Edwardsville, Edwardsville, IL; M. Adams, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, IL. The land resources of the Department of Defense (DoD) are essential for military training and testing activities and for providing important habitat for more than 300 federally protected plant and animal species. Unfortunately, the effects of military pollutants on these species are unknown. Thus, this study will examine genotoxic and oxidative stress responses in gopher tortoises (*Gopherus polyphemus*) on Camp Shelby, a US Army training installation. These tortoises are exposed to chemicals from unexploded ordinance. Blood was collected from these tortoises to examine levels of glutathione, lipid peroxidation, and DNA damage at various sites throughout the base. Glutathione and lipid peroxidation was determined by fluorometric assays, while DNA damage was determined using flow cytometry and the comet assay. It was found that oxidative stress responses were generally higher at sites with higher levels of military activity. However, one site with low military activity showed high levels of DNA damage and oxidative stress responses, which may be related to habitat or other chemical contamination.

475 Estrogenic Toxicogenomics Effects of Sewage on Chinook Salmon (*Oncorhynchus tshawytscha*). H. Osachoff, K. Chander, L. Yu, R. Skirrow, J. Bruno, G. van Aggelen, Environmental Toxicology, Environment Canada, North Vancouver, British Columbia, Canada; H. Osachoff, C. Kennedy, Department of Biology, Simon Fraser University, Burnaby, British Columbia, Canada; T. Mommsen, Department of Biology, University of Victoria, Victoria, British Columbia, Canada. Using a toxicogenomics approach, we investigated the effects of sewage (municipal waste water effluent) diluted to receiving environment concentrations on gene expression in underyearling chinook salmon (*Oncorhynchus tshawytscha*). Quantitative real-time PCR (Polymerase Chain Reaction) and a custom rainbow trout cDNA microarray were used to assess liver gene expression changes in the various concentrations of sewage-exposed fish compared to controls. Data presented focus on the estrogen-responsive subset of genes, including: vitellogenin (structural egg protein often used as a biomarker), vitelline envelope proteins (alpha, beta, and gamma: three structural egg proteins), and estrogen receptors (transcription activators). Our experiments use male and female saltwater-acclimated juvenile chinook salmon that have very little to no estrogenic gene expression at that age unless stimulated by an exogenous estrogen or estrogen-mimicking chemical. Results show the gene induction in sewage-exposed fish across time, sewage concentrations and gender. All estrogen-responsive genes were clearly induced, some of them very strongly, when compared to controls. Points of discussion will include: how gene expression data often does not fit traditional toxicological dose response curves, the utility of vitelline envelope proteins as salmonid estrogenic biomarkers, and the differences in gene expression in males versus females

476 Gene Expression Analysis of Largemouth Bass Exposed to Mixtures of Pesticides in a Muck Farm Near Lake Apopka. N.D. Denslow, N. Garcia-Reyero, K.J. Kroll, N.J. Szabo, J. Griffith, T. Gross, D. Barber, Physiological Sciences, University of Florida, Gainesville, FL; R. Conrow, St Johns River Water Management Commission, Palatka, FL. Rarely are fish exposed to single contaminants in the wild – it is more usual that they are exposed to complex mixtures. To determine the effects of mixtures compared to individual compounds, we exposed laboratory fish to individual pesticides and to mixtures through their diet for 90 days over their reproductive season. The pesticide levels per gram of food were 124 ug/g p,p'-DDE, 1.95 ug/g dieldrin or a mixture of the two, 150 ug/g p,p'-DDE and 3 ug/g dieldrin. A second set of fish were placed in a mesocosm built in a highly contaminated muck farm near Lake Apopka and this exposure was for equivalent time. We found that dietary exposure increased body burdens of laboratory treated fish to 5.22 ± 1.1 ug/g p,p'-DDE, 0.11 ± 0.03 ug/g dieldrin, or to 5.35 ± 0.82 ug/g p,p'-DDE and 0.18 ± 0.06 ug/g dieldrin for the mix. A three-month exposure of the fish in the mesocosms increased internal burdens of p,p'-DDE, dieldrin, toxaphene, chlordanes, and methoxychlor to levels in the ppm range. Previously we have determined that these concentrations of pesticides reduce plasma hormone levels in exposed fish. Selected genes involved in endocrine function were analyzed by quantitative real time PCR, including aromatase a, StAR, androgen receptor, ERalpha, ERbeta2 and ERbeta1. Dietary exposure to dieldrin down regulated StAR, AR and the three ERs, but little effect

was seen for p,p'-DDE on these genes in the gonad. Exposure to the mixture showed decreased expression of StAR and AR. Fish exposed in the mesocosm showed decreased expression of StAR, AR and the two ER's beta. These samples will be analyzed by microarray analysis on a new 13,000-gene bass microarray to determine additional biological processes that may be impacted by the individual exposures and the mixtures. The results demonstrate that LMB rapidly accumulate OCPs following dietary exposure and that exposure leads to significant changes in endocrine function.

477 Mining for genomic biomarkers of metal exposure in *Daphnia magna*. H.C. Poynton, R. Zuzow, J.R. Varshavsky, S. Chan, A.V. Loguinov, C.D. Vulpe, Nutri. Sci. and Toxicology, UC Berkeley, Berkeley, CA. The emergence of genomic techniques has presented many exciting new possibilities in ecotoxicology including the ability to classify chemicals based on their expression pattern or fingerprint. The goal of our research is to illustrate the potential applications of gene expression profiling for environmental monitoring. This project focuses on three well-characterized metal pollutants: copper, cadmium, and zinc, and the invertebrate indicator species, *Daphnia magna*. Using a custom *D. magna* cDNA microarray containing approximately 5000 cDNA clones, we identified distinct expression fingerprints in response to sublethal Cu, Cd, and Zn exposures. We then challenged the *D. magna* microarray to determine the presence of a specific metal toxicant in blinded field samples collected from two copper mines in California. The expression profiles from the Cu containing field samples clustered with the Cu specific gene expression fingerprints. We also found that in our upstream samples, which contained undetectable Cu levels, few genes were differentially expressed and there was no overlap with the expression profiles of the higher, toxic samples, suggesting that expression profiles can distinguish between polluted and non-polluted field sites. Chronic toxicity was also assessed for the field samples collected from one of the copper mines. Mine samples resulting in reproductive effects clustered together and also closely with laboratory Cu exposures with similar chronic effects. By linking gene expression fingerprints to physiological endpoints such as reproduction, we will better be able to understand and predict the ecological consequences of pollutants based on an expression profile.

478 Linking molecular and higher level stress responses in the crustacean *Daphnia magna* following exposure to ibuprofen. A. Callaghan, L. Heckmann, R.M. Sibly, R. Connon, H.L. Hooper, School of Biological Sciences, University of Reading, Reading, United Kingdom; S.J. Maund, Syngenta Crop Protection AG, Basel, Switzerland; T. Hutchinson, Global Safety Assessment, AstraZeneca R&D, Södertälje, Sweden. This study aimed to link molecular and higher level stress responses in the crustacean *Daphnia magna* following exposure to the non-steroidal anti-inflammatory drug ibuprofen (IB). IBs are analgesic drugs that disrupt eicosanoid (fatty acid signalling molecules) biosynthesis in mammals. *Daphnia* were exposed to three concentrations of ibuprofen (20, 40 and 80 mg IB l⁻¹) and molecular changes in global gene expression were measured using microarrays supplemented with real-time quantitative PCR analysis of key genes following acute exposure (2-48h). The effects of IB were assessed on somatic growth, moulting, reproduction, survival and population growth rate and structure following chronic exposure (8-14 days) of daphnids. IB had a very targeted effect on reproduction (14-day EC50 of 13.4 mg IB l⁻¹) in the chronic experiments, whereas survival was only reduced at the highest test concentration (80 mg IB l⁻¹). Microarray expression revealed a total of 272 cDNAs significantly differentially expressed following a 24h exposure to IB, resulting in a gene list of 96 unique genes. Genes were assigned to functional categories using Gene Ontology and the Kyoto Encyclopedia of Genes and Genomes. Transcriptomic profiles of key genes in the crustacean eicosanoid metabolism revealed changes related to disruption of the *Daphnia* endocrine system, along with changes in genes associated with juvenile hormone metabolism and oogenesis. This links well with the observed disruption of egg production. Combining molecular and whole organism stress responses provides a framework to begin to understand stress responses and the application of microarrays to link early changes in gene expression with changes in populations.

479 OMICS – Essential risk assessment tool or Rube Goldberg contraption? C. Vulpe, H. Poynton, H. Wintz, Univ. of California, Berkeley, Berkeley, CA. Ecotoxicogenomics promises much for ecological risk assessment but its practical utility remains unproven. It is not clear if and when the technology will become more widely available to risk assessors and what role genomics will play in the regulator's tool box. We will use examples from

our own work and other group's to highlight some of the pressing issues about the use of ecotoxicogenomics in risk assessment. Some of the questions to be addressed include whether the role of ecotoxicogenomics will be limited to providing insight into mode of action or whether genomic endpoints can be used for regulatory decisions. We will examine the current data on the use of genomics applied to field situations and compare the findings with laboratory studies. The use of NOTEL (No Observed Transcriptional Effect Level) has been suggested as a possible endpoint and we discuss the current evidence and potential utility of NOTEL in risk assessment.

480 Causal Inference in Epidemiology, Toxicology and Environmental Safety Based on Genomic and Proteomic Data: Common Approaches, Similar Issues. C. Breckenridge, R. Pepper, Human Safety Assessment, NAFTA, Syngenta Crop Protection, Inc., Greensboro, NC. Technological advances in gene expression analysis, in the evaluation of signaling pathways and the use of new, powerful techniques in characterizing "ligand – receptor interactions" are permitting the correlation of these parameters with more traditional metrics in epidemiology (e.g. disease prevalence), toxicology (e.g. clinical, enzymatic and histopathological effects) and ecotoxicology (e.g. reproductive and population parameters). However, the development of a conceptual framework, akin to the famous Bradford Hill criteria developed in epidemiology and used effectively to guide causal inference in both epidemiology and more recently in mechanistic toxicology, is lagging. The objective of this presentation will be to develop the beginnings of such a framework for genomic and proteomic data and to test it against examples from epidemiology, toxicology and environmental sciences. In each of these cases, phenotypic anchoring, defined in the broadest sense, is expected to play an important role.

481 Utility of Genomics and High-Throughput Approaches for the Assessment of Industrial Chemicals and Pesticides. T.R. Henry, Office of Prevention, Pesticides & Toxic Substances, U.S. Environmental Protection Agency, Washington, DC; J. Holmes, Office of Pesticide Programs, U.S. Environmental Protection Agency, Washington, DC. A challenge facing the chemical industry, national and international regulatory agencies, and associated stakeholders is application of the current risk assessment paradigm with associated data generation requirements, combined with the need to evaluate the potential effects posed by thousands of chemicals. Governmental agencies, the regulated community and stakeholders are also facing the challenges of generating and interpreting data for chemical risk assessments in a cost-effective and efficient manner. For chemicals that lack data on toxicological and exposure potential, the challenge is to efficiently and credibly predict toxic potency and levels of exposure to make reasonable decisions as to whether or not empirical studies are required to further refine a risk assessment. In the context of regulatory programs where data generation is required to make regulatory decisions, the challenge is to develop the means to move, in a scientifically credible and transparent manner, from a paradigm that requires extensive hazard testing, followed by the elimination of information not relevant to the assessment, to a paradigm that provides the means to use a hypothesis- and risk-driven approach to identify the specific in vivo information most relevant to the assessment. New developments in molecular technologies, including genomics, proteomics, and metabolomics, hold considerable promise to enhance and optimize test methods and testing strategies, in the coming years. The advent of "omic" technologies in the coming years could dramatically increase the 'synergy' between QSAR and in vitro assay methods for chemical and toxicity endpoint ranking, prioritisation and screening. The full potential of scientific advances in risk assessment will be realized if these disciplines are integrated in a concerted and systematic fashion to establish decision support systems that provide the means of focusing assessment resources on those chemicals, uses, and endpoints most relevant to the risk management issues at hand. This abstract has been subjected to review by EPA's Office of Prevention, Pesticides and Toxic Substances and was approved for publication. Approval does not signify that the contents reflect the views of EPA.

482 Next Steps: Integrating Toxicogenomics Data into the Regulatory Paradigm. D. Volz, Environmental Safety - Americas, Syngenta, Greensboro, NC; D. Bencic, ORD/EERD, US EPA, Cincinnati, OH. An eminent challenge facing risk assessors within the government and chemical industry is the interpretation and utilization of toxicogenomics data for ecological risk assessments (ERAs). However, prior to implementation, an agreement must be reached as to how these data will be used within a regulatory framework. Immediate questions facing ecological risk assessors

include (but are not limited to): (1) How can toxicogenomics data be used as indicators of exposure, provide insight into chemical mode of action, and/or predict pathologic or morphologic change? and (2) How can toxicogenomics data help determine the extent and ecological relevance of exposure and act as early indicators of subsequent population- or community-level effects? The appropriate incorporation of these data into ERAs is critically dependent on which question(s) are being asked by the risk assessor. These questions and challenges can only be seriously addressed through discussions and collaborations among scientists, risk assessors, and regulators representing all stakeholders. The remaining time of this platform session will be focused on a moderated discussion, allowing session attendees to openly discuss and provide insights regarding the above-mentioned questions. In addition, we intend to recommend the establishment of a formal Ecotoxicogenomics Working Group which provides the scientific/regulatory expertise, framework, and direction necessary for suitable integration of toxicogenomics data into the ecological risk assessment paradigm. While we recognize the limited time available, our hope is that this brief discussion will catalyze the necessary dialogue and interactions among ecotoxicologists, genomics scientists, and risk assessors within academia, government, and industry.

483 Effect of copper on the sorption of 2,4,6-trichlorophenol onto multi-walled carbon nanotubes. X. Shan, Z. Pei, B. Wen, S. Zhang, State Key Laboratory of Chemistry and Ecotoxicology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, China; G. Chen, Research Institute of Subtropical Forestry, Chinese Academy of Forestry, Fuyuan, Zhejiang 3111400, China; Y. Xie, T. Liu, Beijing Synchrotron Radiation Laboratory, Chinese Academy of Sciences, Beijing 100049, China. The effect of copper on the sorption of 2,4,6-trichlorophenol (2,4,6-TCP) on multi-walled carbon nanotubes (MWCNTs) and/or of 2,4,6-TCP on copper sorption were studied using a batch equilibration method. MWCNTs are an effective adsorbent for 2,4,6-TCP because MWCNTs have high sorption affinity and short apparent equilibrium time. The sorption capacity of MWCNTs was increased remarkably by nitric acid oxidation due to the increase of surface area and introduction of functional groups. Copper markedly diminished the sorption of 2,4,6-TCP and 2,4,6-TCP also significantly suppressed copper sorption. No significant desorption hysteresis of 2,4,6-TCP was observed. X-ray absorption and Fourier transform infrared spectroscopic studies provided an evidence for competitive adsorption of copper and 2,4,6-TCP for carboxylic, phenolic and hydroxyl groups of MWCNTs, which was in part responsible for the overall observed suppression effect of copper on the sorption of 2,4,6-TCP and vice versa. The high sorption capacity and reversible sorption of 2,4,6-TCP imply the potential release of 2,4,6-TCP once 2,4,6-TCP adsorbed MWCNTs enter the environment, leading to a high risk problem.

484 Toxicity of nanoparticles to soil organisms. J.J. Scott-Fordsmand, P. Krogh, Terrestrial Ecology, Aarhus Universitet, Silkeborg, Denmark; A. Johansen, Environmental Chemistry and Microbiology, Aarhus university, Roskilde, Denmark. Nanotechnology is playing an increasing role in society and there is an increasing concern with regard to their potential effects. Very little is known about the toxicity of nanoparticles especially toward soil organisms. The present study aims at identifying the soil organism toxicity for a range of inorganic element based nanoparticles. The toxicity is evaluated by the standard population responses including both mortality and fecundity, under different environmental conditions. The results are related to the particles characteristics, such as size and to the inherent toxicity of the element in its free form.

485 Follow the Yellow Brick Gut: Electron Microscopy of Gold Nanoparticle Uptake by *Daphnia magna*. S.B. Lovern, Biology, Augustana College, Rock Island, IL; R. Klaper, Great Lakes WATER Institute, Milwaukee, WI; H.A. Owen, Biological Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI. The use of nanoparticles in consumer goods is no longer an idea of the future, as over 475 currently available commercial products claim to contain nanoparticles. With increased use comes an increased potential of unintended exposure. However, there remains little information available about the interactions of aquatic organisms with released manmade nanoparticles. Our past work has shown mortality and behavioral changes for *Daphnia magna* when exposed to various types of nanoparticles. One of the key questions is the level of uptake of these particles, especially in aquatic species. In this project, we examined the uptake and release of gold nanoparticles in *Daphnia*. *Daphnia* were exposed to sublethal concentrations of gold for time durations of 1, 6, 12, and 24 hours. Transmission Electron

Microscopy was then used to examine gut tissue for the presence of gold. The highest concentration of gold particles was found after 12 hours of exposure. Clearance of particles from the gut was investigated at this time point by moving organisms to fresh water without nanoparticles and observing particle retention in the gut tissue over time. The initial general trend of high gold concentration in the mouth with low levels in the tail region was reversed over time, suggesting clearance of particles through the gut with time.

486 Fate and transport of titania nanoparticles in a freshwater mesocosm. A. Miracle, A. Bunn, Natural Resources Division, Pacific Northwest National Lab, Richland, WA; J. Ward, Marine Sciences, Pacific Northwest National Lab, Sequim, WA; D. Gaspar, Materials Science, Pacific Northwest National Lab, Richland, WA. Titania nanoparticles are currently associated with air, soil, and water and with numerous products directed at human use and consumption (e.g., sunscreen, cosmetics, and food coatings). The environmental fate and transport of TiO₂, or any nanomaterials entering dynamic aquatic environments are largely unknown. The ecological and physical fate and transport of TiO₂ nanoparticles can not be predicted based solely on the chemistry of titanium. The properties of TiO₂ are dependent on size, surface chemistry, and composition of the particle and the environment where the particles have been released. The movement, toxicity, and bioaccumulation of these materials are difficult to study in a complex ecosystem. Because these materials are durable and recalcitrant, the accumulation of TiO₂ in the environment could be significant over time and cause unforeseen impacts on ecosystems. Fate and transport of TiO₂ nanomaterials in a bench-scale mesocosm system was assessed through nanomaterial partitioning and complexation in river water, sediment, and tissue media. Samples from the mesocosm were characterized using inductively coupled plasma mass spectrometry, transmission electron microscopy and scanning electron microscopy with energy dispersive X-ray spectroscopy. Research data sets like these will build the foundation for future use in fate and transport of other nanomaterials in different water systems (fresh, estuarine, and marine) and in building an empirical model that investigates environmental fate and transport and the ecological impact of nanomaterials.

487 An in vitro biomimetic assay for assessing the stability of engineered nanomaterials under oxidative environmental conditions. K.M. Metz, J.A. Pedersen, Environmental Chemistry and Technology, UW-Madison, Madison, WI; A.M. Mangham, R.J. Hamers, Department of Chemistry, UW-Madison, Madison, WI; J.A. Pedersen, Department of Soil Science, UW-Madison, Madison, WI. Once released into the environment, engineered nanoparticles may be transformed by redox processes resulting in altered toxicity and fate. Microorganisms play an important role in mediating environmental redox reactions either directly through the synthesis of enzymes or indirectly via biogenic oxidant/reductant production. Here, we report the development of an in vitro biomimetic assay for the investigation of nanomaterial stability under oxidative environmental conditions. The assay is based on the extracellular hydroquinone-driven Fenton reaction used by the brown rot fungus *Gloeophyllum trabeum* to produce hydroxyl radicals and degrade a wide variety of organic compounds. Initial experiments focused on the chemical stability of functionalized CdSe(ZnS) core-shell quantum dots. The fluorescent properties of these semiconductor nanocrystals and their potential to elicit biological responses made quantum dots an ideal candidate to demonstrate the utility of the biomimetic oxidative assay. Quantum dot transformation was assessed by UV-vis spectroscopy, ICP-OES, FTIR, zeta-potential measurement, and dynamic light scattering. Quantum dots functionalized via ligand exchange were readily degraded under simulated oxidative environmental conditions. Initial results indicate the ZnS shell is dissolved and cadmium is released from the quantum dot core. The influence of pH and organic reductant on the transformation of quantum dots functionalized via different surface chemistries, proposed degradation pathways and transformation products will be discussed.

488 Genomic data as an indicator of the differences in effects of nanoparticles with differing structure on *Daphnia* spp. R. Klaper, S. Lovern, Great Lakes WATER Institute, UW-Milwaukee, Milwaukee, WI. There is a question as to how to predict the impact of exposure to nanomaterials on organisms, and specifically how small changes in the structure of a particle will impact the physiological response of an organism to exposures. Genomic data, specifically gene expression patterns, are sensitive measurements of the biochemical mechanisms that may be affected in an organism with exposure. In addition genomics may provide a means to identify how small changes in chemical structure of a particle will affect toxicity. We exposed *Daphnia*

magna and *Daphnia pulex* to one of four nanoparticle suspensions at levels below those found to induce mortality in 50% of the population. Particles included fullerenes, hydrogenated fullerenes, hydroxylated fullerenes, and titanium dioxide. Genes that differed in expression among treatments was identified by creating a suppressive subtraction library as well as microarray analysis. Expression levels were then quantified using quantitative PCR. Gene expression pattern differed with particle type and toxicity. Genes affected by particle exposure included chitinase, transmembrane proteins, and ribosomal proteins among others. Genomic data can provide a means with which to separate the effects of each particle type and elucidate what biochemical pathways may be affected by exposure.

489 In vitro assay for assessing the gastrointestinal stability of engineered nanomaterials. P. Wicinski, T.C. King Heiden, W. Heideman, R.E. Peterson, J.A. Pedersen, Molecular and Environmental Toxicology Center, University of Wisconsin-Madison, Madison, WI; K.M. Metz, J.A. Pedersen, Environmental Technology and Chemistry Program, University of Wisconsin-Madison, Madison, WI; R.J. Hamers, Department of Chemistry, University of Wisconsin-Madison, Madison, WI. The toxicity of engineered nanoparticles is expected to depend in part on their stability in biological systems. Depending on the route of exposure, engineered nanoparticles may be altered as they encounter pH changes, potential ligands and reactive oxygen species. Changes to the surface of engineered nanoparticles may lead to the dissolution of inorganic nanoparticles, potentially releasing toxic elements. To assess the stability of engineered nanomaterials in the human digestive system, we adapted an in vitro assay previously used to evaluate the bioaccessibility of metals in contaminated soils. The compositions of the simulated gastric and intestinal fluids, temperature and residence times closely mimic conditions in the stomach and duodenum of the small intestine. Initial experiments focused on the gastrointestinal stability of CdSe/ZnS core-shell quantum dots functionalized with polyethylene glycol (PEG) of two different molecular weights (PEG350 and PEG5000). The fluorescent properties of quantum dots allowed convenient measurement of the size and concentration of these semiconductor nanocrystals. Transformation of quantum dots under simulated gastrointestinal conditions was characterized by Fourier transform infrared spectroscopy, UV-Vis spectroscopy, and inductively coupled plasma-optical emission spectroscopy. Most alterations to the quantum dots occurred during the gastric phase of the assay and included removal of the PEG ligands, erosion of the ZnS shell and release of cadmium. These alterations were more pronounced for quantum dots functionalized with the lower molecular weight PEG350 than for PEG5000-coated quantum dots. Mucin, a glycoprotein secreted by the mucosal lining of the stomach, protected a portion of the quantum dots from simulated gastric fluid-induced degradation. Toxicity of quantum dots, after being exposed to simulated gastrointestinal conditions, was assessed using an embryonic zebrafish assay. While PEG350-coated quantum dots show little or no toxicity to zebrafish embryos, alterations of the quantum dots by prior degradation in gastric fluid increased toxicity.

490 Fate and Effects of carbon nanoparticles within *Daphnia magna*. B.C. Seda, S.J. Klaine, A.S. Mount, Biological Sciences, Clemson University, Clemson, SC; P. Ke, Physics and Astronomy, Clemson University, Clemson, SC. A major difficulty associated with testing toxicity of carbon-based nanoparticles to aquatic organisms is their inherent instability due to their hydrophobicity. However, these nanoparticles can form stable colloidal suspensions especially in the presence of natural organic matter (NOM). We have been successful in stabilizing a variety of carbon nanoparticles, including C60 and C70 fullerenes, multi-walled carbon nanotubes, nanocoils, and nanowires, with NOM and quantifying the concentration of these nanoparticles. *Daphnia magna* were exposed to NOM-stabilized carbon nanoparticle suspensions and analyzed by fluorescence microscopy assays to determine the extent of apoptosis due to oxidative stress. Further, nanoparticle aggregates were observed forming outside of the gut tract. Confocal laser microscopy and transmission electron microscopy were used to characterized the cellular location of these aggregates. These data suggest that carbon nanoparticles can translocate from outside of the gut tract and can cause oxidative stress in *D. magna*.

491 The cellular and gene expression effects of manufactured nanoparticles on primary cell cultures of rainbow trout macrophages. F. Goetz, R. Klaper, Great Lakes WATER Institute, UW-Milwaukee, Milwaukee, WI; J. Chen, Department of Chemistry & Biochemistry, UW-Milwaukee, Milwaukee, WI. The immune system is one of the first physiological mechanisms to interact with foreign entities and, therefore,

will be key to understanding how organisms will be affected by exposure to nanoparticles. The overall goal of this study is to use a rainbow trout primary macrophage cell culture system to assess the effects of various types of manufactured nanoparticles on cell survival and gene expression in the innate immune system. Several nanoparticle types, including a manufactured C60 nanoparticle with covalently linked cyclodextrin, were tested in the trout macrophage cell assay and the effects on cell survival assayed using resazurin reduction analysis (QBlue Cell Viability -BioChain) and lactate dehydrogenase enzyme activity. The effects of nanoparticles on candidate gene expression in the macrophages were also analyzed using a quantitative polymerase chain reaction (QPCR). These included two proinflammatory genes, tumor necrosis factor (TNF) and interleukin 1 beta (IL-1b), and a proviral gene, interferon alpha. Results show that C60 fullerenes stimulated the expression of both TNF and IL-1b in trout macrophages.

492 Aging Effect of Pyrethroids in Sediment. J. Gan, Y. Xu, Environmental Sciences, University of California, Riverside, CA; F. Spurlock, California Department of Pesticide Regulation, Sacramento, CA. Pyrethroids are extremely hydrophobic and their sediment toxicity depends closely on their desorption behavior. We evaluated the effect of aging on desorption kinetics of sediment-borne pyrethroids. Two sediments were spiked with four pyrethroids, and were incubated for 7, 40, 100, and 200 d at room temperature. Desorption measured using sequential Tenax extractions was well described with a three-compartment model. The rapid desorption fraction (F_{rapid}) decreased quickly over time, which was accompanied by an increase of the very slowly desorption fraction (F_{vs}). The aging effect was similar for all four pyrethroids, with half-life for F_{rapid} being 56 d in one sediment and 74 d in the other. When coupled with degradation, the half-lives of the rapidly desorbing (and thus potentially bioavailable) concentration were reduced to 1 - 2 months for all pyrethroids. Results show that aging decreased desorption of pyrethroids from sediment, rendering rapid attenuation of bioavailable residues over time. Therefore, actual sediment toxicity of pyrethroids may quickly diminish under field conditions due to aging effect.

493 Statewide Investigation of the Role of Pyrethroid Pesticides in Sediment Toxicity in California's Urban Waterways. B.S. Anderson, B. Phillips, J. Hunt, Environmental Toxicology, UC Davis, Monterey, CA; R. Holmes, Central Valley Water Board, Rancho Cordova, CA; D. Crane, A. Mekebri, California Department of Fish and Game, Rancho Cordova, CA; V. Connor, State Water Resources Control Board, Sacramento, CA. In recognition of growing concerns about reports of increased incidences of sediment toxicity linked to pyrethroid pesticides, a state-wide assessment of sediment toxicity in urban creeks has been conducted in California. The primary objective was to examine the role of pyrethroids in toxic sediment samples. Ninety sites, located within 50 m of residential stormwater outfalls, were sampled and screened for toxicity in eight regions. Sites were selected based on land use, pyrethroid pesticide use, past evidence of sediment toxicity and/or evidence of organophosphate pesticide contamination, and isolation from agriculture inputs. Results of the toxicity screening were used to identify 30 core sites to be used as the focus for this investigation. Toxicity was assessed at the core sites using U.S. EPA standard 10-d sediment toxicity tests with the resident amphipod (*Hyalella azteca*), and were conducted at two temperatures to provide additional lines-of-evidence of the cause of toxicity. The results showed widespread sediment toxicity, and an increase in the magnitude of toxicity when tests were conducted at the colder temperature. Pyrethroid pesticides, piperonyl butoxide, the organophosphate pesticide chlorpyrifos, and legacy organochlorine pesticides were measured in creek sediments from the core sites. This presentation summarizes results of the statewide study and discusses the relationship between sediment toxicity and pesticide concentrations.

494 Statewide Assessment of Sediment Toxicity and Pyrethroid Pesticides in California's Urban Waterways: Toxicity Identification Evaluation Results. B.M. Phillips, S.L. Clark, J.P. Voorhees, K. Siegler, B.S. Anderson, J.W. Hunt, R.S. Tjeerdema, Environmental Toxicology, UC Davis, Monterey, CA; R.W. Holmes, Central Valley Regional Water Board, Rancho Cordova, CA; A. Mekebri, D. Crane, California Department of Fish and Game, Rancho Cordova, CA. As part of a state-wide assessment of pyrethroid pesticides and sediment toxicity in urban creeks, the toxicity of four sediments was investigated using toxicity identification evaluations (TIEs). After screening sites throughout the state, thirty were chosen to examine the spatial occurrence and magnitude of sediment toxicity and to evaluate the potential role of pyrethroids in observed toxicity. Toxicity was assessed using

the resident amphipod (*Hyalella azteca*), and TIEs were conducted on both sediment and interstitial water. Solid-phase treatments included the addition of binding resins for organics and metals, powdered charcoal for binding organics, and several treatments designed to reduce or increase toxicity caused by pyrethroid pesticides. Binding resins were eluted to measure the toxicity and concentrations of compounds removed from the solid-phase sediments. Interstitial water TIEs included solid-phase extraction columns to reduce and return toxicity caused by organics and metals, as well as treatments that focused on pyrethroid toxicity. Preliminary results indicate pyrethroids contributed to toxicity in some samples. Results also demonstrate the utility of current and emerging sediment TIE methods. Analyses of the sediment and Phase II solvent elutions for concentrations of pyrethroid pesticides, organochlorine pesticides, and piperonyl butoxide (a pyrethroid synergist) will corroborate the TIE results.

495 An Assessment of Benthic Communities with Concurrent Physical Habitat, Pyrethroid, Metals and PAH Analysis in an Urban and Residential Stream in California. L. Hall, W. Killen, University of Maryland, Queenstown, MD; R. Alden III, Northern Illinois University, DeKalb, IL. This study, the first year of a multiyear program, was designed to characterize benthic communities and physical habitat in both an urban (Kirk Creek) and residential (Pleasant Grove Creek) water body in California in late spring of 2006. Concurrent water quality evaluations, pyrethroids, physical sediment parameters, bulk metals, SEM/AVS and PAHs were also measured during the study. The relationship of various benthic metrics to physical habitat metrics, pyrethroids, metals and PAHs was evaluated. In general, total physical habitat scores in both streams were considered to be both poor and similar. Benthic communities in both streams were dominated by tolerant species such as oligochaetes, chironomids, snails and seed shrimp. Approximately 110 and 142 taxa were reported in Kirk Creek and Pleasant Grove Creek, respectively. Potentially toxic concentrations of pyrethroids, metals and PAHs were found at some sites in both streams. Univariate and multivariate statistical analysis designed to determine relationships between benthic metrics and four stressors - total and individual pyrethroids (using toxic units with *Hyalella azteca* to normalize the data), physical habitat metrics, metals and PAHs - showed the following: (1) benthic community metrics are related to both pyrethroids and physical habitat at a similar level of significance in Kirk Creek although the pyrethroids showing the relationships have uncertainty as the concentrations are below effects thresholds; (2) benthic community metrics are related primarily to physical habitat and not pyrethroids in Pleasant Grove Creek; and (3) the relationship between benthic community metrics and both metals and PAHs is minimal in both Kirk Creek and Pleasant Grove Creek.

496 Detection of pyrethroid insecticides in surface runoff from residential homes. D. Haver, J. Kabashima, Orange County, University of California Cooperative Extension, Costa Mesa, CA; L. Oki, Plant Sciences, University of California Davis, Davis, CA; S. Bondarenko, J. Gan, Environmental Sciences, University of California Riverside, Riverside, CA. Recent studies in California have attributed sediment toxicity in urban streams to contamination of pyrethroid insecticides. However, the use of pesticides in urban areas, in general, is a poorly understood topic. For instance, although pesticides in urban streams are thought to come from residential areas, the use patterns, sources, fate, and transport pathways are essentially unknown. In a statewide collaborative project, runoff samples are being collected at drainage outfall sites in residential neighborhoods in Sacramento County and Orange County. Four neighborhoods in each county have been selected for monitoring based on their size, type and age of homes, and drainage conditions. Both irrigation and storm runoff samples are collected, and analyzed for a suite of pesticides including all pyrethroids. Bifenthrin, permethrin, and cyfluthrin are consistently found in the runoff samples, and cypermethrin and cyhalothrin are detected less frequently. Higher concentrations are found in storm runoff samples than in irrigation-induced runoff samples, and pesticide levels appear to correlate with suspended solid content of the runoff water. Contribution from storm runoff likely dominates the overall pesticide export. This finding provides the first direct evidence that pyrethroid products used by homeowners and professional applicators contribute to the pyrethroid appearance in urban streams. This finding may have significant implications for regulators as well as for development of management or mitigation strategies.

497 Aquatic ecological risk assessment of synthetic pyrethroids used for mosquito control in Suffolk County, Long Island, New York. D.V. Preziosi, Integral Consulting Inc., Berlin, MD; J.L. Durda, Integral Consulting

Inc., Annapolis, MD; R.A. Pastorok, Integral Consulting Inc., Mercer Island, WA; D. Ninivaggi, Division of Vector Control, Suffolk County Department of Public Works, Yaphank, NY. Increasing attention is being given to the threats posed to human health and the environment by non-endemic mosquito-transmitted diseases. One means of controlling mosquitoes is through the use of insecticidal chemicals, such as synthetic pyrethroids, to treat areas where mosquitoes reside or frequent. Some of these chemicals, however, may cause effects in non-target organisms. We present the results of an evaluation of aquatic life risks potentially associated with the use of synthetic pyrethroids to control mosquitoes in Suffolk County (Long Island, New York). The work was conducted as part of an overall effort recently completed by Suffolk County to develop a long-term management plan for vector control. The synthetic pyrethroid compounds evaluated were permethrin, resmethrin, and sumithrin. The aquatic ecological risk assessment drew upon comprehensive regional survey information on habitat types and species prevalent in Suffolk County. A variety of aquatic settings were identified for risk evaluation, including estuaries, tidal and freshwater wetlands, rivers, lakes, and vernal pools. Environmental monitoring data were then used in conjunction with mechanistic fate models to predict exposures under short-term to multi-year timeframes. Information on aquatic habitats and species, exposure conditions, and the toxicity of the evaluated synthetic pyrethroids were combined in a multi-tiered, multi-scenario risk evaluation. In the lower tiers, worst-case assumptions on exposure and degradation were applied to derive conservative estimates of risk. Scenarios estimated to be at risk in the lower tiers were evaluated in progressively higher tiers incorporating time-dependent degradation, exposure, and bioavailability. Key facets of this work included development of environmental decay models linked to toxicologically relevant exposure durations, probabilistic analysis of chemical partitioning and chemical bioavailability, and a separate assessment of potential long-term aquatic community impacts using USEPA's AQUATOX model.

498 Quantifying the Presence of Current-Use Insecticides and Toxicity of Sediments in Urban Residential Watersheds in Central Texas. E.P. Hintzen, J.B. Belden, Environmental Studies, Baylor University, Waco, TX. In the US, residential use of pyrethroid and other recently developed insecticides has increased substantially in recent years, yet the impact of these insecticides on benthic invertebrates in urban streams is largely unknown. The objective of this study was to determine the presence and concentration of current-use pesticides in the sediments of residential streams in central Texas, a region characterized by intensive lawn management and a fire ant problem. Sediment samples were collected from several sites in urban streams in central Texas over the course of a pesticide application season. The sediments were extracted and analyzed using gas chromatograph with MS/MS for the presence of several pyrethroids and other common insecticides. Ten-day sediment toxicity tests using *H. azteca* were also conducted with the sediment samples. Out of 51 sediment samples, 41% contained 1-3 TUs, and 23.5% contained greater than 3 TUs. In samples with 0-3 TUs there was variable mortality, but never greater than 60%, while all but one sample with >3 TUs had greater than 60% mortality (20% of all samples). Bifenthrin was by far the most commonly detected insecticide and was present in 94% of samples. It was also the largest contributor to TUs, with a mean of 65% of TUs explained by bifenthrin. Lambda-cyhalothrin was the next most important insecticide, and was detected in 57% of sediments and contributed a mean of 23% of TUs. Permethrin, cyfluthrin and cypermethrin were less frequently detected and contributed less than 4% of TUs. Other urban pesticides such as fipronil and its metabolites, diazinon and chlorpyrifos were never detected in high enough concentrations to significantly contribute to toxicity. Results of this study suggest that pyrethroids may be a problem in central Texas, which may be indicative of a problem in all southern states with intensive lawn care practices and fire ant problems.

499 Clutch morphology and timing of exposure impact susceptibility of aquatic insect eggs to esfenvalerate. K.R. Johnson, J.J. Jenkins, P.C. Jepson, Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR; P.C. Jepson, Integrated Plant Protection Center, Oregon State University, Corvallis, OR. Aquatic eggs are passive biological systems that may be exposed to waterborne contaminants during the embryonic developmental period. Synthetic pyrethroids exhibit strong affinities for the non-polar hydrocarbons found in aquatic egg chorions and clutch gelatin, and may be adsorbed by developing eggs. Consequently, aquatic insect embryos may be at risk from low levels of pyrethroid insecticides. Further, the morphology of aquatic insect eggs and egg clutches is highly variable, and it is plausible

that aspects of egg clutch morphology and embryonic development may contribute to individuals' susceptibility to synthetic pyrethroids. We exposed the eggs of three stream insects (*Baetis* sp. mayflies, *Brachycentrus americanus* caddisfly, *Hesperoperla pacifica* stonefly) to esfenvalerate, a synthetic pyrethroid insecticide. Egg mortality and post-hatch effects, including survivorship and growth, were used as endpoints to gauge toxic effects. Egg clutch morphology and the timing of esfenvalerate exposures in respect to embryonic development both impacted developing eggs. Late stage *B. americanus* egg clutches were the most susceptible to esfenvalerate contamination, with significant post-hatch effects occurring following 48-hour exposures to 0.035 µg/L esfenvalerate.

500 Causes of discrepancies between laboratory toxicity tests and field studies with pyrethroids. J.M. Giddings, Compliance Services International, Rochester, MA; A. Barefoot, DuPont Agricultural Products, Wilmington, DE; M. Dobbs, Bayer CropScience, Research Triangle Park, NC; L. Hall, Univ. Maryland, Queenstown, MD; P. Hendley, K. Henry, Syngenta Crop Protection, Greensboro, NC; G. Mitchell, FMC, Princeton, NJ; N. Poletika, Dow AgroSciences, Indianapolis, IN; D. Wustner, Valent, Walnut Creek, CA. Aquatic mesocosm studies with pyrethroids have shown that no-observed-effect concentrations (NOECs) for many populations and for communities as a whole are typically higher than the standard toxicity test endpoints used in ecological risk assessment (e.g., NOEC or LC50 of the most sensitive species measured in the laboratory). Similarly, biomonitoring studies have found little or no measurable effect on invertebrate communities in urban streams even though sediment samples collected from those streams, containing measurable concentrations of pyrethroids, are sometimes toxic to *Hyalella azteca* in the laboratory. We examine some of the chemical, biological, ecological, and experimental factors that cause laboratory toxicity data for pyrethroids to overestimate the ecological effects of pyrethroids in the field. These factors include environmental fate processes, bioavailability, exposure conditions, differential species sensitivity, population recovery, interactions among populations in communities, habitat, spatial heterogeneity, and sampling technique. Each factor will be examined and improved approaches to quantifying potential field impacts will be discussed.

501 Effect of Temperature on Heavy Metal Toxicity in Earthworm *Lumbricus terrestris*. M.A. Khan, A. Khan, S.A. Ahmed, Biological Sciences, University of Illinois at Chicago, Chicago, IL. A 2o C-rise in acclimation temperature (10-12oC) increased the acute toxicity of copper, cadmium, lead, and zinc to earthworms. The toxicity increased further at 14-16oC by 17, 33, and 5% respectively for copper, zinc, and lead. A 10oC rise in acclimation temperature made copper 132%, lead 40%, and zinc 149% more toxic to worms. While a 2oC and 4oC rise in acclimation temperature increased the rate of respiration by 15% and 40%, respectively, a 10oC rise lowered the rate of respiration by 84%. Pre-exposure to sublethal concentrations of heavy metals abolished some of the temperature-enhanced increase in respiration. The data indicate that global climate change may affect the survival of poikilotherms in heavy metal polluted environments.

502 Copper uptake and depuration by juvenile and adult Florida apple snails (*Pomacea paludosa*): bioconcentration and bioaccumulation factors. T.C. Hoang, E.C. Rogevich, G.M. Rand, Environmental Studies, Florida International University, North Miami, FL; E.C. Rogevich, Department of Biological Sciences, Florida Atlantic University, Boca Raton, FL; R.A. Frakes, T.A. Bargar, South Florida Ecological Services, U.S. Fish and Wildlife Service, Vero Beach, FL. The use of copper (Cu) in Florida citrus agriculture (fertilizers and fungicide) has elevated Cu concentrations in soil/water systems in South Florida. Aquatic organisms living in this environment are at risk of being exposed to Cu. The present study characterized Cu uptake and depuration by juvenile and adult Florida apple snails (*Pomacea paludosa*) from water, soil, and diet. During the 28 d uptake phase, juvenile apple snails were exposed to aqueous Cu and adult apple snails were exposed to Cu contaminated soil, water, and food. During the 14 d depuration phase, both juvenile and adult apple snails were held in laboratory freshwater with background Cu concentrations < 4 µg/L. Juvenile apple snails were fed Cu-free lettuce. Adult apple snails were fed either Cu-free or Cu-contaminated lettuce during the exposure phase and Cu-free lettuce during the depuration phase. For juvenile apple snails, whole body Cu concentrations increased with time and reached a plateau at 24.6, 48.4, and 61.9 mg/kg at exposure concentrations of 6.0, 8.2, and 12.2 µg/L Cu, respectively. This resulted in an average bioconcentration factor of 1493. Apple snails depurated Cu rapidly with a half-life time of 11 d. The data followed Michaelis-Menten kinetics better than one compartment first order kinetics. For adult apple snails, Cu

uptake from soil ingestion and/or dermal contact was higher than Cu uptake from water and diet. Dietary uptake of Cu resulted in higher bioaccumulation factors (BAFs) compared to uptake from soil. Most of the accumulated Cu was located in soft tissue (about 60% in viscera and 40 % in foot), which is usually consumed by predators. The shell contained < 1% of the total accumulated Cu. Results of the present study revealed potential for Cu transfer through the food chain to the apple snail and potential risk to apple snail predators.

503 Characterization of the structural and functional diversity of soil microbial communities in smelter-impacted and non-impacted soils. J.A. Humphries, S.B. Cox, M.J. Hooper, Environmental Toxicology, Texas Tech University, Lubbock, TX; J.A. Humphries, J.C. Zak, Biological Sciences, Texas Tech University, Lubbock, TX. A century of mining and smelting activity at the Anaconda Smelter site in Anaconda, Montana has severely contaminated the surrounding soils and groundwater with metals. Soil microbial communities from six smelter-impacted sites and a non-impacted site were compared to determine the long-term effects of a gradient of metal concentrations on microbial activity, biomass, microbial community functional diversity (Biolog microtiter plates), and microbial community structural diversity (denaturant gradient gel electrophoresis (DGGE)). The most profound effects of metal contamination on microbial biomass and activity were observed within microbial communities native to the severely contaminated sites; however, microbial communities exposed to chronic low levels of metals were also significantly affected. The functional and structural diversity of the microbial communities native to the smelter-impacted soils were shifted, relative to the microbial community from the non-impacted site, indicating that microbial community structural and functional endpoints are sensitive to metal stress. The observed shifts in microbial community structure and function were significantly correlated with soil metal concentration and several soil physiochemical properties (pH, OM, NO₃, NH₄, etc.), which provides evidence of the importance of many different environmental variables on microbial community dynamics in soils. Preliminary evidence of functional redundancy was observed within the microbial communities native to the smelter-impacted sites, based on overlapping carbon substrate utilization patterns. However due to selection-bias, redundancy pertains only to a subset of the community and may not be ecologically relevant. Nevertheless, the effects of metal contamination on microbial communities in this study are pronounced and results provide preliminary insight into the complex relationship between soil microbial community structure and function in anthropogenically disturbed soils.

504 Does DGT adsorbed Cd from fertilizer field studies predict plant availability and accumulation in soil? A. Perez, K.A. Anderson, Oregon State University, Corvallis, OR. Metals in fertilizers can contribute significantly to the total and bioavailable metal burden in agricultural systems. Over time repetitive application may lead to accumulation in soils and increase metal availability to crops, including uptake into the edible portion. The metal fraction that is available to crops has been correlated with the passive sampling device, Diffusive Gradient in Thin Films. Field studies were conducted using three environmentally relevant dose levels of cadmium rich commercial phosphate fertilizers applied at four agricultural sites for three years. Significant Cd treatment effect was observed in surface soil, soil solution, and DGT adsorbed Cd. DGT adsorbed Cd can be best predicted using a linear combination of the variables: Cd load from fertilizer, cation exchange capacity, percent organic matter, pH, NH₃, NO₃, K, and irrigation practice. Wheat and potato crops showed increasing Cd concentrations in the edible portion with treatment 2004-2006. Crops grown in treatment 3x plots contained an average of 43.9 µg/kg Cd more than the control crops. DGT adsorbed Cd was strongly correlated with soil solution at all sites. Soil solution measurement was a better indicator of Cd found in the edible portion of plant. Total Cd burdens in agricultural soils increased each year. Average surface soil Cd increased by 1.07 µg/kg/y, while DGT and soil solution average Cd did not increase over the three year study. This data can be used for model projections to predict potential accumulation in plant and soil.

505 Heavy Metals in Constructed Wetland BMPs treating Urban Stormwater Runoff: Assessment and Chemical Speciation of Wetland Sediments. S. Murthukrishnan, A. Selvakumar, T.P. O'Connor, U.S. EPA, ORD, NRMRL, Edison, NJ. The presence of heavy metals in stormwater runoff is a major concern due to their toxicity, bioavailability, and persistence in the environment. The sources of heavy metals are varied, and their geochemical partitioning in stormwater runoff is significantly influenced by the land-use pattern. The current focus of stormwater research efforts is

evaluating runoff quality and the effectiveness of adopting best management practices (BMPs) to minimize heavy metal inputs to receiving waters. Structural BMPs such as constructed wetlands primarily rely on sedimentation to reduce heavy metal loads associated with stormwater particulate matter prior to discharge into receiving water bodies. The continued accumulation of heavy metals in these sediments can result in their migration and increase the risk for ground and surface water quality deterioration downstream. Additionally, due to changes in geochemical partitioning, they may also be toxic to benthic invertebrates and aquatic microorganisms downstream of the BMP. These accumulated sediments have to be routinely removed to minimize the risk of contamination and maximize the operational efficiency of these BMPs. However, the frequency of such maintenance practices and the handling of sediments require a full understanding of the quantity and quality of the deposits, especially with reference to their heavy metal content. Chemical speciation studies help in understanding and controlling the behavior of heavy metals, and are recognized as a necessary requirement in designing an effective BMP maintenance protocol. This research is being conducted at U.S. EPA's Urban Watershed Research Facility in Edison, NJ, to evaluate the relative efficiencies of wetland and retention pond mesocosms in attenuating heavy metal loads in urban stormwater runoff. BMP removal efficiencies were assessed for both particulate and soluble heavy metals. The geochemical associations of heavy metals in wetland sediments were investigated by sequential fractionation procedures in order to understand heavy metals behavior in BMP sediments. Additionally, a stormwater wetland BMP in the Staten Island Blue Belt (New York) was monitored to investigate the effects of maintenance and clean up procedures on sediment heavy metal loads and their speciation. Results from different stormwater sampling and sediment monitoring events will be discussed.

506 Disentangling Mercury Pollution from other Ecoregional Threats to the Persistence and Health of Amphibian Populations Inhabiting Protected Areas in the Conterminous United States. M.S. Bank, Department of Environmental Health, Harvard University, School of Public Health, Boston, MA. Mercury (Hg) contamination in the U.S. is well-documented and continues to be a public-health issue of great concern. Fish consumption advisories have been issued throughout much of the U.S. due to elevated levels of mercury, and mercury contamination in young children and pregnant women is a major public health issue for certain sectors of the global human population. Mercury contamination and its potential ecotoxic effects on amphibians inhabiting upland, riparian, lentic and lotic ecosystems has received little attention, yet these species may be widely distributed across watersheds, are possible vectors of mercury transport into the surrounding riparian zone and uplands, and comprise an energy base upon which higher trophic levels in riparian systems depend. Protecting quality of terrestrial ecosystems in the U.S. has enormous ramifications for economic and public health of the nation's residents and is fundamental to maintaining the biotic integrity of surface waters, riparian zones, and environmental health of forested landscapes nationwide. Determining Hg concentration levels for terrestrial and surface water ecosystems also has important implications for protecting the nation's fauna. Here I present data from coastal and inland aquatic and terrestrial ecosystems from both the east and west coast of the U.S. The goal of this investigation is to better understand the fundamental mechanisms of methylmercury (MeHg) transfer in terrestrial-based invertebrate food webs and share findings with fellow scientists and relevant landscape managers and policy makers. Specifically I (1) evaluate effects of abiotic (i.e., aquatic and terrestrial geochemical properties such as pH, DOC, and redox potential, etc.) and biotic factors such as food web dynamics (i.e., trophic structure and energy flow – via analysis of natural abundance $\delta^{15}\text{N}$ and $\delta^{14}\text{C}$ stable isotope analysis, and ecosystem community structure) on Hg levels in selected amphibians, (2) develop a predictive model relating measured Hg levels in selected biota to trophic structure, disturbance regimes, and watershed and stream-scale variables, and (3) identify biological mercury hotspots in terrestrial ecosystems and build and test predictive models that identify factors influencing both Hg accumulation in amphibians, and overall ecosystem sensitivity to net MeHg production.

507 North American Soil Geochemical Landscape Project. A.N. Rencz, Geological Survey of Canada, Ottawa, Ontario, Canada; D.B. Smith, United States Geological Survey, Denver, CO. The need for soil geochemical data for assessing human health and environmental hazard risks is well recognized. However, at present there is no common understanding of soil geochemical background variation and its origin for those agencies dealing

with human health and environmental risk assessment and management. The North American Soil Geochemical Landscapes Project - a tri-national initiative between United States, Canada, and Mexico – was designed to (1) develop a continental-scale framework for generating soil geochemistry and relevant biological and organic compound data; and (2) provide soil geochemical data that are available and useful for a wide range of applications and disciplines. This project is the first multi-national multi-agency collaboration of its kind starting with common focus and protocols. The Project is based on low-density sample collection (40 km spacing) over a spatially balanced grid - a total of 13,212 sites over North America. There is a core set of Project protocols and also additional ones to meet the needs of users in each country. These include standardized sampling of the 0-5 cm "human health" layer, and the O-, A-, B- and C-horizons and analysis of the <2mm and <0.063 mm fractions for selected trace, minor, and major elements (including Hg, Pb, As, and Cd) and limited organic components. A split of the 0-5-cm surficial soil will be tested for the presence or absence of *Bacillus anthracis* (anthrax). Work in the summer 2007 is being undertaken in the Maritimes, southern Ontario, and some northern permafrost areas in Canada, and in the New England states, Nebraska, and along a transect across Alaska in United States. Within the North American landscape there is an enormous amount of naturally-occurring variation in soil geochemistry. Results of a Canada-United States pilot study consisting of two sampling transects (E-W and N-S) showed the following: (1) significant, systematic regional variations in soil geochemistry and microbiology; (2) regional variability related to natural soil-forming factors, including geology, rainfall, and temperature; and (3) regional differences that signalled inputs from anthropogenic sources (e.g. Hg).

508 Heavy Metal Assessment Within the Live Oak Rifle and Pistol Range at the Grand Bay Reserve. T. Rice, K.E. VanDeven, E. Cioffi, Biological Sciences, University of South Alabama, Mobile, AL. Following the ban on lead base gasoline and paint, shooting ranges have become one of the main contributors to environmental lead contamination. Problems associated with lead contamination range from loss of species diversity to deformities among resident inhabitants. Interestingly, a considerable number of shooting ranges are situated within national preserves. The Grand Bay Reserve, also known as Grand Bay National Estuary Research Reserve (GB NERR), was established in 1999 by the National Oceanographic and Atmospheric Administration (NOAA) and is maintained by the Mississippi Department of Marine Resources. Grand Bay Reserve is located in Jackson County, Mississippi between Pascagoula, MS and the Alabama state line. The abandoned Live Oak Rifle and Pistol Range (the main study site) lies within the boundaries of the GB NERR and consists of forested areas, seasonal wetlands, and a permanent pond. This project is the first and most in depth to be conducted at the Live Oak Rifle and Pistol Range. I propose to determine the concentrations of lead, copper, and zinc within and adjacent to the abandoned Live Oak Rifle and Pistol Range. Four collection sites have been set up across the range and include: short-range target, long-range target, pond immediately behind the range, and the shooting area. Samples are being collected from the roadside ditch and boat dock estuary areas, and will serve as baseline reference sites for each heavy metal analyzed. Biotic samples collected at each site include water, sediment, vegetation, and live specimens for analysis. Measurements of abiotic variables are also being collected in an effort to better understand patterns of metal distribution and bioavailability across sampling sites. All collected samples are processed using microwave-assisted digestion (modified EPA Method 3051) and analyzed with Graphite Furnace Atomic Absorption Spectroscopy (modified EPA Method 7000A). Preliminary analyses indicate possible localized lead contamination at the Live Oak Rifle and Pistol Range, and significant concentrations in the biota. Concentrations of lead in the water samples seemed to be related somehow to the resident organismal samples, possibly due to porous nature of the organisms and osmotic regulation. Concentrations of Pb detected in the Grand Bay Reserve samples are comparable to those reported for other shooting ranges.

509 Estimating Risk from Copper in Soil: Challenges with Using Drinking Water Criteria. A.M. Thatcher, ARCADIS BBL, Golden, CO; M.P. Bartee, ARCADIS BBL, Cranbury, NJ; P.E. Goodrum, ARCADIS BBL, Syracuse, NY. The USEPA has not published an oral reference dose (RfD) for copper. In the absence of an RfD, USEPA cites the drinking water effect level (DWEL) as a basis for evaluating toxic effects. As a result, human health risk assessments for copper in soil use RfDs based upon studies evaluating effects of copper dissolved in drinking water, as epidemiological data regarding

ingestion of copper in soil are limited. Estimating potential risks from exposure to copper in soil based upon an RfD derived from drinking water studies poses significant challenges. The primary challenge is in interpreting the available effects data as it may relate to a soil ingestion scenario. Whereas epidemiological studies often evaluate the toxic response to a bolus of water, soil exposure scenarios involve incidental ingestion of soil, which may occur over a 24-hour period. However, several homeostatic mechanisms prevent the absorption of excess copper, and the first barrier to adsorption of excess copper is the gastrointestinal lining. Solubilized copper in a glass of drinking water may deliver an acute dose sufficient to stimulate vagus nerve endings producing a response, or the mere taste of copper in the water could produce the same response. This may not be the case for tiny amounts of soil that are swallowed throughout the day in an incidental soil ingestion scenario. In addition, when administered as a dose in drinking water, copper is 100 percent solubilized and often is administered to subjects in a fasted state. These factors result in high bioavailability of copper in the stomach immediately following ingestion. However, limited data are available regarding factors affecting copper availability in the soil matrix, including the rate of dissolution of soil in the stomach. These differences in the drinking water RfD exposure scenario and the soil ingestion scenario must be considered when conducting a risk assessment for copper in soil.

510 Screening Level Methods for Assessing Groundwater Discharge Impact on Surface Water Systems. N.R. Grosso, A. Guiseppe-Elie, K. Garon, E.E. Mack, Corporate Remediation Group, DuPont Company, Wilmington, DE. Initial evaluation of the potential impact of a groundwater plume discharge on surface water may be approached from two perspectives – the upland plume perspective and the surface water perspective. Both involve challenges with respect to temporal and spatial scales of assessment. Steps for a screening level evaluation from the upland perspective are presented. This evaluation includes developing a preliminary conceptual model with the help of a risk assessor and hydrogeologist using conservative screening water quality criteria or appropriate sediment benchmark numbers. The evaluation from the upland perspective requires knowledge of the groundwater velocity, constituents of potential concern and general fate and transport properties, the sensitivity of potential ecological receptors or habitats, hydrologic characteristics of the receiving water body and the physical nature of the sediments. For evaluation from the surface water perspective, some surface water and sediment investigation is needed. Based on a screening level evaluation, a potential risk may be identified. In this case, the potential impact of a groundwater plume would be evaluated in the context of other potential sources to surface water and sediment whether ongoing or legacy.

511 A Desktop Analysis of Groundwater-to-Surface Water and Groundwater-to-Sediment Pathways. C.J. McCarthy, CH2M HILL, Houston, TX; J. Weier, CH2M HILL, Atlanta, GA. As part of a site investigation in Texas, marine aquatic communities adjacent to an industrial chemical facility were studied for potential adverse effects associated with exposure to elevated concentrations of organic constituents. A screening-level ecological risk assessment (SLERA) was conducted without collecting surface water or sediment because of the potential for non-site related contaminants in the aquatic system. Instead, the evaluation included use of existing soil and groundwater data to model risk to marine aquatic communities in surface water and sediment. The Texas Risk Reduction Program offers guidelines for developing groundwater screening concentrations protective of the groundwater-to-surface-water (^{SWG}) and groundwater-to-sediment (^{SED}GW) pathways. Existing groundwater data were compared to these screening concentrations to identify initial constituents of potential ecological concern (COPECs). Very low sediment screening benchmarks for PAHs, coupled with necessary conservatism and uncertainty factors in modeling the pathway from groundwater to surface water and sediment, produced a long list of COPECs, including many non-polar organics such as PAHs. Most of the COPECs identified were non-detected groundwater constituents with method detection limits above the ^{SWG} and ^{SED}GW values. The COPECs seemed unlikely and inconsistent with expectations based on the available groundwater data and the fate and transport profiles for these substances. Hence, the subsequent phases of the risk evaluation included using the U.S. Environmental Protection Agency Summers Model to predict concentrations that would leach from soil to groundwater. With the incorporation of the Summers Model, risks were identified only for bis-2-ethylhexylphthalate and acrolein, primarily driven by one or two samples. A probabilistic risk assessment approach was incorporated using Thiessen polygons to generate

area-weighted exposure point concentrations. After incorporating the Summers Model and Thiessen polygons, the conclusion of the SLERA was that the soil-to-groundwater leaching pathway would not result in groundwater concentrations high enough to produce unacceptable exposures and risks for aquatic biota exposed to surface water and sediment. This approach was effective in evaluating site-related risk to an adjacent waterbody with multiple potential contamination sources and no simple method of attribution to sources.

512 The Trident Probe Capabilities and Applications for Identifying and Mapping Groundwater Discharge Zones. B. Chadwick, J. Guerrero, G. Rosen, SPAWAR Systems Center San Diego, San Diego, CA; J. Groves, C. Smith, R. Paulsen, Coastal Monitoring Associates, San Diego, CA; A. Burton, Wright State University, Dayton, OH; M. Greenberg, Environmental Protection Agency, Edison, NJ. The Trident Probe is a simple direct-push device that provides a means of rapidly identifying and mapping groundwater discharge zones. The basic system includes a subsurface temperature/conductivity probe, and a porewater sampling probe. These probes are designed to sample at subsurface depths of 1-3 ft below the sediment water interface. In application, suspected discharge zones are generally isolated using the temperature and/or conductivity sensors, exploiting the contrast of these characteristics between groundwater and surface water. The porewater probe can then be used to collect confirmatory samples and/or samples for contaminant analysis. Additional sensing probes that are being evaluated include pH and a novel sensor for grain size classification. Initial testing results for these new sensors are presented, along with results from a range of case studies using the basic system. Potential applications for integration with small-volume porewater toxicity tests are also discussed.

513 Source determination for chemicals in transition zone water—upland groundwater plume discharge vs. legacy sediment contamination. C. Hawley, W. Locke, A.R. Wood, Integral Consulting Inc., Broomfield, CO. As part of the remedial investigation at the Portland Harbor Superfund site on the lower Willamette River in Portland, Oregon, a technical framework was developed and applied to characterize and differentiate upland and sediment sources of chemicals detected in transition zone water. The investigation focused on nine upland sites with complete or potentially complete pathways of upland groundwater plume migration to the river. Potential areas of groundwater plume discharge were identified based on physical and chemical indicators. Transition zone water and sediment samples were collected from the potential groundwater discharge areas and nearby reference locations. Data analysis focused on determining whether chemicals of interest in transition zone water originated from groundwater transport from upland sources or from desorption/diffusion of pre-existing sediment contamination attributable to other sources. Multiple lines of evidence were considered in this analysis, including subsurface stratigraphy, surface sediment texture, seepage meter measurements, transition zone water chemistry at depths ranging from 30 to 150 cm below the sediment interface, upland groundwater chemistry, river water chemistry, and bulk sediment chemistry. Tools applied to differentiate upland groundwater sources from existing in-water sources included mapping of groundwater discharge zones based on physical and chemical indicators, spatial analysis of transition zone water and bulk sediment sampling results, identification of indicator chemicals, major ion evaluation, and sediment-water equilibrium analysis. The limitations and general applicability of this lines-of-evidence approach are summarized.

514 Groundwater contributions to sediment toxicity—A case study of Patrick Bayou, Texas. J.L. Durda, Integral Consulting Inc., Annapolis, MD; D.V. Preziosi, Integral Consulting Inc., Berlin, MD; D. Nielsen, Integral Consulting Inc., Mercer Island, WA; L.P. Bruzy, Shell Chemical LP, Houston, TX; P. Conwell, URS Corporation, Houston, TX; J. Stevenson, Shell Chemical LP, Deer Park, TX. Assessment and management of contaminated groundwater releases into receiving water bodies have gained increasing regulatory focus. We present a case study of work we conducted in Patrick Bayou, Texas, to address regulatory concerns that groundwater was contributing to observed sediment toxicity. We developed a weight-of-evidence approach that was built upon an array of analytical tools to assess this relationship. We used existing site data, rather than conducting more intensive field investigations. Key steps in the process included initial development of a site conceptual model to guide the overall assessment, statistical evaluation of the inter-relationships in media-specific chemistry, assessment of chemical mass loading to the bayou, spatial analysis of groundwater and sediment toxicity data, and risk assessment. We present the results of our analyses and

discuss their significance in the context of the overall management decisions at the site. In addition, we discuss the applicability of our approach and findings to assessing and managing groundwater risks at other contaminated sites.

515 Case Study of Contaminated Groundwater Discharge: How In Situ Tools Link an Evolving Conceptual Site Model with Management Decisions. M.S. Greenberg, U.S. EPA-Environmental Response Team, Edison, NJ; P. Duncan, J. Williams, C. Black, U.S. EPA-Region 10, Seattle, WA; S. Leja, L. Wilhelm, Washington Dept. of Ecology, Seattle, WA; R.G. Henry, U.S. Fish & Wildlife Service, Edison, NJ. In this paper, we show how simple in situ tools provide key insights into groundwater transport and exposure pathways. We illustrate how integration between managers, hydrogeologists, and ecologists, through the use of an evolving conceptual site model, helps direct management decisions. An initial conceptual site model was used to guide a preliminary investigation to determine the extent to which contaminant exposure from discharging groundwater occurs in a waterway. Regulatory agency managers, informed by phased input of data, supported extending the site investigation subtidally to identify the nature and extent of waterway contamination and to provide the basis for developing remedial alternatives. Approaches and tools used in this reconnaissance investigation included monitoring ambient surface water for groundwater signatures, installing minipiezometers within the sediment, and installing diffusion samplers and seepage meters. Despite high concentrations of contaminants in nearby piezometer samples, the diffusion sampler array indicated few locations with contaminant accumulation in the top 20 cm of the sediment. At the location where deployed, seepage meters demonstrated a high degree of connectivity and the potential for mass loading in the waterway. In the collective experience of the authors, this is one of the 1st sites where this comprehensive suite of tools has been applied in a regulatory setting to evaluate the movement of industrial contaminants beneath and into a waterway. This approach was effective because of integration of disciplines, unification of previously separate groundwater and sediment investigations, and collaboration across separate agencies and programs. In large part because of the results, the facility and agency managers agreed, and have begun a comprehensive subtidal investigation, to characterize the distribution of sediment and groundwater contamination and to quantify the groundwater flux to the surface water.

516 SPME Measurement of Pore Water PAH Transport in Sediment Caps. P. Gidley, L. Lockard, S. Kwon, U. Ghosh, Civil and Environmental Engineering, University of Maryland Baltimore County, Baltimore, MD. A common remediation strategy for contaminated sediments is capping. Capping material is usually clean sediment, sand or gravel found near a contaminated site. There is a need to understand the fate and transport of contaminants in sediment and engineered sediment caps due to the potential risk to human and environmental receptors. In this research, experimental column studies were combined with new analytical techniques and numerical modeling to build on the current knowledge of contaminant transport. Polycyclic aromatic hydrocarbons (PAHs) were chosen as the contaminant of interest. PAHs are often a regulatory driver at contaminated sediment sites. Glass columns (44 inches long, 2 inches inner diameter) were constructed with six equally spaced sampling ports. Approximately six inches of sediment, contaminated with creosote from a former wood treatment facility in Eagle Harbor, WA, was placed at the base of the columns. The experimental cap was constructed with a 2ft layer of clean capping material obtained from the existing cap at the same site. The columns had 14 inches of overlying water above the capping material. Small volume (1.5 ml) pore water samples were collected from the six ports and ten PAHs were measured using solid phase micro-extraction (SPME) followed by gas chromatography and mass spectrometry. The SPME method allowed for the laboratory column studies to continue, virtually uninterrupted, while being sampled. With a flow rate of approximately 25 ml/hour through the columns, breakthrough of PAHs was observed after 5 days of column operation. After 76 days of operation (47 bed volumes), low molecular weight PAHs were depleted in the sediment pore water. High molecular weight PAHs were released into the aqueous phase as their mole fraction increased in the creosote phase. The performance of this standard cap was compared with a similar column with 2% (wt.) activated carbon added to the capping material. Activated carbon amended columns did not show breakthrough after 68 days (42 bed volumes). In-situ pore water PAH measurements in the cap may be important to reveal any migration of PAH through the cap especially in situations where there is little sorption in the cap material due to low organic carbon content.

517 Characterization of Contaminant Transport Potential Through in Place Sediment Caps. J. Wilkie, V. Magar, ENVIRON International Corporation, Chicago, IL; E. Foote, B. Sass, Battelle, Columbus, OH; M. Mills, U.S. Environmental Protection Agency, Cincinnati, OH; U. Ghosh, University of Maryland, Baltimore, MD; C. Jones, Sea Engineering, Inc., Santa Cruz, CA. Field activities were performed to examine fate and transport of creosote-based contaminants over time through an existing sediment cap at the Wyckoff/Eagle Harbor Superfund Site in Bainbridge Island, Washington. The study incorporates an analysis of sediment cores, in-situ measurements, laboratory experiments, and hydrodynamic modeling. The primary objective of this study was to develop a mechanistic understanding of contaminant migration through sediment caps. More specifically, the project included the following tasks: 1. Groundwater upwelling areas were investigated using conductivity measurements to identify areas where freshwater is entered the marine environment. 2. PAH concentration profiles in the sediment cap were investigated in areas where groundwater upwelling was measured, and where no upwelling occurred. 3. Total PAH concentrations in sediment cores were measured on site using a rapid-sediment immunoassay analysis kit known as the Enzyme-Linked Immuno Sorbent Assay (ELISA). 4. Off-site detailed PAH chemistry was performed to identify parent and alkylated PAHs. 5. Hydrodynamic modeling incorporating vertical gradients, tidal effects, and water levels was used to examine sediment compression and post-cap consolidation behavior. Field results indicate no PAH upwelling potential in the absence of groundwater upwelling potential. However, in areas where there is groundwater upwelling, there appears to be some potential for PAH migration. Hydrodynamic modeling results indicate that a 10X decrease in hydraulic conductivity of sediments beneath the cap will increase flux through the intertidal zone by approximately 4X. These results suggest that placement and post-cap sediment consolidation processes can greatly influence groundwater and porewater hydrodynamics, with the potential ultimately to retard groundwater flow through a sediment cap. Modeling efforts will be expanded to predict upwelling potential under a broader range of site conditions and cap designs. This study was funded by the Department of Defense Strategic Environmental Research and Development Program, project ER-1370. Field support also was provided by the USEPA Office of Research and Development, USEPA Region 10, and the USACE Seattle District.

518 Evaluation of Microbial Communities at the Ground Water/Surface Water Interface in a Hyporheic Mesocosm. A.L. Bunn, A.L. Miracle, D.R. Geist, S.K. Wurstner, Pacific Northwest National Laboratory, Richland, WA. The hyporheic zone is the critical region where groundwater enters into surface waters and has the greatest potential for groundwater contaminants to impact receptors in the ground water/surface water interface. Evaluating the hyporheic zone within riverine systems poses many challenges to monitor and evaluate contaminant and microbial interactions. Outdoor, intermediate-scale hyporheic mesocosms were constructed to explore molecular methods for characterizing microbial communities that colonize various geochemical regions established by the mixing of groundwater and river water. The system has been designed to evaluate issues associated with indigenous biotic interactions with fluid flow and reactive transport from at a combined experimental and pilot field stage. The sediment is cultivated with microorganisms using water from the Columbia River and ground water contaminated with uranium from former near-shore waste sites. The mesocosms are being operated to evaluate the microbial community associated with the geochemical changes of the hyporheic system for development and evaluation of biosignatures and predictive biomarkers. Methods of biosignatures will include subtraction hybridization, gene expression profiling via microarray, and proteomic fingerprinting of microbial communities in the river water, groundwater and hyporheic saturated areas of the mesocosm's sediment profile.

519 On a Recovery Path: Latest Water Column Mercury and Fish Mercury Content in a Highly Eutrophic Lake, Onondaga Lake, NY. S. Todorova, C. Driscoll, Civil and Environmental Engineering, Syracuse University, Syracuse, NY. Mercury (Hg) contamination becomes a pronounced issue in the U.S. and all over the world because of its impact on various ecosystem components. From known Hg species that exist in the environment, monomethylmercury (MMHg) is the one of greatest concern. MMHg is highly toxic compound that biomagnifies through the food web placing risk to humans who consume significant quantities of fish. Contamination history in Onondaga Lake extends back more than a century. Along with different organic compounds, the lake was a recipient of more

than 75 tons of inorganic Hg during the operation of a chlor-alkali plant near the shores of the lake. Even after the operation ceased in 1986, lake sediments continue to be a source of MMHg to the water column and habitat of the lake. Major water quality improvements have occurred in Onondaga Lake between 1990 and 2006, including decrease in primary production, improved water clarity, water column oxygen sustain for longer periods, and wastewater treatment plant upgrade resulting in higher NO₃- concentrations at spring turnover. The present study focuses on the latest changes in water column Hg content in the lake and associated fish population. Analysis of a two-year monitoring program are presented and compared to available earlier data. Results to date reveal that shorter periods of MMHg production in the lake have been established decreasing the overall MMHg pool in the lake. No substantial decrease in the total Hg and MMHg water column concentrations has been observed. Long-term Hg data on three fish populations: smallmouth bass, largemouth bass and walleye did not exhibit any considerable changes in the Hg concentrations and constantly exceeded the U.S. EPA recommended limit of 0.3 mg/kg. Interestingly, for the last few years, the average Hg concentrations of those species have increased. The effect of phosphorus concentrations and hypolimnetic export of MMHg on fish Hg content are discussed.

520 Seasonal variability in mercury cycling and bioaccumulation in the Florida Everglades. G. Liu, Y. Cai, Department of Chemistry, Florida International University, Miami, FL; T. Philippi, J. Richards, Department of Biological Sciences, Florida International University, Miami, FL; G. Liu, Y. Cai, L. Scinto, Southeast Environmental Research Center, Florida International University, Miami, FL; P. Kalla, D. Scheidt, C. Appleby, Science and Ecosystem Support Division, U.S. Environmental Protection Agency, Region 4, Athens, GA. Elevated levels of Hg have been reported in fish and wildlife in the Florida Everglades. The Everglades exhibits clear seasonal patterns in hydrometeorology, physical, chemical, and biological characteristics. The seasonal variation in hydrological and biogeochemical characteristics influences Hg cycling and bioaccumulation. Understanding the seasonal variation in Hg biogeochemical cycling is important in revealing mechanistic processes about the sources or transport of Hg in the Everglades. The U.S. EPA Region 4 Regional Environmental Monitoring and Assessment Program (R-EMAP) conducted Phase III sampling at approximately 250 stations, half in dry and half in wet seasons, in entire Everglades freshwater marsh in 2005. This project provides us an opportunity to investigate seasonality in Hg cycling at the landscape level. Higher total Hg (THg) concentrations were observed for soil, flocculent material (floc), and periphyton in the wet season than in the dry season, probably driven by substantially greater wet Hg deposition in the wet season. Seasonal differences were not observed for THg in water, due to parallel increases in water depth (from greater rainfall volumes) and Hg deposition in the wet season. Higher methylmercury (MeHg) concentrations were present for water and soil in the dry season while periphyton MeHg was higher in the wet season. Floc MeHg showed no significant differences between the two seasons. The seasonal variations in MeHg production and transport and in volume (mass) of environmental compartments (water, floc, and periphyton) could account for the seasonality of MeHg distribution. Mosquitofish MeHg, bioaccumulation factor (BAF) for MeHg in mosquitofish, and biomagnification factor (BMF) for MeHg from periphyton to mosquitofish were all higher in the wet season, indicating stronger Hg bioaccumulation in the wet season. Seasonality in Hg bioaccumulation could be ascribed to changes in biotic factors (e.g. food structure) and in abiotic factors (e.g. temperature and dissolved organic matter (DOM)) accompanying alternate seasons.

521 Methylmercury Distributions in Bay and Wetland Sediments of the San Francisco Bay Region. D. Yee, San Francisco Estuary Institute, Oakland, CA; C. Conaway, G. Scelfo, UC Santa Cruz, Santa Cruz, CA; S. Olund, USGS WRD, Middleton, WI. Releases of mercury occurred in the San Francisco Bay region as a result of mercury and gold mining beginning in the 1800s. Although inputs from surrounding mine-impacted watersheds continue to maintain hot-spots of mercury in some Bay and wetland locations, for the most part mercury has been uniformly distributed throughout the Estuary, with the majority of sediment concentrations ranging 0.2-0.4 µg/g. Surface sediment samples were collected for the San Francisco Estuary Regional Monitoring Program for Water Quality (RMP) from sites distributed throughout the Estuary in the summers of 2002 to 2006. Sediment samples from wetland sloughs and high marsh plains in the Petaluma River watershed were collected for a CalFed funded study in 2005

and 2006. Samples were analyzed for mercury, methylmercury (MeHg), and a suite of ancillary sediment parameters (TOC, TN, grain size, redox potential) measured in the field or in the laboratory. Reports in the literature have shown correlations of MeHg to total mercury, TOC, and grain size (% fines) in sediments; these relationships were examined in the samples collected. However, mercury was found to show little correlation to MeHg, with % MeHg (as a fraction of total Hg) typically <1% and varying greatly among sites within a habitat type. Of the ancillary parameters, measurements corresponding to bacterial substrate such as sediment organic carbon or total nitrogen, and indicators of microbial anaerobic processes such as surficial redox potential (Eh) were found to be among those most strongly correlated to MeHg concentrations. Activity of sulfate reducing bacteria under anaerobic conditions is expected to produce the majority of MeHg found in estuarine sediments, and correlations of these parameters with sediment MeHg support this expectation. Given the small percentage of mercury present as MeHg and the lack of correlation to total Hg, despite small loads of Hg from non-mining sources relative to the pool in sediments, these sources of mercury may be important to methylmercury cycling in the Estuary, with major implications for management approaches in the region.

522 Spatial variation in mercury distribution and biogeochemical cycling in the Florida Everglades. Y. Cai, G. Liu, Department of Chemistry, Florida International University, Miami, FL; T. Philippi, J. Richards, Department of Biological Science, Florida International University, Miami, FL; Y. Cai, G. Liu, L. Scinto, Southeast Environmental Research Center, Florida International University, Miami, FL; P. Kalla, D. Scheidt, C. Appleby, Science and Ecosystem Support Division, U.S. Environmental Protection Agency, Region 4, Athens, GA. Mercury (Hg) has been one of the major water quality concerns in the Florida Everglades since elevated levels of Hg were reported in fish and wildlife in late 1980s. The post-deposition biogeochemical cycling of Hg exhibits profound spatial patterns, influenced by distinct spatial variations in hydrological, physical, chemical, and biological characteristics across the Everglades. It is important to investigate spatial variations in Hg cycling and the biogeochemical processes that control these variations because it is the unique characteristics of the Everglades ecosystem, rather than high loading of Hg, that makes Hg available for bioaccumulation and results in elevated Hg levels in Everglades wildlife. The U.S. Environmental Protection Agency (EPA) Region 4 Regional Environmental Monitoring and Assessment Program (R-EMAP) integrates research, monitoring, and assessment by using a probability sample design to sample the entire Everglades freshwater marsh. The ecosystem-wide sampling allows us to investigate spatial patterns in Hg cycling and bioaccumulation at the landscape level. The data analyzed here covered approximately 250 randomly located stations sampled in 2005, half in May (the dry season) and half in November (the wet season), across the Everglades. High water total mercury (THg) occurred in the northern Everglades (WCA 2 and LNWR), due in part to high dissolved organic matter (DOM) that retains Hg in the water through complexing with Hg. Approximately at the same location, methylmercury (MeHg) was high in water, soil, and flocculent material (floc), indicating high MeHg production in this area probably owing to high sulfate and nutrients from adjacent agricultural area discharges. Contrary to Hg in water or soil, high periphyton THg and MeHg were not observed in the northern Everglades. High mosquitofish THg and bioaccumulation factor (BCF) occurred in the central and southern Everglades (WCA 3 and ENP), indicating that strong Hg bioaccumulation requires not only high MeHg production, but also an appropriate combination of biogeochemical controls making MeHg available to aquatic organisms.

523 Linking the River Continuum Concept to mercury concentrations in a stream biota. M. Tsui, Water Resources Science Graduate Program, University of Minnesota, St. Paul, MN; M. Tsui, J.C. Finlay, Ecology, Evolution and Behavior, University of Minnesota, St. Paul, MN; E.A. Nater, Soil, Water and Climate, University of Minnesota, St. Paul, MN. River Continuum Concept (RCC) is a well-known approach in describing how the energy and material flows change as the sizes of streams and rivers increase. In this study, we examined how RCC affects the accumulation of mercury (Hg) in a ubiquitous insect larvae (*Hydropsyche*), we tested this by collecting water and biota along a gradient of stream sizes (watershed area from 0.22 to 150 km²) in a pristine northern California forested watershed where wetland influence is minimal (DOC < 1.0 mg/L). We found that aqueous total-Hg varied little while aqueous methyl-Hg increased downstream. Concurrently, we found that total-Hg and methyl-Hg of *Hydropsyche* downstream, increased

by more than 3 folds. These results suggest elevated net methylation of Hg downstream, which may be due to the increasing numbers of anaerobic microenvironments in the larger rivers than headwater streams. Overall, RCC is an important approach to relate to the biogeochemistry of Hg and possibly other contaminants in the stream and river ecosystems.

524 Mercury toxicity in liver of northern pike from Isle Royale National Park. P. Drevnick, R.R. Otter, J.T. Oris, Zoology, Miami University, Oxford, OH; A.P. Roberts, Biological Sciences, University of North Texas, Denton, TX; R. Klaper, Great Lakes WATER Institute, University of Wisconsin-Milwaukee, Milwaukee, WI. Fish in many lakes across North America are known to be contaminated with mercury, including fish in inland lakes of Isle Royale National Park, Michigan, USA. To assess exposure and effects of mercury in fish, we collected 124 northern pike (*Esox lucius*) from eight of the Park's inland lakes. Total mercury was determined in skeletal muscle and liver from each individual. Concentrations of mercury in skeletal muscle of legal-sized northern pike (>61 cm total length) commonly exceeded the US EPA fish tissue criterion of 0.3 µg/g, but were much lower than previously reported. Concentrations of mercury in liver increased exponentially with concentrations in skeletal muscle, to a maximum of 3.0 µg/g, and were associated with oxidative stress, histopathological lesions, and poor fish health. These results suggest fish health may be affected by concentrations of mercury common in fish across North America.

525 Use of methylmercury accumulation by migrating zooplankton to evaluate mercury sources. J. Kubitz, ENTRIX, Inc., Barrington, IL. Methylmercury concentrations were monitored during the nightly migration of zooplankton to assess the relative contributions of atmospheric deposition and sediments to the food webs of three north temperate lakes. Metal-free Wisconsin plankton nets and "clean-hands/dirty-hands" techniques nets were used to collect zooplankton during nocturnal zooplankton migrations. Methylmercury concentrations were used compare the relative contributions from atmospherically-derived methylmercury with methylmercury derived from the hypolimnion; in one lake, the hypolimnion overlays mercury-contaminated lake sediments. The source contribution information from this study was also used to evaluate mercury management remedies for the Deer Lake Area of Concern in northern Michigan.

526 A Mercury Mass Balance for the Lower Passaic River and Newark Bay Complex. J. Atmadja, E.A. Garvey, S. Gbondo-Tugbawa, Malcolm Pirnie, Inc, Fair Lawn, NJ; A. Accardi-Dey, E. Zamek, Malcolm Pirnie, Inc, White Plains, NY; S. McDonald, Malcolm Pirnie, Inc, King of Prussia, PA. The lower Passaic River was one of the major centers of the American industrial revolution, with early manufacturing developing in the area around Great Falls in Paterson, New Jersey. In subsequent years, industrial operations sprang up along the banks of the Passaic River and Newark Bay, as the cities of Newark and Paterson grew. More recently, Newark Bay has been transformed into a major shipping center, with routinely dredged shipping channels along its length. Coincident with these developments, industrial and municipal discharges have contaminated the sediments of both water bodies, prompting the current investigations on the possible risks and remedial actions for the two waterways. As part of an early action remedial investigation in the lower Passaic River, an empirical mass balance model (EMBM) was developed for several contaminants including mercury. The model quantified the relative contaminant and solids contributions to the river's recently deposited surface sediments from several sources including the upper Passaic River, Newark Bay, tributaries, CSO/SWOs, and resuspension of contaminated river-bottom sediment. The results from the EMBM for the lower Passaic River showed that mercury loads from external sources are not sufficient to account for the annual accumulation of mercury on the river bottom. A significant contribution is needed from resuspension of older contaminated sediments, representing nearly 50 percent of the total annual load to the river bottom. Of the remainder, Newark Bay accounts for 25 percent and the upper Passaic River accounts for 20 percent of the contaminant load. As compared to other contaminants studied, this is the largest relative contaminant contribution by Newark Bay to the lower Passaic River. A separate mass balance was performed for Newark Bay to examine the relative mercury contributions to Newark Bay itself. In this mass balance, contributions from the lower Passaic River, the Hackensack River, the Arthur Kill, the Kill van Kull and from CSO/SWO discharges were examined and found insufficient to represent the annual load. The results identify the presence of an unknown source representing approximately 40 percent of the annual load to the bay.

527 Mercury Dissolution from Dental Amalgam Under Anaerobic and Aerobic Environments. J. Zimmerman, J. Vandeven, ENVIRON International Corporation, Arlington, VA; M. Olthof, M. Hausmann, R. Kirkland, ENVIRON International Corporation, Nashville, TN. In this study we measured dissolved mercury concentrations that result when dental amalgam resides under the most extreme conditions likely to exist in four environments: 1) amalgam separators in dental offices; 2) sewer lines immediately downstream from dental offices; 3) POTW biological treatment units; and 4) sediments underlying waters receiving POTW effluents. Based on measured dissolved mercury concentrations, the total amount of mercury released over 8 weeks from amalgam into artificial saliva solution in shaker bottles modeling the amalgam separator environment was less than 0.01% of the total mercury in the form of amalgam added to bottles. In testing how addition of strong oxidizing agents affects dissolution, we found that up to 46% of the mercury in amalgam was released in solutions of 10% v/v Clorox® bleach in artificial saliva. This is generally in agreement with the findings of previous studies showing increased dissolution in strongly oxidizing solutions. In experiments with aerobic and anaerobic digester reactors, there was no significant difference in dissolved mercury concentration between reactors with and without amalgam added. The average dissolved mercury concentrations were approximately 100–200 ng/L in the anaerobic reactors and approximately 4–6 ng/L in the aerobic reactors. These findings suggest that release of mercury from amalgam particles in these biologically active environments over the period of the experiment (approximately 60 days) does not result in significantly increased dissolved mercury concentrations. This could be due to either 1) low rates of release from amalgam; or 2) higher rates of release coupled with transformation mechanisms that remove mercury from solution (e.g., adsorption to bacteria or colloidal matter). Our study provides basic information regarding the concentrations of dissolved mercury resulting when dental amalgam is present in four model environments. Future studies that analyze for other parameters, including total mercury concentration and individual dissolved mercury species concentrations would help elucidate physical and chemical processes occurring in each of the environments. Acknowledgements: This study was funded by the American Dental Association and the California Dental Association.

528 A Critique of Current Practices in Contaminated Sediment Assessment and Management. T. Bridges, USACE-ERDC, Vicksburg, MS. The challenges posed by contaminated sediments are daunting. The most obvious challenges to scientists and engineers are technical in nature; however, challenges related to governance, decision processes, and project management are also formidable. A listing of 6 major impediments to progress on issues related to contaminated sediments is presented here. First, interactions among parties engaged at contaminated sediment sites are best described as adversarial, rather than collaborative. Protracted disagreements about what data should be collected, and ultimately what those data mean, have resulted in significant delays (measured in years if not decades) at many sites. More varied and frequent solicitation of external peer review/consultation with technical experts would facilitate progress. The earlier and more often such review/consultation occurs the greater the likelihood that positive benefits will result. Second, data are being collected at contaminated sediment sites without the benefit of a logic framework defining how, specifically, those data will be used to inform decisions, e.g., how the data will be used to distinguish among the range of management alternatives available. Third, contaminated sediment programs continue to struggle with the challenge of integrating multiple goals and objectives for projects, including those associated with reducing risks from contaminants, ecosystem restoration, recreation, navigation, economic development, etc., even though approaches for facilitating such integration are readily available. Fourth, cleanup projects are not being implemented in a manner consistent with the principles of adaptive management. Bias in favor of the most aggressive, costly and intrusive remedial options continues to exist. Monitoring during and after implementation of remedies is woefully inadequate, severely constraining our ability to credibly support conclusions about whether management actions are succeeding or failing at reducing risk. Opportunities to learn and thereby advance the state-of-the-practice are frequently ignored. Fifth, programs concerned with contaminated sediments are resistant to innovation. Practical guidance for managing innovation and its attendant uncertainties should be developed for project managers as a means of encouraging innovation. Sixth, a disappointing degree of progress has been made toward risk-based decision making and remedial design.

529 Philosophy and Economic Aspects of Dredging Contaminated Sediments - A North American Perspective. R. Mohan, Arcadis BBL, King of Prussia, PA. Environmental dredging is often preferred by agencies in North America as a remedial option to address contaminated river and harbor sites due to its ability to remove the bulk of the 'mass' associated with the constituents of concern. However, dredging does leave behind residuals - the impacts of which is a topic of wide debate. Also, the release of resuspended sediments and associated risks during dredging is another area of concern. Add to this, the fact that while the cost of dredging itself is mostly manageable, the end of chain processes following dredging (such as dewatering, sediment treatment and disposal) can be expensive, depending on the nature of sediments. This paper will address the general philosophy of dredging sediments, contrast it to navigation dredging, both from an effectiveness and economic perspective. Data needs, numerical modeling as a tool to plan projects, common pitfalls of past projects, and future industry trends will be presented. Finally, relevant case studies will be discussed.

530 Process, performance and issues in the assessment of contaminated sediment in Great Lakes using the Canada-Ontario Agreement Framework. L. Grapentine, D. Milani, Environment Canada, Burlington, Ontario, Canada. Contaminated sediment is one of the major impediments to the restoration of environmentally disturbed areas in the Great Lakes. The recently developed Canada-Ontario Decision-Making Framework for assessing ecological impacts of contaminated sediments is an important tool in the management of these areas. Based on the sediment quality triad and other multiple-lines-of-evidence approaches, the Framework provided step-by-step guidance for integrating information on sediment chemistry, toxicity to benthic invertebrates, benthic invertebrate community structure, and contaminant bioaccumulation to determine overall sediment quality and recommend management direction. Over the last several years, sediment assessments were conducted in 13 "Areas of Concern" in the Laurentian Great Lakes using the Framework methodology. Outcomes ranged from finding no adverse biological effects to concluding that sediments are toxic, disturbing to resident invertebrates, and pose a risk of contaminant biomagnification to fishes and wildlife. Assessment interpretation and management recommendations are determined by the combination of outcomes from the individual lines of evidence. Follow-up studies can be required to address unresolved issues such as sediment stability, subsurface sediment quality, probable cause(s) of adverse effects, and ecological risks to fishes and wildlife. Advantages of the Framework are its comprehensiveness, consistency and transparency. Disadvantages are high data requirements and technical complexity. The Framework follows generally accepted assessment procedures and is similar to other approaches applied to the Great Lakes and elsewhere.

531 Comparative Risk Assessment of Contaminated Dredged Material Disposal Options in Canada. S. Agius, Disposal at Sea Program, Environment Canada, Gatineau, Quebec, Canada. Environment Canada (EC) is considering re-evaluating the disposal options available to its permittees when the disposal of contaminated sediments is required. To be considered for disposal at sea, a permit applicant must evaluate the material according to waste assessment guidance as found in the Canadian Environmental Protection Act 1999 (CEPA). Schedule 6 of this guidance obliges EC to compare the risks associated with various disposal options before making permit decisions. In the context of disposal at sea, EC currently has no established Comparative Risk Assessment (CRA) Framework for contaminated dredged materials with which to effectively carry out this obligation. The international group of experts in attendance at the Contaminated Dredged Materials Management Decisions (CDMMD) Workshop in 2006 made a number of recommendations as to what an objective, transparent, and policy-based CRA Framework should involve and what it might look like. Work to develop CRA processes for the effective management of contaminated dredged materials is underway in the US and the UK, and Canada is considering its options to improve its own decision making processes. EC would like to present the CRA framework recommendations that emerged from CDMMD, and solicit feedback on them and on possible implementation strategies, during a platform presentation at SETAC 2007.

532 Optimizing Remedy Decision-Making for Contaminated Sediments under Superfund. M.P. Logan, U.S. EPA, Chicago, IL; L. Evison, U.S. EPA, Washington, DC. U.S. EPA guidance for cleanup of contaminated sediment promotes even-handed consideration of in-situ and ex-situ

remedies for sites, selection of combination remedies when appropriate, and the consideration of comparative net risk in decision making. However, adoption of these principles has been slow in the U.S. With the exception of several notable recent sites, dredging remains the dominant remedy of choice regardless of site characteristics, due predominately to a perception of increased long-term effectiveness and permanence and a perception of lower long-term monitoring and maintenance costs, which is especially important to States at Fund-lead sites. As demonstrated by a recent review of the effectiveness of Superfund dredging remedies by the National Academy of Sciences, employing a more site-specific set of risk reduction tools is essential if the Superfund program is to optimize cleanup effectiveness. Decision-support tools which are consistent with Superfund program requirements and promote science-based decision-making can help. These tools include targeting and piloting likely remedies early in the remedial investigation or feasibility study process, phased decision-making, and combining remedies to use dredging, in-situ capping, and monitored natural recovery as appropriate at sites. This session will discuss the U.S. EPA's Superfund program's efforts to optimize decision-making for contaminated sediments, including recent examples of site applications.

533 Interactive Sediment Remedy Assessment Portal (ISRAP): A Tool to Facilitate Design of Long-term Remedial Monitoring Strategies. Y.J. Kirtay, B. Chadwick, H. Halkola, C. Kurtz, Environmental Sciences Branch 2375, SPAWARSYSCEN San Diego, San Diego, CA; J. Conder, ENVIRON Corporation, Irvine, CA; V. Magar, ENVIRON Corporation, Chicago, IL; A. MacGregor, ENVIRON Corporation, Denver, CO. As Department of Defense (DoD) contaminated sediment sites move toward remedy implementation, a uniform approach for the design and implementation of long-term sediment monitoring programs is needed. Such an approach should ensure that long-term monitoring is clearly tied to remedial action objectives and that clear exit criteria are established to facilitate timely and cost-effective site closure while protecting human health and the environment. Though several resources identify general monitoring needs and approaches for sediment sites and specific details concerning monitoring tools, there is no current framework that links remedy-specific and goal-specific monitoring needs with appropriate monitoring tools and approaches. In support of the need for such a framework an Interactive Sediment Remedy Assessment Portal (ISRAP) is under development that will provide remedy-specific recommendations for sediment monitoring programs. A key component of the ISRAP is an online, interactive matrix that will help remedial project managers (RPMs) focus on key issues associated with site-specific monitoring needs and facilitate a comparison of effective monitoring tools. It is envisioned that the ISRAP will be useful to RPMs at a variety of stages in the Remedial Investigation/Feasibility Study (RI/FS) process, but will be particularly useful in understanding and planning for monitoring needs following remedy implementation at contaminated sediment sites. The web-based nature of the tool will enable the matrix content to be adapted and updated to keep pace with the evolving nature of sediment remediation practices and sediment monitoring approaches, and will enable a technical peer-review by members of the sediment monitoring community.

534 Randle Reef Sediment Remediation Project (Hamilton Harbour). R. Santiago, Environment Canada, Toronto, Ontario, Canada; C. Vieira, Ontario Ministry of the Environment, Hamilton, Ontario, Canada; B. Fitzgerald, Hamilton Port Authority, Hamilton, Ontario, Canada. Contaminated sediments are recognized as significant contributors to impaired water quality in the Great Lakes. Hamilton Harbour sediment contamination of polycyclic aromatic hydrocarbons (PAHs), and various heavy metals around the Randle Reef site contributed to the International Joint Commission's (IJC) identification of the Harbour as an Area of Concern. Randle Reef (Hamilton Harbour AOC), is considered one of Canada's most contaminated sediment sites. This project is designed to accomplish the recommended sediment cleanup around the Randle Reef site. The project is led by Environment Canada, with the Hamilton Port Authority (HPA), and the Ontario Ministry of the Environment (MOE) as project partners. The three agencies are responsible for overseeing the engineering design for the project. The proposed remediation of the site involves constructing a 9.5 hectare engineered containment facility (ECF) that will manage PAH and heavy metal contaminated sediments in two ways: (1) the ECF will be constructed on top of some of the most highly contaminated sediments (in situ 130,000m³), isolating those sediments in place; and (2) other highly contaminated sediments (500,000m³), will be dredged and placed inside

the ECF. The engineering design for this project is underway and will be completed in the summer of 2008. The ECFs will be designed to have a service life of at least 200 years. Eight environmental studies have been identified and initiated to assess the effectiveness of the clean up of Randle Reef. Prior to the construction of the ECF, baseline data are being collected. There are plans to conduct these studies during various stages of the construction, after the construction of the ECF and dredging are completed. The project has funded an independent study to quantify the economic and non-monetary benefits related to the remediation of contaminated sediments in Randle Reef. Preliminary results identify over \$126 Million in return on investment for this sediment cleanup project which is estimated at \$90 Million.

535 Environmental Remediation of Contaminated Sediments in Cells 1 and 3 of the Bays in Sector 103 – Montréal Harbour G Area. P. Turgeon, S. Côté, B. Vallee, Geo-environnement, Dessau Soprin, Montreal, Quebec, Canada; C. Bélanger, Environnement Canada, Montreal, Quebec, Canada. In the context of the St. Lawrence action plan, Environment Canada carried out a characterisation study of the sediments in the Montreal Harbour area, in the province of Québec. The results of the study indicated that bottom sediments were seriously contaminated by many elements, such as petroleum hydrocarbons, PAH (Polycyclic Aromatic Hydrocarbons) and metals, particularly in the bays of sector 103. This contamination was caused by former practices in the port: factories and municipalities which for many decades dumped their effluent into the river without any pre-treatment. In 1998, in an Environment Canada initiative, three private companies, Imperial Oil, Shell Canada Products and Xstrata, as well as the Montreal Port Authority, formed a remediation group. This "Groupe de restauration" committed themselves to the voluntarily remediation of contaminated sediments of cells 1 and 3 of the bay in sector 103 which is in the municipality of Montréal-East. About 40 000 m3 of contaminated sediments will be removed from the river in the port zone and managed according to local regulations. In the first years of the new millennium, different pilot tests, scenario development, and an environmental impact assessment gave rise to a unique project which was authorised by a special Québec government ministerial decree in March 2006. The work planned for 2007 includes the construction of the necessary infrastructure for the decontamination operation, the removal and drying of 40 000m3 of sediment, and finally the bio-treatment of a part of the sediment which will be recovered. The other part of the sediment will be eliminated in an authorised disposal site, and may or may not be biologically decontaminated. A project-specific environmental control program has been set-up to mitigate the impact of the work on the local population, fauna and flora. This project, which is monitored by an advisory committee composed of environmental groups and public organisations, is remarkable in its scope and exemplarity, given that it is one of the largest remediation projects of its kind in Canada. It represents a major improvement of the health of the Saint-Lawrence River, and adheres to the principles of sustainable development. This project represents a collective wish that this initiative will be the first of many contributions to the rehabilitation of this important waterway.

536 Beyond the Toxicity Test: St. Clair River Sediment Remediation Project of the Nearshore Dow Outfall Area. T. Moran, N. Orr, J. Houtby, Pollutech EnviroQuatics Limited, Point Edward, Ontario, Canada; C. Creber, Dow Chemical Canada Inc., Sarnia, Ontario, Canada. Dow Chemical Canada Inc. (Dow) has implemented numerous measures to mitigate impacts to the St. Clair River associated with the historical operations on the Sarnia Site. These measures focussed initially on source elimination; removal of chemicals in water discharged to the river, separation of sewers, reduction of discharge point/outfall reduction; collection and monitoring of all stormwater; and, more recently, involved the removal of the contaminated sediments in the near shore area along their river frontage (i.e., Dow Outfall Area). The contaminants of concern in these sediments were mercury, semi-volatile organic compounds including hexachlorobenzene, hexachlorobutadiene, octachlorostyrene, and volatile organic compounds including 1,2-dichloroethane, carbon tetrachloride, and tetrachloroethylene. A risk management approach was employed to evaluate potential remedial alternatives (goals/effectiveness, implementability, and cost) and included extensive regulatory and public consultation. Dow selected a combination of a hydraulic sediment removal technology and mechanical excavation, with a combination of landfill disposal and treatment of the sediments once removed. The hydraulic sediment removal process removed sediment and transferred it to an onshore treatment facility, where the water was separated from the sediment and treated before discharge back to the St. Clair River. Solids were

treated such that they could be disposed of as either non-hazardous waste or remain on site to be treated using bioremediation technology. A three-phased, three-year approach was selected. The first phase allowed for the evaluation of the effectiveness of the sediment removal technology, water treatment processes, environmental control, and monitoring procedures. Subsequent years then allowed for management of sediments based upon different zones of contamination requiring different management and treatment strategies. Dow's sediment remediation project initiated in 2002 was completed in 2005 with the application of washed river stone to act as habitat enhancement. This presentation will provide an overview of the entire project with key messages addressing the need for community communications prior to and during the project, operational risk management, environmental diligence to minimize downstream impacts and the benefits and limitations of such an operation.

537 Adsorption of Fluorochemicals to Ion Exchange Resins and Granular Activated Carbon. B.T. Mader, M.D. Malinsky, C. Lange, Environmental Laboratory, 3M Company, St Paul, MN. Fluorochemicals can be present in groundwater at relatively low levels (i.e. parts per billion). One route for their removal from groundwater is to concentrate them via absorption onto a media and then dispose of the media or desorbed concentrate. The unique chemistries of fluorochemicals make the prediction of their adsorption capacities on ion exchange resins and granular activated carbon difficult as adsorption models may not have sufficient physical-chemical property data, or were generated using data for relatively non-polar organic compounds. A series of laboratory studies were done to evaluate the adsorption of PFOA, PFOS, PFBS, and PFBA on a variety of adsorption media. Batch isotherms and column tests were conducted using commercially available ion exchange resins and granular activated carbon (GAC) as well surface modified GAC and common flocculants. Data from these studies will be presented.

538 Remediation of the Perfluorinated Surfactants, PFOS and PFOA: A Review. M.R. Hoffmann, C.D. Vecitis, H. Park, J. Cheng, Environmental Science & Technology, Caltech, Pasadena, CA; B.T. Mader, Environmental Laboratory, 3M, Maplewood, MN. The perfluorinated surfactants, perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), have become globally ubiquitous due to their environmental persistence and have been detected at ppb levels in human serum from around the world. Incineration is the only conventional degradation technique able to destroy these perfluorinated surfactants. However, incineration requires extreme conditions and is not feasible for the low levels present in large volumes of surface waters unless adsorption applied as a pre-treatment. A number of possible degradation methods, more for PFOA than PFOS, have been presented in the literature. These methods cover a range of mechanisms such oxidation (i.e. hydroxyl and sulfate radicals), reduction (i.e. Fe(0) and aqueous electrons), direct photolysis and in situ pyrolysis through ultrasonic irradiation. We shall critically review and compare all of these techniques in terms of their degradation rate, reaction products, volumetric cost and ease of scalability.

539 Complete Sonochemical Mineralization of the Perfluorinated Surfactants PFOS and PFOA. C.D. Vecitis, H. Park, J. Cheng, M.R. Hoffmann, Environmental Science & Technology, Caltech, Pasadena, CA; B.T. Mader, 3M Environmental Laboratory, 3M, Maplewood, MN. The perfluorinated surfactants, perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) are recognized as ubiquitous in the environment as well as bio-accumulative, persistent, and recalcitrant towards conventional water treatment technologies. Acoustic cavitation as driven by high-frequency ultrasound is utilized for the degradation of dilute aqueous solutions of these perfluorinated chemicals. Fluorine, carbon and sulfur temporal mass balances show mineralization occurs immediately following initial perfluorinated surfactant degradation. Essentially complete conversion of PFOS and PFOA to carbon monoxide, carbon dioxide, fluoride ion and sulfate ion occurs due to pyrolytic reactions at the surface and vapor phase of transiently collapsing cavitation bubbles. Estimated half-lives, which are calculated from high-temperature gas-phase kinetics and applied to the temperatures conditions obtained during sonolytic degradation of PFOS and PFOA, agree with the experimentally observed kinetics that suggest mineralization occurs immediately after the initial interfacial pyrolysis, which is the overall rate-determining step.

540 Sonochemical Degradation of PFOS and PFOA: Matrix Effects. J. Cheng, Y. Wang, C.D. Vecitis, H. Park, M.R. Hoffmann,

Environmental Science & Technology, Caltech, Pasadena, CA; B.T. Mader, 3M Environmental Laboratory, 3M, Maplewood, MN. Landfills used for the disposal of manufacturing waste and AFFF usage sites have been determined to be a source of perfluorinated chemicals to the environment. The perfluorinated chemical plume has a tendency to move faster than other organics due to their weak and slow sorption to most surfaces. The effect of leachate, groundwater and AFFF matrices versus 'pure' MilliQ water were tested on the sonochemical degradation PFOS and PFOA. The groundwater matrix had a minor effect on PFOS and PFOA sonochemical degradation rates while both the leachate and AFFF matrices had a detrimental effect on the rates. Investigations were made into the cause the matrix effect in both cases, preliminary data shows for the leachate iron is responsible and for the AFFF organics/alkyl surfactants are responsible. The PFOS and PFOA sonochemical degradation rates were partially rectified by application of the sonozone process (simultaneously use of ultrasonic irradiation and ozone dispersion).

541 Anaerobic Biotransformation of Fluorochemical Alcohols Under Methanogenic Conditions Does Not Form Perfluorinated Carboxylates or Sulfonates. C.C. Lange, Environmental Laboratory, 3M Company, St. Paul, MN, MN. The anaerobic biodegradability of fluorochemicals (FCs) is not well studied and as a result the fate of FCs in anaerobic environments is poorly understood. In order to attain a preliminary understanding of FC sources and fate in anaerobic environments, nine fluorochemical substances were tested for anaerobic biodegradability. Experiments were performed in the laboratory in anaerobically-sealed batch cultures using municipal anaerobic digester sludge as the microbial inoculum. Cultures were incubated for up to 108 days. The test substances evaluated were EtFOSE alcohol, MeFBSE alcohol, 6:2-fluorotelomer alcohol (6:2-FTOH), 8:2-fluorotelomer alcohol (8:2-FTOH), perfluorooctanoate (PFOA), perfluorobutanoate (PFBA), perfluorooctane sulfonate (PFOS), perfluorobutane sulfonate (PFBS) and 6:2 fluorotelomer sulfonate (THPFOS). Quantitative analysis of the extracts for the test substances and their respective anticipated end-products was performed by LC/MS/MS. The results showed that each of the four fluorinated alcohol substrates underwent biotransformations. The predominant biotransformation observed was the oxidation of the primary alcohol end group to the corresponding carboxylic acid. EtFOSE alcohol and MeFBSE alcohol additionally underwent partial N-dealkylation to form perfluorooctane sulfinate and perfluorobutane sulfinate, respectively. The lower molecular weight alcohol test substances biodegraded with the fastest apparent rate and highest percentage degraded at the end of their incubations, with MeFBSE Alcohol > 6:2-FTOH > 8:2-FTOH > EtFOSE Alcohol. Biotransformations did not result in formation of any perfluorinated carboxylic acid or sulfonic acid end-products, as has been observed previously in laboratory testing under aerobic biodegradation conditions with the similar alcohols as test substances. The substances PFOA, PFBA, PFOS, PFBS and THPFOS appeared to be recalcitrant to biodegradation under the methanogenic test conditions of this study.

542 Modelling the fate and transport of PFCAs emitted from direct sources using a global-scale chemical fate model. J.M. Armitage, I.T. Cousins, ITM, Stockholm University, Stockholm, Sweden; M. Macleod, ETH Zurich, Swiss Federal Institute of Technology, Zurich, Switzerland; M.H. Russell, R.C. Buck, duPont, E. I. duPont de Nemours & Co., Inc, Arlington, DE. Perfluorocarboxylic acids (PFCAs) are widely distributed in the environment and have been detected in wildlife and humans around the globe. While these observations have spurred both scientific and regulatory interest, many questions remain as to the sources and transport pathways. In terms of ecological exposure, the measured levels in biota are ultimately a function of the relative concentrations in the main exposure media (e.g. water column or diet) and the relative bioaccumulative potential of each particular PFCA. In this investigation, a global distribution model parameterized on a 15 by 15o grid was used to generate predicted concentrations of PFCAs in the global environment. The model accounts for the fact that these compounds exist in both dissociated and neutral forms at environmentally-relevant pHs and provides estimates of the mass fluxes associated with various transport pathways. Insights into the potential contribution of PFCAs emitted from direct sources (i.e. PFCA manufacturing and subsequent uses) to observed levels in the environment are presented by examining the results of long-term dynamic simulations. These results are then interpreted in the context of the current understanding of biological uptake pathways and consideration of relevant exposure.

543 High Resolution Atmospheric Modeling of Fluorotelomer Alcohols and Perfluorocarboxylic Acids in the North American Troposphere. G. Yarwood, S. Kemball-Cook, ENVIRON International Corporation, Novato, CA; M. Keinath, S.T. Washburn, ENVIRON International Corporation, Emeryville, CA; R.L. Waterland, S.H. Korzeniewski, R.C. Buck, M.H. Russell, E. I. du Pont de Nemours and Co., Inc., Wilmington, DE. A high spatial and temporal resolution atmospheric model is used to evaluate the potential contribution of fluorotelomer alcohol (FTOH) and perfluorocarboxylate (PFCA) emissions associated with the manufacture, use and disposal of DuPont fluorotelomer-based products in North America to air concentrations of FTOH, perfluorooctanoic acid (PFOA) and perfluorononanoic acid (PFNA) in North America and the Canadian Arctic. A bottom-up emission inventory for PFCAs and FTOHs was developed from sales and product composition data. A detailed FTOH atmospheric degradation mechanism was developed and incorporated into the model to simulate FTOH degradation to PFCAs and model atmospheric transport of PFCAs and FTOHs as well as FTOH degradation to PFCAs. Modeled PFCA yields from FTOH atmospheric degradation agree with experimental smog-chamber results and support the degradation mechanism used. Estimated PFCA and FTOH air concentrations and PFCA deposition fluxes are compared to monitoring data and previous global modeling. Predicted FTOH air concentrations are generally in agreement with available monitoring data. Overall emissions from the global fluorotelomer industry are estimated to contribute approximately 1-2% of the PFCAs in North American rainfall, consistent with previous global emissions estimates. Emission calculations and modeling results indicate that atmospheric inputs of PFCAs in North America from fluorotelomer-based products will decline by an order of magnitude in the near future as a result of current industry commitments to reduce manufacturing emissions and lower the residual fluorotelomer alcohol raw material and trace PFCA product content.

544 Modelling the environmental fate of perfluorooctanoic acid and its precursors from fluorotelomer acrylate polymer emissions. R. van Zelm, M. Huijbregts, D. van de Meent, Environmental Science, Radboud University Nijmegen, Nijmegen, Netherlands; M. Huijbregts, D. van de Meent, Laboratory for Ecological Risk Assessment, National Institute of Public Health and the Environment, Bilthoven, Netherlands; M. Russell, E.I. duPont de Nemours & Co, Wilmington, DE; T. Jager, Department of theoretical biology, Vrije Universiteit Amsterdam, Amsterdam, Netherlands; V. Koch, Clariant Produkte GmbH, Sulzbach, Germany. Perfluorooctanoic acid (PFOA) has been of increasing scientific and regulatory interest as it is proven to be a very persistent compound in the environment. There are various possible sources of PFOA formation in the environment. In this study, we analyzed the contributions of PFOA concentrations in the European environment due to (i) formation from fluorotelomer acrylate polymer (FTacrylate) emitted to landfills and waste water, (ii) formation from traces of 8 carbon fluorotelomer alcohol (8:2 FTOH) in FTacrylate and (iii) PFOA in FTacrylate. FTacrylates are used to coat textiles, paper and carpet to achieve water, oil and stain repellency. For this purpose, we developed a dynamic multi-species version of the EU-TGD multimedia fate model. With the specific ability of this model to determine the fate of a chemical and its degradation products, we identified the contributions of the different chemicals to current and future PFOA concentrations in the environment. The half-life of FTacrylate is particularly uncertain and from degradation studies of the FTacrylate in soil it can be assumed that it is more than 1000 years. Therefore, we varied the FTacrylate half-life between 1000 and 10,000 years. If the half-life is 10,000 years, traces of 8:2 FTOH contribute for a large part to the PFOA concentrations in freshwater and sea water up to year 2100. If the half-life of FTacrylate is 1000 years, however, PFOA concentrations in the water compartments dominantly result via degradation of the FTacrylate. Traces of PFOA in the FTacrylate emissions hardly contributed in both scenarios. This indicates that it depends on the half-life of FTacrylate what is the most effective way to decrease PFOA concentrations in the environment up to 2100 and, as FTacrylate will stay in landfills for centuries, more insight has to be gained in the degradation of FTacrylate in landfills.

545 Potential Long Range Transport Mechanisms of PFOA and PFO. L.K. Reid, D.A. Ellis, D. Mackay, Canadian Environmental Modelling Centre, Trent University, Peterborough, Ontario, Canada; C.J. McMurdo, D.A. Ellis, Department of Chemistry, Trent University, Peterborough, Ontario, Canada. This research focuses on the proposal that an environmental transport mechanism for perfluorooctanoic acid (PFOA) and perfluorooctanoate

(PFO) may be the generation of aerosols from a body of water containing the conjugate base (PFO). Bulk water, of varying types (e.g. river, lake, and ocean) were spiked with PFOA. Aerosols were then generated and samples of the bulk water and condensed aerosols were collected over time. Significant PFO enrichment in the condensed aerosols was observed, indicating that PFO preferentially partitioned to the aerosol droplets from the surface of the bulk water under these experimental conditions. It was hypothesized that the observed aerosol enrichment was related to the surface activity of the conjugate base. Samples of the headspace atmosphere were also collected and indicated the presence of gas phase PFOA in the system being produced also upon aerosol formation. A subsequent experiment investigated the aerosol-gas phase kinetics of PFO - PFOA, from which a half-life and rate constant were calculated for PFO with respect to aerosols in the experimental system ($t_{1/2} \sim 7$ secs). This research concluded that PFO adsorbed to aerosol droplets had a short half-life on the aerosol before it was emitted to the headspace atmosphere as gas phase PFOA. These results suggest that PFOA and PFO may have the potential to undergo long-range transport via atmospheric aerosols. The rapid partitioning of PFO from the surface of aerosol water droplets to the air suggests that the formation of aerosols may result in the volatilization of PFOA to the gas phase from a body of water. Furthermore, the results also indicated that gas phase PFOA in the atmosphere is not readily scavenged by water droplets and, hence, is not likely to be rained out to the degree that is currently believed.

546 Development of an Amphibian Development, Growth and Reproduction Testing Protocol Using *Xenopus tropicalis*. S.J. Degitz, MED, USEPA, Duluth, MN; A.W. Olmstead, National Research Council, Duluth, MN; B.A. Bennett, K. Woodis, S. Ostazeski, Student Contractor Services, Duluth, MN. Partial life cycle testing methods have been developed for amphibian species that evaluate early embryonic development and metamorphosis. However, there are no standardized tests for evaluating chronic effects on growth, development and maturation of the amphibian HPG. This project addresses the need to develop and standardize amphibian growth and reproduction full life cycle tests. A protocol for an amphibian growth and reproduction test along with guidance for its use and applicability is being developed as part of the implementation of the Endocrine Disruptor Screening Program (EDSP). Additionally, efforts are being undertaken in collaboration with scientists from the EU and Japan in support of an effort by the Organization for Economic Cooperation and Development (OECD) to develop assays for internationally-harmonized EDC testing. The purpose of these studies is to develop a more comprehensive understanding of the sexual maturation of *Xenopus tropicalis*, establish the relevant endpoints for evaluating reproductive dysfunction, and to establish an approach for full life cycle testing. The outcomes of these studies will assist the EPA's Office of Research and Development (ORD) in providing guidance to the EPA's Office of Science Council and Policy (OSCP) as to whether full life cycle testing is needed, and what critical windows of development and vulnerability a full life cycle test addresses that are not apparent using shorter-term partial life-cycle testing. This abstract does not necessarily reflect EPA policy.

547 Problem Formulation for Species-Specific Ecological Risk Assessments. P. Doelling Brown, A. Pease, M. Corbin, Office of Pesticide Programs, U.S. Environmental Protection Agency, Washington, DC. In many cases, ecological risk assessments focus on a generic suite of species to evaluate risk associated with a particular chemical or at a particular location. Often, these surrogate species are selected not because they occur at the site or are of particular ecological significance, but because toxicological, metabolic, and life history data are available to be incorporated into the assessment. Standardized exposure methods and models are often used as well. However, in some cases, ecological risk assessments are developed for a single species of ecological concern. Adapting existing generic site- or national-level risk assessment methods to species-specific assessments can be difficult, but a well-thought out problem formulation ensures a focused, yet comprehensive risk assessment. Critical elements for a species-specific assessment include: defining the likely exposure routes and/or pathways, based on the organism's life history and the fate and transport properties of the chemical in question; determining assessment endpoints for the organism based on life history and ecological requirements; examining the spatial relationships between the stressor and the organism; and selecting reasonable toxicological data (measures of ecological effect) to evaluate the endpoints. In many cases, data for amphibians, or even closely related species may not be available, thus a clear and concise problem formulation provides a framework for developing reasonable risk conclusions

based on the best available scientific data and methodologies. Several case studies for amphibians will be presented. Adaptations of generic methods for these assessments include modifications of the exposure assessment to address a groundwater-fed spring system, selection of assessment endpoints for both aquatic and terrestrial phases of the organisms, and evaluation of potential food chain and habitat degradation effects.

548 Qualifying Best Available Endangered Species Location Data for Use in Effects Determinations: California Red-Legged Frog Case Study. K.H. Carr, Monsanto Company, St. Louis, MO; C.N. Thomas, DuPont Crop Protection Products, Newark, DE; A.T. Hall, Bayer CropScience, Research Triangle Park, NC; A. Rives-Frank, D.A. Howes, Compliance Services International, Lakewood, WA. In order to ensure comprehensive assessments are conducted and protection goals are met for threatened and endangered species, information on the biology and distribution of such species are paramount to the risk evaluations. NatureServe, a conservation-based data distributor with a network of national heritage programs, is the only source of a fully aggregated national dataset on species distribution at this time. While the Services are responsible for endangered species location data, the Services' regional or species-centric approach to such data collection, collation, storage, and, when needed, distribution, makes it difficult to aggregate such data at a national level. As a part of meeting its data requirements, the FIFRA Endangered Species Task Force (FESTF) has provided US EPA OPP access to 'best available data' on threatened and endangered species for national level endangered species assessments through access to the aggregated NatureServe data. There was simply no national-level source other than that provided by NatureServe. The content of the aggregated data as delivered through FESTF's multijurisdictional data system (FESTF MJD) was reviewed and data quality issues as well as alternate sources of information were discussed. This presentation addresses how the national level data set can be utilized and subsequently refined when local issues require more current information than can be maintained on a national level. The use of species location data for the California Red-legged frog is used as a case study on qualifying data for use in multiple levels of assessment.

549 Assimilation of Trophically Available Lead in a Reptilian Predator Model. S. Brasfield, J. Coleman, L.S. Inouye, R.P. Jones, J.A. Steevens, R. Boyd, L. Yoo, US Army Engineering Research and Development Center, Vicksburg, MS. Firing range contamination by lead (Pb) projectiles continues to be a concern as the Army manages the training environment. Pb transfer from organisms at the food chain base (i.e., invertebrates) to higher level consumers (i.e., birds, reptile, etc.) is particularly important in evaluating potential risks linked to Pb contamination. Current environmental assessments overestimate risk by assuming 100% Pb transfer within the food chain. Previous study evaluated uptake of Pb in four prey species, and based on these results, tenebroid beetle larvae (*Tenebrio molitor*) were selected. Prey invertebrates were exposed to sub-toxic Pb levels and fed to lizards as whole organisms, whole homogenate, exoskeleton filtrate centrifuged fractions of exoskeleton (pellet) and fraction pellets with metals-rich granules (MRGs), and cytosol (supernatant). Assimilation efficiency of ingested Pb when consumed as a contaminant in the whole organism or as a component of the aforementioned individual fractions was determined. When fed whole beetle larvae or gavage whole larvae homogenates, lizards were found to excrete large percentages (66-114% and 94-110%, respectively) of the ingested 210Pb over a 5 day period. Not surprisingly, organs dissected from laboratory exposed lizards (collected and euthanized at end of exposure period) showed almost no demonstrable Pb accumulation as estimated by 210Pb gamma counts.

550 Mercury accumulation along a contamination gradient and nondestructive indices of exposure in amphibians. C.M. Bergeron, C.M. Bodinof, W.A. Hopkins, Wildlife Ecotoxicology and Physiological Ecology Program, Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA; J.M. Unrine, Savannah River Ecology Laboratory, University of Georgia, Aiken, SC. Amphibians are critical constituents of aquatic and terrestrial communities, playing important roles in the transfer of energy and nutrients through food webs. Because amphibians efficiently convert ingested energy into biomass and are often prey items, they can serve as critical links between the lowest and highest trophic levels within a community. The South River (VA, USA) was historically impacted by point source mercury (Hg) emissions from a former DuPont facility (Waynesboro, VA, USA) which resulted in a large Hg contamination gradient, spanning from low concentrations upstream from the point source to high Hg concentrations downstream from the plant. To determine whether amphibians

accumulate Hg in their tissues, we collected adults from three species (*Plethodon cinereus*, *Eurycea bislineata*, and *Bufo americanus*) and larvae from the latter two species along the contamination gradient and upstream reference sites. Initial analyses of whole body Hg concentrations reveal up to a 100-fold difference in Hg accumulation ranging from 0.088 to 9.31 ug Hg/g dry mass in the reference and most contaminated areas, respectively. In addition, nondestructive sampling techniques are non-existent for small amphibians and were investigated in our study. Blood samples were collected from *B. americanus*, but the small body size of the salamander species precludes this technique. For *E. bislineata* and *P. cinereus*, which exhibit tail autotomy as a natural defensive mechanism to prevent capture by predators, we analyzed body and tail tissue separately. Initial analyses reveal that Hg concentrations in tail tissue were strongly correlated ($r^2=0.97$) with Hg concentrations in the remaining carcass. Our results suggest that amphibians may be an important link in the transfer of Hg through food webs and that nondestructive methods may be a viable option for sampling these organisms without greatly impacting local populations.

551 Exposure of Amphibians to Semi-Volatile Organic Compounds in the Sierra Nevada Mountains and California Cascades: Relationship between Tadpole Tissue and Sediment Concentrations. *K. Stanley*, S. Simonich, Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR; R. Huber, S. Simonich, Department of Chemistry, Oregon State University, Corvallis, OR; C. Davidson, Environmental Studies Program, San Francisco State University, San Francisco, CA; D. Bradford, N. Tallent-Halsell, Office of Research and Development, United States Environmental Protection Agency, Las Vegas, NV. Pesticides and other semi-volatile organic compounds (SOCs) undergo regional and long-range atmospheric transport. One such example is the transport of current-use pesticides from the intense agricultural Central Valley of California into the adjacent Sierra Nevada and Cascade Mountains. Amphibian species, including the mountain yellow-legged frog (*Rana muscosa*) and the Cascades frog (*Rana cascadae*), are declining in these ranges and pesticides have been implicated in these declines. Upon entering mountain ecosystems, pesticides and other SOC's may be deposited into the aquatic environment where they may accumulate in the sediment. Tadpoles live in close contact with the sediment; this may be an important route of exposure for these organisms. Tadpole and sediment samples were collected concurrently from 28 lakes in the Sierra Nevada Mountains and 32 lakes in the Cascade Mountains in the summer of 2005. Pacific tree frog tadpoles (*Pseudacris regilla*) were collected as a surrogate species for mountain yellow-legged frog at all Southern Sierra sites and at Cascades sites where the Cascades frogs are no longer common. Using methods developed in our laboratory, tissue and sediment samples were processed and analyzed for over seventy SOC's, including polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and several classes of pesticides. Of these the most commonly detected compounds in both matrices included the widely used pesticides endosulfan and dacthal. The relationship between SOC concentrations in the tadpole tissue and sediment will be discussed and correlations with regional pesticide use in California will be presented.

552 Distribution of pesticides and other contaminants in amphibian habitats of central and southern California. *D.W. Sparling*, Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, IL; G. Fellers, Western Ecology Research Center, U.S. Geological Survey, Pt. Reyes, CA; L. McConnell, Beltsville Agriculture Research Center, U.S. Department of Agriculture, Beltsville, MD. Several species of amphibians are showing severe population declines in the Sierra Nevada Mountains of central and southern California. Contaminants, especially pesticides from the highly agricultural areas of the Central Valley, are a major factor in these declines. Previous studies have shown that pesticides are being aerially deposited in remote areas of the Sierras and that mortality and sublethal problems are more frequent in areas downwind of the Central Valley than more northern reference sites. This study examines the distribution of 27 organic contaminants among 56 ponds during 2001 and 2002. Five transects were developed from Lassen Volcanoes National Park to Sequoia National Park. Each transect extended from the Pacific coast into the Sierra Nevada. Wetlands were sampled at areas corresponding to the coast, east of the coast mountain range, Central Valley, foothills and mid range (ca. 2000 m) into the mountains. Water, sediment and adult Pacific treefrogs were analyzed for chemicals. Adult and larval treefrogs were also measured for cholinesterase activity. Seventeen organic contaminants were found in water, 21 were

found in sediments and 10 were identified in adult frog tissues. The most commonly occurring organics in sediment included endosulfan sulfate, a-HCH, chlorpyrifos and g-chlordane. In water common organics were a- and g-chlordane; endosulfan I, II, and sulfate; g-HCH, chlorpyrifos and malathion. a-Endosulfan, a-chlordane, mirex, trans-nonachlor, trifluralin and various brominated diphenyl ethers were found in amphibians. Of these chemicals a very clear signal was found between the distribution of sediment endosulfan in its various forms and declining amphibian populations. Sample areas that have experienced severe population declines are significantly more likely to have endosulfan detections and have higher concentrations of endosulfan in sediments than those areas were amphibian populations remain comparatively healthy. Combined with recent data on the toxicity of this pesticide to three species of California anurans it appears that endosulfan poses serious risks to amphibians in the Sierra Nevada Mountains.

553 On-going evaluation of risks to amphibian populations in Bermuda. *J. Bacon*, Bermuda Zoological Society, Pembroke West, United Kingdom; D. Fort, Fort Environmental Laboratories, Stillwater, OK. The discovery that environmental contaminants were contributing to the abnormalities and declines in Bermuda's cane toad (*Bufo marinus*) populations prompted the initiation of an environmental risk assessment (ERA). The objectives are to determine the risks the identified contaminants (principally petroleum hydrocarbons and heavy metals) pose to amphibians, other wildlife and potentially human health in Bermuda. Input for the ERA includes results from collaborative laboratory and field investigations into causality, exposure pathways, other stressors (immunotoxicological, uv light exposure and pesticide/fertilizer exposure), sources of contaminants, and larger-scale impacts (population modeling and a human health assessment). A high incidence of external abnormalities in metamorphic and adult cane toads (16%-30% annually island-wide) has been recorded since 2000. Tissue residue analyses revealed elevated levels of petroleum hydrocarbons and metals in both metamorphic and adult toads. A significant maternal effect on larval survival, growth and development was also observed as were abnormal gonads and livers in adult toads. Based on further study, both maternal toxicant transfer to developing tadpoles and environmental exposure during development were identified as exposure pathways. Recent research also showed a contributory effect of uv light exposure on limb malformations induced by contaminated water and sediments. A detailed evaluation of the toxicities of specific pesticides and fertilizers used in Bermuda to cane toads was also performed. Immunotoxicological studies are currently being conducted to determine if the cane toads are immunocompromised and potentially more susceptible to the primary stressors. Historic dumping and vehicles are considered the primary sources of the contaminants of concern. A workshop involving several government ministries will be conducted to discuss the results of the ERA and the implementation of a management plan to address the identified risks.

554 A GIS-Based Risk Assessment of Illicit Crops and their Threats to Amphibian Biodiversity in Colombia. *A.C. Bejarano*, University of South Carolina, Columbia, SC; L. Correa Fajardo, Sistema Integrado de Monitoreo de Cultivos Ilícitos (SIMCI), United Nations Office for Drug Control and Crime Prevention- Government of Colombia, Bogotá D.C., Colombia; M.D. Álvarez, Columbia University, New York, NY. Colombia is one of the most biologically diverse countries in the world. Over the last decade Colombia has become the largest producer of illicit crops, coca for cocaine production and opium poppy, in the Western Hemisphere. The expansion of illicit crops threatens multiple already at-risk ecosystems with habitat fragmentation. The chemicals used to clear the land, process of the crops into illegal drugs, and eradicate coca are also thought to have a negative impact on biodiversity. Amphibians are a particular focus of attention, as declining worldwide numbers, small ranges, and susceptibility to habitat loss and chemical exposure, make them vulnerable to environmental injuries from illicit crops. We used recent geo-referenced distribution data for both illicit crops and Colombian amphibians to estimate the risks arising from the expansion of illicit crops. At least 20 narrowly endemic species are directly threatened by the expansion of these crops in the Chocó—a global biodiversity hotspot and an area with one of the highest species endemism in the world—and Nechí regions. Other important areas for amphibian diversity at high risk from illicit crops include the western slope of the northern East Andes and the Amazonian slopes of the East Andes. The Orinoco-Amazonian ecotone where illicit crops are rapidly expanding has comparatively fewer amphibians, but this might be an artifact of sampling. Illicit crops are not a particular threat in densely populated, recently abandoned agricultural areas of high biodiversity—such as the coffee-

growing regions of the Andes. This first quantitative analysis of relative threats to amphibians suggests specific areas to focus future research and conservation efforts.

555 Interaction of Estrogens with the Solid Components of Wastewater. R. Marfil-Vega, M.T. Suidan, Civil and Environmental Engineering Department, University of Cincinnati, Cincinnati, OH. There is a lack of information about the behavior of EDCs in sludge samples. Better understanding of the chemical interactions between these compounds and the sludge solids can provide insights into innovative ways to eliminate them from the environment. Seven sex hormones (estradiol, ethinylestradiol, estrone, estril testosterone, progesterone, and androstenedione) were spiked into a synthetically prepared wastewater. There, it was found that the sum of the aqueous and solid phase concentrations of the four estrogens did not add up to their theoretical concentration in the influent and that these concentrations decreased over time in the chilled feed. The remaining hormones present in the feed did not exhibit such behavior. We are conducting studies to clarify the mechanism causing the non closure of the mass balance for the four compounds cited above in the absence of biological activity, as well as to identify the causing agent. For these new experiments, ¹⁴C-radiolabeled estradiol is added to the synthetic influent to provide an additional tool in determining what processes are occurring. The two possible causes considered are irreversible adsorption onto the solid components (such as clay and rabbit food) of the feed and/or abiotic reactions that degrade estrogenic compounds over time. The concentration of steroids is measured in the aqueous and solid phases of the synthetic wastewater separately; for this purpose a new solids extraction method is being developed.

556 Estrogenic EDCs in Canadian wastewater treatment plants: occurrence, environmental risks, and removal. M. Fernandez, I. Buchanan, Civil and Environmental Engineering, University of Alberta, Edmonton, Alberta, Canada; M. Ikononou, J. Blair, Contaminant Sciences, Institute of Ocean Sciences, Sidney, British Columbia, Canada. Several estrogenic endocrine disrupting chemicals (eEDCs) including industrial chemicals, natural and synthetic steroidal estrogens, and various naturally occurring phytoestrogens have been identified as priority pollutants with major source inputs being municipal wastewater treatment plant (WWTP) effluents. WWTP point source inputs have been associated with adverse physiological effects including intersex and full sex reversal in fish living down stream. Results from a survey of 30 EDCs and in vitro estrogenic activity in wastewater from five different Canadian WWTPs is presented. The relative risks these effluents pose to fish species are discussed based on observed estrogenic levels and whole organism exposure experiments with Chinook salmon (primary and secondary effluent from one plant only). To gain a better understanding of the behavior and primary removal mechanisms of eEDC during wastewater treatment a detailed mass balance assessment for priority eEDCs and estrogenic activity (via RYA) was performed at a full scale biological nutrient removal (BNR) plant from the original survey. The plant chosen for this investigation was a full scale municipal wastewater treatment plant serving an urban population of 750,000. Two sampling campaigns were performed: (1) an intensive 7-day campaign isolating 4 treatment stages (i.e. primary, secondary, UV disinfection and membrane filtration) followed by (2) a semi-weekly 4-month sampling. The results presented include: (A) determination of unit operation / process eEDC removal efficiency; (B) validation of a mass balance model using rate and partition coefficients from a recently developed sorption / biodegradation model for steroidal estrogens in the bioreactor; (C) correlations between eEDC removal efficiency and WWTP ambient / operational parameters.

557 Prediction of Biotransformation of Estrogenic Hormones in Municipal Wastewater Treatment. H. Monteith, S. Snowling, O. Schraa, H. Andres, Hydromantis, Inc., Hamilton, Ontario, Canada. Constituents in treated municipal wastewater effluents, such as synthetic hormones, pesticides and industrial chemicals in commercial products, can exert endocrine disrupting properties in receiving waters. One group of constituents that has been scrutinized intensively for their endocrine-disrupting potential is synthetic hormones, chiefly the estrogen hormones 17 α -ethinylestradiol and mestranol used in human birth control. Mechanisms for the biotransformation of natural and synthetic estrogenic hormones in secondary wastewater treatment have been postulated in the literature. Biotransformation rate constants have been proposed, but there has been no testing and calibration of these rates with actual plant concentration data. In addition, while the knowledge base of hormone concentrations in treatment plant influents

and effluents is substantial, the ability to evaluate the factors governing the extent of secondary biodegradation of metabolites under different operating conditions could not be attempted due to a lack of adequate modeling tools. This paper will discuss the application of a dynamic model for predicting the fate of hormones during municipal wastewater treatment, with calibrations using published concentration data. Applications of the dynamic model will include: -How would a shorter hydraulic retention time (HRT) affect the primary and ultimate degradation of the hormones? -What effect might a higher solids retention time (SRT) have on the fate of the hormones? -If the dissolved oxygen level in wastewater treatment falls below a critical concentration (e.g., 0.5 mg/L) how will the biodegradation of hormones be affected? -Are there optimizing procedures which can be used to promote the ultimate biodegradation of the hormones? The wastewater treatment simulator will also provide the distribution of effluent concentrations of the hormone metabolites for use in fate models which represent the receiving environment, including water sediments and biota. Keywords: hormones, estrogens, wastewater, model, biotransformation

558 Behavior of endocrine-active compounds through municipal wastewater and sludge treatment. J. Gray, E.T. Furlong, National Water Quality Laboratory, US Geological Survey, Denver, CO; P.J. Phillips, USGS, Troy, NY; K. Esposito, B. Stinson, Metcalf and Eddy, Inc., New York, NY; D.W. Kolpin, USGS, Iowa City, IA. Endocrine-active compounds (EACs) can induce biological effects in fish and other aquatic organisms at environmentally relevant (low nanogram per liter, ng/L) doses. Many EACs, including steroid hormones, detergent metabolites, and other industrial chemicals, are present in domestic wastewater and are removed to varying degrees by biological wastewater-treatment processes. Less attention has been given to the fate of EACs subjected to biosolids treatment. Disposal of biosolids through land-application represents another potential source of EACs to the environment. Liquid and solids samples were collected at selected points of treatment throughout four large municipal wastewater-treatment plants (WWTPs) across the United States to evaluate the efficiency of individual unit operations for EAC removal, and to conduct a mass balance for EACs across solid and liquid treatment processes in these plants. Preliminary data indicate 50–90% removal of many EACs from the liquid phase during biological treatment, and the solids were enriched in EACs relative to the liquid streams. For example, in one plant, 17-beta-estradiol (E2) had 75% removal from the liquid phase. It was observed at 0.9 ng/L in secondary effluent and is commonly observed in treated biosolids, indicating a sorptive loss process. But estrone, an E2 metabolite, was detected at elevated levels (30 ng/L) during intermediate stages of treatment, highlighting the role of biotransformation in the removal of E2. This result indicates that the attenuation of estradiol results from a combination of physical and biological processes, and that removal is not complete from either the solid or liquid phase.

559 Pharmaceuticals and Chloroxylenol in treated wastewater effluent samples from across the United States, 2003-2006. P.J. Phillips, US Geological Survey, Troy, NY; S.G. Smith, Z.D. Steven, E.T. Furlong, US Geological Survey, Lakewood, CO; D.W. Kolpin, US Geological Survey, Iowa City, IA; K. Esposito, Metcalf and Eddy, New York, NY; B. Stinson, Metcalf and Eddy, Laurel, MD. Four opiates (codeine, hydrocodone, methadone, and oxycodone), one barbiturate (butalbital), three muscle relaxants (carisoprodol, metaxalone, and methocarbamol), a tranquilizer (diazepam), an antihistamine (chlorpheniramine), an amphetamine (phendimetrazine), and an anti-microbial (chloroxylenol) were analyzed in filtered effluent samples collected from wastewater treatment plants (WWTP) across the United States. These WWTP serve populations between 10,000 and several million people, and 10 of the sites receive hospital effluent. Treated effluent samples were collected once between 2003 and 2006 at 19 WWTP; 7 of the 12 compounds were detected at 3 or more sites. At least one opiate was detected at 9 of the 19 sites, and opiate concentrations were generally less than 1 μ g/L. Butalbital and methocarbamol were detected in 9 and 10 sites, respectively, with concentrations as high as 0.6 μ g/L for butalbital, and 13 μ g/L for methocarbamol. Diazepam, phendimetrazine, and metaxalone were detected at one site each, and detected concentrations ranged from 0.06 μ g/L (diazepam) to 12 μ g/L (metaxalone). Chloroxylenol was detected at 15 sites, and most concentrations ranged from 0.1 to 1.8 μ g/L. These data were supplemented by multiple effluent samples (20 to 25) collected from two additional WWTP with substantial inputs from PMF (Pharmaceutical manufacturing and formulation) facilities; these samples had much higher detection frequencies and concentrations for most of these pharmaceuticals.

For example, concentrations of hydrocodone, methadone, oxycodone, and butalbital ranged between 3 and 40 µg/L, and concentrations of metaxalone were generally above 500 µg/L for the 20 samples collected from one of these two WWTP; these compounds were detected in over 80 percent of the samples from this site. The median concentration of carisoprodol exceeded 10 µg/L for samples from the second WWTP site receiving discharge from a PMF facility. These data indicate that some facilities receiving PMF discharge can have very high concentrations of drugs in their effluent.

560 Pharmaceutical Transport and Transformation Through Wastewater-treatment Processes. E.T. Furlong, J.L. Gray, National Water Quality Laboratory, US Geological Survey, Denver, CO; P.J. Phillips, New York Water Science Center, US Geological Survey, Troy, NY; K. Esposito, B. Stinson, Metcalfe & Eddy, New York, NY; D.W. Kolpin, Iowa Water Science Center, US Geological Survey, Iowa City, IA. The importance of point-source discharges of treated wastewater as sources of pharmaceuticals and other emerging contaminants has been repeatedly been demonstrated in recent studies. However, the processes controlling the transformation or removal of these compounds from wastewater influent to discharged effluent are only beginning to be understood. In this study, liquid and solid waste samples were collected at important treatment stages through four large municipal wastewater-treatment plants (WWTPs) across the United States utilizing different varying treatment technologies (mesophilic anaerobic digestion, mesophilic aerobic digestion, thermophilic anaerobic digestion, and lime stabilization). The pharmaceutical concentrations of these samples were determined to evaluate the efficiency of each treatment stage for pharmaceutical removal, transfer between liquid and solid phases during treatment, and to determine a pharmaceutical mass balance within the treatment train in these specific WWTPs. Preliminary results suggest that pharmaceutical concentrations in liquid-phase samples decrease substantially after activated sludge treatment, frequently by 90 percent or more. Concentrations of several pharmaceuticals, including diphenhydramine, miconazole, and carbamazepine, were highest in primary unthickened sludge, decreased substantially (by 50 percent or more) in secondary unthickened sludge, and remained relatively constant in subsequent sludge-treatment steps.

562 New Model for Pharmaceuticals: Description and Application to Hamilton Harbour. S.A. Csiszar, N. Gandhi, M. Diamond, Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario, Canada; R. Alexy, Institute of Environmental Medicine and Hospital Epidemiology, Freiburg, Germany; M. Belmont, M. Diamond, Geography, University of Toronto, Toronto, Ontario, Canada; D. Bennie, J. Struger, C. Marvin, National Water Research Institute, Burlington, Ontario, Canada. The lower Great Lakes are receiving waters for treated municipal waste water and agricultural effluent. A growing literature documents the occurrence in these discharges of pharmaceuticals, chemicals in personal care products, and veterinary compounds. Hence, there is considerable interest in the estimating the persistence, fate, and then projecting future concentrations of these compounds in response to changes in loadings. Many of these chemicals are polar in comparison to well-studied POPs such as PCBs. Also, many of these compounds ionize at ambient water pH. We present an adapted fugacity-based model that simultaneously considers neutral and ionic forms of a compound in an aquatic system. We apply the model to Hamilton Harbour for which we estimate the fate of ibuprofen, gemfibrozil, triclosan and naproxen. To address uncertainties in some physical-chemical parameters, we conducted an uncertainty analysis in which we scanned the parameter space of the sorption coefficient for the ionized form and transformation rates in water of ionized and neutral forms in order to optimize the correspondence between measured and modelled water concentrations. We report on this correspondence, as well as the persistence and fate of these 4 compounds.

563 Pharmaceuticals and Personal Care Products (PPCPs), Hormones, and Alkylphenol Ethoxylates (APEs) in the North Shore Channel of the Chicago River. T. Nettekheim, E.W. Murphy, Great Lakes National Program Office, USEPA, Chicago, IL; L. Zintek, Chicago Regional Laboratory, USEPA, Chicago, IL; L.B. Barber, USGS, Boulder, CO; J.M. Lazorchak, A.L. Batt, ORD NERL, USEPA, Cincinnati, OH; M.A. Mills, ORD NRMRL, USEPA, Cincinnati, OH; C.P. Rice, Agricultural Research Service, USDA, Beltsville, MD; H.L. Schoenfuss, St. Cloud State University, St. Cloud, MN; D.T. Lordi, S. Dennison, T. Minarik, Research and Development, Metropolitan Water Reclamation District of Greater Chicago, Cicero, IL. U.S. EPA's Great Lakes National Program Office (GLNPO) developed a study on the North Shore Channel to supplemental a national

study that is determining the occurrence of 39 PPCPs in composited fish fillets and liver samples from five sites (plus one reference site) where waters are dominated by waste water treatment plant (WWTP) effluents. The supplemental study on the North Shore Channel is a collaborative partnership between GLNPO, U.S. EPA Chicago Regional Laboratory (CRL), the U.S. EPA Office of Water, the U.S. EPA Office of Research and Development, USGS, USDA, St. Cloud State, Baylor University, Clarkson University, and the Metropolitan Water Reclamation District of Greater Chicago. The three main objectives of the supplemental study are to: (1) determine if there is reproductive impairment to resident fish; (2) estimate effluent and stream concentrations of PPCPs, APEs, and hormones; and (3) document seasonal differences in concentrations of these compounds in effluent, stream, and fish. Reproductive impairment was assessed by examining fish gonads for evidence of imposex, analyzing male fish blood for vitellogenin (vtg) - an egg yolk precursor protein expressed only in female fish and is normally dormant in male fish, and examining the livers for abnormalities. Whole fish were homogenized and analyzed for APEs, hormones, and over 100 additional PPCPs. Effluent and stream samples were also analyzed for APEs, hormones, and over 100 additional PPCPs. The first effluent, stream, and fish sampling event occurred in September and October 2006. The second effluent, stream, and fish sampling event occurred in March and April 2007. The preliminary results from these 2 sampling events will be presented.

564 Studying the effects of environmental pollutants in birds, a historical primer. W.W. Bowerman, Forestry and Natural Resources, Clemson University, Clemson, SC; K.A. Grasman, Biology, Calvin College, Grand Rapids, MI. Birds have signaled the effects of environmental pollutants to humans for centuries. The term “canary in a coal mine” is often used to indicate one of these historical uses. Post-World War II, with the spread of modern agriculture and the great use of organochlorine pesticides, environmental impacts were observed in a number of avian taxa. Sea eagles (*Haliaeetus spp.*) and peregrine falcons (*Falco peregrinus*) populations experienced great declines in populations. Passerines including the American robin (*Turdus migratorius*) were found to found dead after spraying of elm trees with DDT. Colonial waterbird populations and many raptor populations also experienced great declines in populations. Many of the methods for testing the safety and effects of pesticides and other compounds were developed in the 1960s and 1970s in response to these avian declines. We will work through the history of avian toxicant testing, both in the laboratory and the field. We will end with an overview of how studies in the Great Lakes region have influenced the way we conduct toxicity testing as an introduction to this special symposium.

565 Linking Cause with Effect to Justify Action to Protect the Global Commons. G.A. Fox, Canadian Wildlife Service, Ottawa, Ontario, Canada. In the 1970s and 1980s biologists documented health effects in a variety of wildlife in the Great Lakes and chemists measured numerous residues in the tissues and environments of wildlife. Infinite associations between effects and chemical exposure seemed possible! Some objective methodology was needed to evaluate these putative linkages to protect health and the environment. In the early 1980s I discovered that epidemiologists had wrestled with the same problem and developed a set of criteria for weighing evidence of causality and justifying precautionary actions to protect public health. In 1989, the Council of Great Lakes Managers sponsored the first Cause-Effect Linkages Workshop where scientists applied epidemiological criteria to case studies of fish, wildlife, and humans to clarify our understanding of the many apparent associations observed between chemical contamination of Great Lakes food chains and adverse effects. Subsequent workshops were held in 1991 and 1995. These criteria were first published in 1964 by the Surgeon General's Advisory Committee on Smoking and Health, and in 1965 by Sir Arthur Bradford Hill. Susser added two more criteria in 1986. In 1993, Willes et al. used the criteria to review the evidence for the Chlorine Coordinating Council and the Chlorine Institute and concluded that “if the application of sound scientific principles is to be followed, these criteria must be applied before a causal relationship is inferred between effects and exposures to specific chemicals in the environment”. The criteria are (1) time-order, (2) strength of the association, (3) consistency of the association, (4) coherence of the association, (5) specificity of the association, (6) predictive power of the association, (7) probability, and (8) predictive performance. The criteria do not provide the proof demanded by the experimentalist but form a process and framework upon which one can build a balanced judgment. They provide no guidance in weighing one criterion against another or for judging the strength of the support provided by the evidence. Absolute proof is impossible. As scientists and citizens of planet Earth, our reason and objectivity require that we recognize uncertainty, and bring our experience, wisdom, ethics, respect and humility to bear on the issue in question. We must recognize that, in reality, “proof” is a mixture of scientific, social, and political factors.

566 Lessons learned from GLEMEDS for future Great Lakes management and policy. M. Gilbertson, Nursing and Midwifery, Occupational and Environmental Health Research Group, Stirling, United Kingdom. Application of Hill's guidelines to the outbreaks of Great Lakes embryo mortality, edema and deformities syndrome (GLEMEDS) in avian species lead to causal statements linking the injury to specific dioxin-like activity. These finding inferred water quality conditions that violated the provisions of the Boundary Waters Treaty and the Great Lakes Water Quality Agreement. The novel definitive causal statements contrasted with traditional toxicological statements concerning “potential effects”. They thereby posed threats to management within the various Great Lakes jurisdictions because they implied that costly remedial actions should be undertaken at local, regional, national and international scales, contrary to neo-liberal policy following Milton Friedman's political economic tenets of small government, deregulation and laissez-faire economics. The imperative for remedial action has become more urgent with publication of further epidemiological research on the effects on children of mothers who consumed fish prior to and during pregnancy and of increasing concentrations of new persistent toxic substances

with dioxin-like activity substituted for those substances proscribed by law. Research on GLEMEDS has provided the species and health endpoints that could be incorporated into the Great Lakes Water Quality Agreement as specific indicators of successful policy implementation.

567 Development of TCDD-EQs using colonial waterbird experiments in the Great Lakes. T. Kubiak, U.S. Fish and Wildlife Service, Pleasantville, NJ. Biological and chemical understanding and use of the 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) equivalent approach (TCDD-EQ) for interpreting non-human chemical residues and related biological outcomes originated in Great Lakes colonial waterbird epidemiological investigations. In the early 1980s, actual chemical data were developed by Canadian and US chemists that for the first time documented 2,3,7,8-TCDD and related compounds in wild, colonial species of fish-eating birds from the Great Lakes. The subsequent challenge was to create an interpretive approach to address the cumulative chemical burdens of the three major classes of chemicals, the polychlorinated- dibenzo-*p*-dioxins, dibenzofurans and biphenyls, that all have dioxin-like congeners, based on the prototypical congener, 2,3,7,8-TCDD. This presentation will provide an overview of what was discovered and how this approach, with its own evolutionary modification over time, has become a common tool for the interpretation of dioxin-like residues in biological samples. Examples will be provided of prospective and retrospective use of colonial waterbird egg residues that helped to explain known biological consequences of these exposures. This twenty-five year old discovery is now widely used for other bird, mammalian and fish species. Scientific understanding of how these chemicals move in aquatic ecosystems now allows sediment target concentrations for remediation and restoration projects to be estimated as well as retrospective assessment of historical exposures and likely past effects, which went unstudied or were not fully interpreted during prior studies.

568 Caspian tern and cormorant population dynamics and the evidence for sink/source: associations with TCDD-EQ embryo and post-hatch exposures. W.W. Bowerman, Forestry and Natural Resources, Clemson University, Clemson, SC; J.P. Ludwig, Ecological Restoration Research and Consulting, Ltd., Port Williams, Nova Scotia, Canada. Caspian tern and cormorant chicks have been banded in Lakes Huron, Michigan and Superior for 37 and 19 years respectively. Of the nearly 50,000 chicks of each species banded, approximately 2,000 band recoveries or encounters through adult trapping programs has occurred. Previous work showed that terns raised in the most contaminated colonies of Saginaw and Green Bays were far less likely to survive to become breeding adults and lived much shorter lives than those raised in the least contaminated Canadian Lake Huron colonies. By 1990-92, 73% of all terns in the whole population had been raised in the clean Canadian colonies. In the 1986-1992 period, 96% of terns nesting in Canada were raised in clean Canadian colonies, but only 44% of those nesting in Green Bay were raised there and less than 20% of those nesting in Saginaw Bay were raised there. Because fledging rates were actually greater from the contaminated sites, the data suggest these contaminated areas affected tern breeding competence and survival to breeding age. Cormorants raised in Green Bay were about half as likely to enter the population as breeding adults compared to those raised in Lake Superior, the North Channel and Georgian Bay of Lake Huron. Intermediately contaminated birds from central Lake Michigan and the Alpena region returned at intermediate rates. Those with higher TCDD-EQ in eggs, rates of TCDD-EQ uptake by chicks in nests and depressed circulating vitamin A resulted in poor recruitment, and lower life spans. Differentially contaminated geographic areas of the Great Lakes pose very different reproductive risks for birds that nest in these areas. Two of the most productive sub-ecosystems of the upper Great Lakes in this period of study were Green Bay and Saginaw Bay with much higher densities of forage fish biomass. However, these highly-contaminated areas have functioned as “sinks” that attract birds to quality nesting habitat and available food. Gross fledging rates are misleading, because fitness is not related to fledging. In essence, contamination appears to be the driver of avian population dynamics on the Great Lakes, similar to the lake trout, with contaminated areas functioning as population “black holes”. Individuals are sucked into these areas to nest, but fail to produce reproductively-competent offspring.

569 Contaminants in Herring Gulls, a flagship biomonitoring program of the Great Lakes Basin, 1974-2007. C. Weseloh, Canadian Wildlife Service-Ontario Region, Toronto, Ontario, Canada; C. Pekarik, Canadian Wildlife Service-Ontario Region, Ottawa, Ontario, Canada. The Herring Gull, *Larus argentatus*, was selected as the main indicator species

of contaminant levels and their effects in wildlife in the Great Lakes by the Canadian Wildlife Service in 1974, after 3-4 years of preliminary study. Its main features were that it commonly occurred in all 5 Great Lakes, was a top aquatic food web predator and, as an adult, was non-migratory; thus insuring that its contaminants were of Great Lakes origin. Egg contaminants data, collected annually from 15 sites, have shown temporal declines of over 90% for most legacy contaminants and have been used to spatially rank the sites from greatest to least contaminated. The program has pioneered the use of a long-term tissue bank for retrospective analyses of new contaminants, the comparative use of individual and pooled analyses, and the assessment of various toxicological endpoints in embryonic, juvenile and adult Herring Gulls.

570 Michigan Herring Gull Biosentinel Program of Great Lakes Breeding Areas. Persistent Organic Contaminants in Eggs Between 2002 to 2006. K.G. Drouillard, E. Bennett, D. Haffner, GLIER, University of Windsor, Windsor, Ontario, Canada; W.W. Bowerman, Forestry and Natural Resources, Clemson University, Clemson, SC; J.G. Sikarskie, College of Veterinary Medicine, Michigan State University, East Lansing, MI; T.A. Allan, J. Garvon, W. Scharff, Biology, Lake Superior State University, Sault Ste. Marie, MI; M. Romanski, Isle Royale National Park, Houghton, MI; J.A. Perlinger, and Environmental Engineering, Michigan Technological University, Houghton, MI. Between 2002 and 2006 the Michigan Department of Environmental Quality implemented a herring gull egg biomonitoring program. Egg collections (n=10-15 eggs) were performed at 10 colonies distributed between Lakes Superior (3 colonies), St. Mary's River (2 colonies), Lake Michigan (2 colonies), Lake Huron (2 colonies) and Lake Erie (1 colony). Eggs were analyzed for PCBs, co-planar PCBs, organochlorine pesticides, dioxins and furans and total Hg. Chemical analyses were performed using pooled eggs, however, in each year 2 colonies had individual eggs examined to establish egg to egg variation. Sum PCBs and sum DDT's ranged from 0.66 to 20.4 and 0.24 to 3.2 µg/g wet weight, respectively among samples analyzed. Spatial patterns for PCBs across the lakes showed the general pattern of Lake Superior < St. Mary's River = Lake Michigan = Lake Huron < Lake Erie. Lake Erie showed between 2 to 3 fold higher contamination for PCBs and co-planer PCBs than other Great Lakes colonies. No temporal patterns were evident among individual colonies for the various contaminants examined. Contaminant trends and risk assessments based on TEQs generated for each colony are presented and examined.

571 Bald eagles as indicators of ecosystem health in the Great Lakes. W.W. Bowerman, Forestry and Natural Resources, Clemson University, Clemson, SC. The bald eagle (*Haliaeetus leucocephalus*) is the largest tertiary avian predator of the Great Lakes Basin. It has been impacted by both anthropogenic and natural stressors. Post-World War II, the use of DDT and other organochlorine compounds caused reproductive problems leading to extirpation of bald eagles from most of the Great Lakes shorelines and islands. Since the banning of many of these compounds in the early 1970s in both the U.S. and Canada, the eagles have experienced an incredible growth and now occupy nests along the shores of all five Great Lakes and most of the connecting channels. Because of the large size of eagles, they provide researchers large tissue samples for analyses. Blood, feathers, organs, and unhatched eggs have been used to determine effect levels for many environmental toxicants. They have been used as indicators of ecosystem health by many state, provincial and federal agencies. This talk will illustrate how eagles are utilized as biosentinels of Great Lakes water quality.

572 Aquatic toxicity and biological oxygen demand of aircraft and airfield deicing and anti-icing formulations. S. Geis, A. Mager, Wisconsin State Laboratory of Hygiene, Madison, WI; C. Huset, P. Ferguson, University of South Carolina, Columbia, SC; S. Corsi, U.S. Geological Survey, Madison, WI. Manufacturers of aircraft and runway deicing and anti-icing formulations have the formidable responsibility of providing products that ensure the safety of winter airport operations. Recently this responsibility has expanded to include minimizing the environmental impact of these formulations due to toxicity and oxygen demand. In this study, 19 formulations were evaluated for their toxicity and biological oxygen demand to freshwater and marine environments. Eight of these formulations were analytically characterized using a toxicity identification evaluation (TIE) approach. The outcome of this research will be used to propose alternative formulations with reduced toxicity and biological oxygen demand.

573 Characterization of toxic components in aircraft deicer fluids. C.A. Huset, K.C. Hyland, L. Ferguson, Chemistry and Biochemistry, University of South Carolina, Columbia, SC; A. Mager, S. Geis, Environmental Toxicology, Wisconsin State Laboratory of Hygiene, Madison, WI. Aircraft deicer and anti-icer formulations (ADAFs) are complex mixtures containing freezing point depressants, corrosion inhibitors, surfactants, dyes, thickeners and anti-foaming agents. Large volumes of ADAFs are used in commercial aviation to remove and prevent ice on aircraft. In previous studies, ADAF toxicity was attributed to benzotriazole corrosion inhibitors and alkylphenol ethoxylate surfactants. However, the bulk of the ADAF toxicity remains unaccounted for. We have performed a toxicity identification and evaluation (TIE) study in order to identify chemical components of the deicers that are responsible for inducing toxicity. Our approach incorporates chemical separation methods to separate ADAF mixtures into discrete fractions which are then evaluated on a three-tier toxicity screening scheme. Separation schemes for the ADAFs utilized preparative reversed phase chromatographic separation preceded by either gel permeation chromatography or vacuum distillation. Screening for acute toxicity was performed on each fraction by Microtox, Pimephales promelas and Ceriodaphnia dubia assays. Identification of ADAF components in toxic fractions was performed using chromatographic (HPLC) and mass spectrometric (electrospray Q-TOF and MALDI-TOF MS) techniques. Quantitation and verification of component identity in toxic fractions was carried out through comparisons to authentic standards where available, and by tandem mass spectrometry and accurate mass measurement. Toxic components identified were primarily ethoxylated surfactants, including octylphenol polyethoxylates, nonylphenol polyethoxylates, lauryl alcohol polyethoxylates and myristic alcohol polyethoxylates.

574 Low Level Effects of 5-Methyl-1H-Benzotriazole on Rainbow Trout (Oncorhynchus Mykiss). D. Cancilla, E.E. Moreland, K. McNeil, Western Washington University, Bellingham, WA. Studies by groups in both North America and Europe have found triazoles to be present in a wide variety of terrestrial and aquatic ecosystems. With improving analytical methodologies, triazole levels ranging from ppm to low ppb have been detected in many of these systems. However, except in a few cases, levels detected in the environment are generally below the levels found to be acutely toxic to a variety of test organisms. Although triazoles have been shown to have the potential to bioaccumulate, little is known about the environmental fate and effects related to the presence of low levels of triazoles in the environment. The research presented in this paper describes the effects of 28 day exposure study of 5-methyl-1H-benzotriazole (5-MeBT) at levels typically found in the environment (0.1-4.0 mg/L) on juvenile rainbow trout (Oncorhynchus mykiss). Survival and behavior were monitored throughout the test and fish were evaluated for condition factor, hepatosomatic index, histological analysis, and circulating plasma cortisol levels. Fish in the 4.0 mg/L treatment were consistently slow in feeding response, consumed less food, had significantly lower condition factors, occupied the lowest level of the test chamber, and were less responsive to changes in dissolved oxygen levels than fish in controls and lower concentrations of 5-MeBT. Suggestion of suppressed circulating plasma cortisol levels indicates that the hypothalamic-pituitary-adrenal axis may also be affected.

575 Fate of the alkylphenol ethoxylate components of ADAF in airport runoff. J.E. Loyo-Rosales, Civil and Environmental Engineering, University of California, Berkeley, CA; S.R. Corsi, U.S. Geological Survey, Middleton, WI; G.R. Harwell, U.S. Geological Survey, Fort Worth, TX; A. Torrents, University of Maryland, College Park, MD; C.P. Rice, U.S. Department of Agriculture, Beltsville, MD. The toxicity of aircraft deicing and anti-icing fluids (ADAF) is not due to their main components, but to additives such as alkylphenol ethoxylates (APEOs). This study addressed the fate of the APEOs in outfalls and receiving waters from General Mitchell (GMIA) and Dallas-Fort Worth (DFW) International Airports. Flow-weighted composite runoff samples were collected during ADAF application events from 2003 to 2006 for GMIA, and 2003 and 2004 for DFW. Samples were taken in sites upstream from the airports, airport outfalls and sites downstream to assess impact in receiving waters. At GMIA, the primary outfall combines flow from the upstream site with flow from storm sewers in the terminal and runways; whereas the secondary outfall serves the air-cargo section. The primary outfall contains higher concentrations of nonylphenolic compounds (NPE), whereas octylphenolic compounds (OPE) are more abundant in the secondary outfall because of the use of different ADAF formulations in the cargo and passenger

areas. In general, NPE concentrations are higher than OPE's, reflecting the contents of the ADAF formulations used, and the lack of OP6-16EO data. Although NPE and OPE concentrations in the outfalls were high, dilution reduced concentrations in receiving waters up to two orders of magnitude to levels similar to the upstream site. Ratios of total NPE concentrations in receiving waters versus the upstream site were between 0.2 and 1.5, implying that NPE concentrations were lower or only 50% higher in the receiving waters, even though the actual mass loadings were much higher in the receiving stream. In contrast, ratios for the OPEs were higher than ratios for the NPEs in all instances, and most of them were above 1.5; suggesting a more rapid elimination of the NPEs. Although the actual mechanism is not clear, previous observations support elimination by sorption to solids, which would be favored for the NPEs because of their higher Kow values. Additionally, decrease of the APEO/APEC concentration ratios from outfalls to receiving waters in all sampling events suggests that biotransformation is possible in spite of the relatively low temperatures.

576 Nonylphenolethoxylates and their metabolites in sediments proximate to major New York City airports. B.J. Brownawell, X. Li, H. Yin, Marine Sciences Research Center, Stony Brook University, Stony Brook, NY; L. Ferguson, Department of Chemistry and Biochemistry, University of South Carolina, Columbia, SC. Nonylphenol ethoxylate surfactants (NPEOs) have been common ingredients in de-icing fluids used at airports and there are concerns about introduction of NPEOs and other deicing fluid ingredients into surface waters from airport run-off. In published and unpublished work, we have measured some of the highest NPEO sediment concentrations ever reported in organically enriched sediments sampled in estuarine embayments proximate to John F. Kennedy (Jamaica Bay) and LaGuardia (Bowery Bay and Flushing Bay) airports. Concentrations of total NPEOs are as high as 60 ppm in depositional sediments of Grassy Bay, adjacent to landing strips at JFK Airport, but also receives treated sewage input from a large sewage treatment plants (STP) as well as other STPs and combined sewers overflows (CSOs) that discharge into Jamaica Bay. Concentrations of NPEOs are even higher (over 90 ppm in one sediment sample) in Bowery Bay, which has also receives effluent from a major STP, but concentrations decrease with distance away from a large CSO, located at the southwest corner of the Bay. Flushing Bay sediment NPEO concentrations are typically between 1 and 6 ppm, where sewage inputs come from several CSOs. Several lines of evidence suggest that these relatively high concentrations do not come from direct run-off from the airports, including: 1) the composition and concentrations of NPEOs and their metabolites with depth in two dated sediment cores from Grassy Bay are very well described from the history of NPEO use and the known history of upgrades in the nearby STP; 2) the spatial variations in NPEO concentrations in Bowery and Flushing Bays are well described by proximity to sewage sources and do not increase in several samples proximate to the largest storm water outfalls at LaGuardia; and 3) the concentrations of the most particle reactive NPEOs correlates with the persistent and particle-reactive sewage tracers ditallowdimethylammonium chlorides. Additional information would be needed to determine whether some of the NPEOs in these sediments comes from airport run-off that is diverted to nearby STPs or CSOs.

577 Occurrence of highly-substituted ethoxy-carboxylates in runoff waters near an aircraft deicing facility. C.P. Rice, N. Lozano, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, MD; J. Loyo-Rosales, Civil and Environmental Engineering, University of California, Berkeley, CA; A. Torrents, Civil and Environmental Engineering, University of Maryland, College Park, MD; S. Corsi, Water Resources Division, U.S. Geological Survey, Middleton, WI. Reports documenting the occurrence of the metabolites of alkylphenol ethoxylates (APEs) are common; however, few data show the occurrence of the oxidative metabolite of the APEs, the carboxylates, and especially those with substitution greater than the 5 ethoxymers. An important reason for this has been the lack of appropriate standards; however a Japanese chemical company is now offering a standard carboxylate mix that contains from 1 to 10 ethoxymers. We are now examining polar extracts for the carboxylates in archived runoff samples from the General Mitchell International Airport that have been previously studied for alkylphenol ethoxylate. Airport runoff containing APEs is unique because the surfactants are released directly to receiving waters without treatment unlike effluent from wastewater treatment facilities, a primary source of APEs to the environment. This typically results in a larger distribution of ethoxymers in airport runoff than in wastewater treatment effluent. Initial data from airport runoff suggests that samples found to have higher levels of 6 to 13-substituted

NP ethoxylates can also contain higher levels of highly-substituted ethoxy carboxylates up to the 9 ethoxymers. By characterizing these more highly-substituted carboxylates in these samples it will be possible to better account for the importance of biotransformation processes in the removal of the NP-ethoxylate mixtures.

578 Aircraft and pavement deicer and anti-icer forensics: Which formulations reach the receiving water and what is their potential impact. S.R. Corsi, Water Resources Discipline, US Geological Survey, Middleton, WI; S.W. Geis, Wisconsin State Laboratory of Hygiene, Madison, WI; J. Loyo-Rosales, University of California, Berkeley, CA; C.P. Rice, U.S. Department of Agriculture, Beltsville, MD. To characterize the effects from runoff of aircraft deicer and anti-icer fluid (ADAF) and pavement deicer formulations (PDF) on receiving water, multiple deicing and anti-icing formulations must be considered. ADAF formulations used on aircraft include Type I fluids (deicers) and Type IV fluids (anti-icers), both of which use a form of glycol as the freezing point depressant mixed with additives to enhance performance. Additives vary among manufacturers and formulations with their compositions held as trade secrets. These additives are responsible for potential toxicity and endocrine disrupting effects of ADAF formulations. Pavement deicers include primarily formate- and acetate-based salts as the freezing point depressants. In addition to these products, the effects of ADAF and PDF can be confounded by the presence of parking lot and roadway deicers such as road salt applied on airport parking lots and by municipalities in the surrounding urban areas. Nine ADAF formulations and two PDF formulations were tested for toxicity using Microtox, *Pimephales promelas*, *Ceriodaphnia dubia*, and *Selenastrum capricornutum*. Results indicate that toxicity among formulations is widely variable. Type IV ADAF is most toxic followed by PDF and then by Type I ADAF. A portion of ADAF toxicity can be explained by the known additives (alkylphenol ethoxylates and tolyltriazoles) and glycols, but much of the toxicity is due to unidentified additives; whereas, PDF toxicity is primarily due to acetate- and formate-based freezing point depressants. Results of toxicity and chemistry analysis of airport runoff samples from General Mitchell International Airport and Dallas/Fort Worth International Airport are compared to toxicity and chemistry of ADAF, PDF, and road salt to identify which products are present and the likely cause of toxicity. Type I, Type IV, and PDF formulations all influence samples with the dominant formulations changing depending on sampling site, climatic conditions, and runoff conditions. Road salt also plays a significant role, effectively dominating the toxic signal observed in some samples.

580 Limiting total dissolved solids (TDS) to protect aquatic life. J.D. Kern, R. Bodkin, P.W. McClellan, MapTech, Inc., Blacksburg, VA. The intent of this presentation is to review the current state of research regarding the impacts of total dissolved solids (TDS) on the aquatic community and to summarize state efforts to address the issue in terms of water quality standards and total maximum daily load (TMDL) development. TDS can impact benthic organisms not only through the impact of specific ion toxicity, but also through causing chronic stress to benthic macroinvertebrates by requiring excess expenditures of energy when regulating water and ions. This leads to reduced growth, reproduction, and ultimately the ability to compete for resources. These impacts can cause shifts in community composition from less tolerant to more tolerant organisms, which results in biological impairments. The correlation between mayflies and conductivity in a Kentucky study provides the most compelling evidence of the negative impact that TDS can have on sensitive benthic macroinvertebrates at concentrations much lower than predicted by conventional toxicity testing. Other chronic or sublethal impacts from TDS have not been fully researched, but negative impacts at other macroinvertebrate life stages are likely to exist. Because of the mounting evidence that TDS impacts in the field are greater than the impacts predicted by laboratory tests, state regulatory agencies are developing water quality standards for TDS that will be protective of benthic macroinvertebrate community health independent of the standard laboratory toxicity testing procedures. Questions still exist as to the level of TDS that is protective of aquatic communities, and the answer may vary among ecosystems, but it is becoming increasingly evident that standard laboratory toxicity testing procedures alone are not adequate for setting water quality criteria that are protective. Analysis of field data to support TMDL development supports this assertion. Additional field testing of a variety of organisms at varying life stages, under a range of conditions of toxicity, temperature, and duration is necessary to fully resolve this question.

581 A multi-tiered approach to E.coli assessments at Door County, WI beaches and the utilization of these assessments in sustainable beach redesign options. G. Kleinheinz, Biology and Microbiology, University of Wisconsin - Oshkosh, Oshkosh, WI; P. Pittner, S. Jorgenson, Miller Engineers & Scientists, Sheboygan, WI. Over the past decade there has been a tremendous amount of research conducted on E.coli and Enterococci and recreational waters. As the utilization of water resources increases, an understanding of the biological contaminants that may pose a risk to public health is critical in order to protect the public utilizing local water resources. This presentation will focus on a multi-tiered approach to beach monitoring and E.coli source-identification in Door County, WI (USA). Door County, WI (USA) has hundreds of miles of Lake Michigan shoreline, dozens of public beaches and is a major component in Wisconsin's \$12 billion dollar per year tourism industry. The research to be discussed includes eleven separate locations and will include traditional beach monitoring data, studies on the impact of rain on E.coli concentrations, E.coli concentrations in beach sand, rep PCR for E.coli microbial source identification, avian waste surveys, and spatial sampling techniques. The use of all this data was then used to develop conceptual redesign plans for eleven beaches. The redesign concepts for these eleven beaches will be presented, along with rationale for the redesign plans, and the challenges faced in permitting and implementing these plans. The ultimate goal of these plans was to redesign the beaches utilizing existing data to maximize E.coli reduction and make each location a more healthy beach for its users. Beach redesign and conceptual plans are based upon sustainable practices for E.coli reduction, and in most cases apply readily adopted and very cost-effective options for beach improvement.

582 Microbial community analysis of public and natural beaches on Lake Michigan: The link between diversity and healthy beaches. S.L. McLellan, J. Van de Walde, Great Lakes WATER Institute, University of Wisconsin-Milwaukee, Milwaukee, WI; E.W. Alm, Biology, Central Michigan University, Mt. Pleasant, MI. Great Lakes Beaches are subjected to numerous anthropogenic impacts. Altered coastal habitats, invasive species, and urban stormwater pollution all can negatively influence the natural microbial community present in beach sand. A growing body of evidence suggests that *Escherichia coli* (E. coli) detected in beach water originates from shoreline sources, including reservoirs in the sand. Potential sources of these reservoirs include fecal pollution from roosting gulls, stormwater runoff, and sewage. Experiments in field plots demonstrate that an E. coli inoculum can increase to 30-100 fold higher densities in autoclaved sand compared with untreated sand, suggesting that the native microbial community might be important for excluding non-indigenous bacteria. We examined public beaches and natural beaches (e.g. undeveloped and low use) to evaluate the presence of E. coli reservoirs and the status of the natural community. Water samples from two of the beaches demonstrated large differences in the taxa present. Samples with evidence of fecal pollution were found to have organisms from the phylum Firmicutes (order Clostridia) and Bacteroidetes (order Bacteroidales). Submerged, foreshore, and backshore sand were found to have increasing diversity and richness moving from the water to dry sand. Comparison of Michigan and Wisconsin beaches demonstrated that foreshore and backshore sands were remarkably similar in microbial community composition, suggesting that specific assemblages are associated with the unique habitat of beach sand. Fecal indicator markers were detected using both culture based and PCR based methods at two public beaches, and levels as high as 35,000 CFU E. coli/ 100 g dry sand were detected at one public beach. Microbial community composition and the presence fecal indicator reservoirs are compared.

583 Population structure of E. coli and association of pathogenic enteric bacteria in green alga *Cladophora* in Lake Michigan. M. Byappanahalli, R. Whitman, D. Shively, United States Geological Survey, Porter, IN; Ishii, J. Ferguson, M. Sadowsky, Department of Soil, Water, and Climate, University Minnesota, St. Paul, MN. The macrophytic green alga, *Cladophora*, harbors high densities of fecal indicator bacteria, E. coli and enterococci, in shoreline waters of Lake Michigan. The main objective of this study was to determine the population structure and genetic relatedness of *Cladophora*-borne E. coli and to determine the potential enteric bacterial pathogens associated with *Cladophora*. A total of 879 E. coli isolates were collected from *Cladophora* tufts (mats) growing on rocks from a breakwater located within the Indiana Dunes National Lakeshore in northwest Indiana. The horizontal, fluorophore-enhanced rep-PCR (HFERP) DNA fingerprinting technique was used to determine the genetic relatedness of the

isolates to each other and to those in a library of E. coli DNA fingerprints. While the E. coli isolates from *Cladophora* showed a high degree of genetic relatedness ($\geq 92\%$ similarity) in most cases, the isolates were genetically distinct. Both spatial and temporal influences contributed to the genetic diversity. Isolates collected from 2002 were distinctly different from those obtained in 2003. *Cladophora*-borne E. coli isolates represented a unique group, distinct from other E. coli isolates in the DNA fingerprint library tested. In *Cladophora* mats, bacterial pathogens, such as shiga toxin-producing E. coli and *Shigella*, were rather sporadic compared to *Salmonella* and *Campylobacter*. Further, genotypically-identical *Salmonella* isolates were associated with geographically and temporally-distinct *Cladophora* algae. In contrast, *Campylobacter* isolates were genetically diverse. These results suggest that E. coli strains associated with *Cladophora* may be a recurring source of indicator bacteria to the nearshore beach and *Cladophora* is a likely secondary habitat for pathogenic bacteria in Lake Michigan. The association of these bacteria with *Cladophora* warrants additional studies to assess potential health impacts to beach users.

584 Linking Stream and Beach Water Quality: Case Studies on Lakes Michigan and Ontario. R. Whitman, M.B. Nevers, US Geological Survey, Porter, IN; K.B. Terbush, K. Strassner, New York State Parks, Recreation, and Historic Preservation, Albany, NY. Many beaches nationwide are impacted by bacterial contamination from creeks that empty directly into their swimming areas. Indicator bacteria can accrue along the watershed, eventually flushing into beach waters. Dunes Creek and Sterling Creek directly impact the beaches of Indiana Dunes State Park on Lake Michigan and Fair Haven State Park on Lake Ontario. Beach closures due to bacterial contamination have been directly linked to these creeks, and numerous efforts have been undertaken to reduce bacterial contamination and improve monitoring accuracy. In this analysis, historical data are examined to determine the range of impact of these creeks on downstream recreational beaches. Bacteria counts from the beach, stream, and upstream sources are analyzed to characterize the movement and concentration of bacteria through these watersheds. Past efforts to develop predictive models are also explored, and the usefulness of such models at these locations is assessed. Typically, indicator bacteria counts at the beach are most influenced by the direction and strength of the emanating creek plume. Depending on wind direction and current activity, beaches on the east or west experience elevated bacteria counts. The ability to apply predictive models at these beaches is determined by availability of appropriate hydrometeorological measurements, including wind, current, and flow data. High concentrations of indicator bacteria are often associated with increased rainfall, but the interaction of precipitation with local hydrological and microbiological factors are also important. We compare and contrast these stream-beach systems in order to discover implications for management, remediation, and protection of recreational water quality.

585 Predictive Modeling of Light-Induced Mortality of *Enterococci faecalis* in Recreational Waters. R.G. Zepp, M. Cyterski, M. Molina, NERL/ERD, US EPA, Athens, GA; R. Jones, J. Willis, NERL/ERD, SSA, US EPA, Athens, GA. One approach to predictive modeling of biological contamination of recreational waters involves the application of process-based models that consider microbial sources, hydrodynamic transport, and microbial fate. This presentation focuses on one important fate process, light-induced mortality. Fecal indicator bacteria such as enterococci have been used to assess possible contamination of beaches and other recreational waters. Past studies have indicated that sunlight plays an important role in reducing concentrations of culturable enterococci and other indicator microorganisms in beach environments. Here we report studies of the light-induced mortality of one species of enterococci, *Enterococci faecalis*, under various conditions in Nanopure and natural waters. Mortality rates of *E. faecalis* were determined in a series of simulated solar irradiations of bacterial enrichments. The applied radiation was passed through sharp-cutoff light filters that blocked different parts of the ultraviolet and visible spectral region. The mortality rates and spectral irradiance were analyzed by the Rundel technique to develop biological weighting functions (BWFs) for the light-induced mortality (R.D. Rundel. 1983. Action spectra and estimation of biologically effective UV radiation. *Physiol. Plant.* 58:360-366). The BWFs were combined with underwater solar irradiance data to model the light-induced mortality of *E. faecalis* in selected recreational waters as a function of depth, underwater light attenuation, time-of-day, season, stratospheric ozone thickness and other environmental factors. Results of the experimental and modeling studies indicate that full exposure to solar radiation in all waters resulted in

rapid mortality of *E. faecalis* with half-lives of a few minutes. The ultraviolet component of sunlight is most important in inducing mortality, although visible radiation also is involved. However, microorganisms generally are not fully exposed to sunlight in aquatic environments, and these studies indicate that variations in underwater light attenuation caused by water constituents such as colored dissolved organic matter and total suspended matter play a key role in controlling light-induced mortality of enterococci. (Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy)

586 Bacterial mortality due to solar radiation, comparing experimental and statistical evidence. W. Frick, Ecosystems Research Div., U.S. EPA, Athens, GA; Z. Ge, Ecosystems Research Div., National Research Council, Athens, GA. Many researchers report that sunlight is a primary stressor of beach indicator bacteria. Some water quality models include code that quantifies the effect of radiation on bacterial decay. For example, the EPA Visual Plumes model includes two coliform and one enterococcus submodels, including the Mancini (1978) coliform model that expresses bacterial mortality as functions of solar radiation, salinity, and temperature. The Environmental Protection Agency (EPA) has developed and tested a program called Virtual Beach (VB), public-domain software. Among other functions, VB facilitates the development of site-specific multi-variable linear regression (MLR) models. Studies, including those using VB, show that MLR models can produce good estimates, both nowcasts and forecasts, using real-time and forecasted explanatory variables, such as turbidity, cloud cover, wind, and rainfall. In this study we investigate the role solar radiation plays in determining bacterial decay. Based on data published by the U.S. Geological Survey for Huntington Beach (Lake Erie) and other sources, including solar radiation data measured by the Ohio State University's Ohio Agricultural Research and Development Center (OARDC) at their nearby Avon site, we used VB to examine the role of radiation on bacterial decay. This work helps to contrast the influence of solar radiation to other factors affecting the fate of bacteria in beach water. Disclaimer: Although this work was reviewed by EPA and approved for presentation, it may not necessarily reflect official Agency policy.

587 The New Digital Watershed/Great Lakes Beach Management System. J.F. Bartholic, Institute of Water Research, Michigan State University, East Lansing, MI. Digital Watershed is a component of the Midwest Spatial Decision Support System Partnership supported in part by EPA Region 5. Interest has been expressed in using and expanding the Digital Watershed system to support Great Lakes beach management purposes and the Beaches Environmental Assessment, Closure, and Health Act (BEACH). This expansion of Digital Watershed would include Web-accessible mapping of Great Lakes beaches and providing access to their recent closing/advisory history and viewing sources of potential contamination, e.g., POTWs. This expansion is clearly feasible and would provide a useful application in Great Lakes beach management based on early discussions of the concept. The new Digital Watershed/Great Lakes Beach Management System will be discussed at the SETAC meeting with the purpose of securing input and partnerships. Digital Watershed system provides a user-friendly mapping system that integrates 8-digit watersheds with the EPA BASINS database for the conterminous United States. This comprehensive database contains all EPA regulated facilities, river networks, DEMs, state soils, and other data layers. The scalability of the system supports delivery of this data to users for watersheds at different spatial scales. Three access methods are provided to view specific 8-digit watersheds. One, address-based entry allows users to locate watersheds with a street address; two, users can select a watershed by clicking on a map location; and three, search entry allows for entering either a watershed name or US Geological Survey hydrologic unit code (HUC) code. Users can zoom, pan, and use other interactive features. A visualization function allows users to generate a 3-D view of any 8-digit watershed. Digital Watershed interoperability features provide seamless connection (a single click) to the Terra server to obtain aerial imagery as well as to Google Earth and Google Maps. Through the use of Web services, DW users can also be connected with Purdue University's Online L-THIA modeling system. The interoperability and extensibility of the DW system allows for adding new data layers and new models over time in response to user needs.

588 A real time system for prediction of nearshore circulation and pathogen transport at Great Lakes beaches. D.J. Schwab, G. Lang, NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI; D. Beletsky, UNIVERSITY OF MICHIGAN, ANN ARBOR, MI. A nested grid

hydrodynamic circulation model with horizontal resolution of 100 m has been developed for several locations around southern Lake MICHIGAN. The model is driven by boundary conditions generated from an operational whole lake model of Lake Michigan with 2 km horizontal resolution. Both models are run in real time using wind fields derived from surface weather stations in and around the lake. The domains of the high resolution nested models generally include one or more tributary inflows. The flow rate from the tributary is set based on real time USGS stream flow reports. The model is fully three dimensional, but for visualization purposes a two dimensional advection model is used to simulate the dispersion of the tributary plume. Time series of tributary water concentration at beaches near the tributaries are presented as potential indicators local water quality. The model is updated four times a day and graphical results are available on the World Wide Web.

589 Experts Scientific Workshop on Critical Research and Science Needs for the Development of Recreational Water Quality Criteria. J.E. Ravenscroft, Office of Water, Office of Science and Technology, US Environmental Protection Agency, Washington, DC. An important goal of the Clean Water Act (CWA) is to protect and restore waters for swimming. Under Section 304(a)(9) of the CWA, the Environmental Protection Agency (EPA) is required to publish water quality criteria for pathogens and pathogen indicators to protect swimmers from illnesses associated with pathogenic microbes in coastal and Great Lakes water bodies. EPA has been conducting research and analyzing information with intention developing new or revised water quality criteria that are scientifically sound, protective of the designated use, implementable for broad CWA purposes, in order to provide for improved public health protection. As part of the ongoing technical review process, EPA convened an expert workshop, modeled after the SETAC Pellston workshop format, to obtain individual input from members of the broad scientific and technical community on the "critical path" research and science needs for developing scientifically defensible new or revised recreational water quality criteria. Forty-three U.S. and international experts from academia, numerous states, public interest groups, EPA, and other federal agencies, met to discuss the state of the science on recreational water quality research and implementation issues. Experts were assigned to one of seven workgroups to discuss the following seven topics essential for EPA's development of new or revised criteria: (1) approaches to criteria development; (2) pathogens, pathogen indicators, and indicators of fecal contamination; (3) methods development, (4) comparing risks (to humans) from different sources; (5) "acceptable risk"; (6) modeling applications for criteria development and implementation; and (7) implementation realities. The report of the workshop proceedings dedicates a chapter to each of these seven topics. Overall, four critical path research areas were identified as high priority: (1) human health impacts from different sources of fecal contamination, (2) measurement issues for different climatic and geographic regions, (3) determining risk level and subpopulations of concern, and (4) indicators and methods for measuring fecal contamination. EPA intends to utilize this input as it develops a critical path science plan that will help guide Agency research activities over the next 2 to 3 years in support of the development of new or revised recreational water quality criteria.

590 Development of a Multi-Residue Analytical Method for the Determination of Pharmaceuticals by LC-Quadrupole-Linear Ion Trap Tandem Mass Spectrometry. D. Barcelo, M. Petrovic, M. Gros, IIQAB-CSIC, Barcelona, Spain. Multi-residue analytical methodologies are becoming the preferred and required tools against single group analysis, as they provide wider knowledge about occurrence of pharmaceuticals in the environment necessary for further study of their removal, partition and ultimate fate. In such methodologies, liquid chromatography-tandem mass spectrometry (LC-MS/MS) is the method of choice due to its specificity and selectivity. Among LC-MS/MS techniques, the most widely employed are triple quadrupole instruments (QqQ). However, hybrid equipments, such as quadrupole-linear ion trap (Q-LIT) or quadrupole-time of flight (Q-TOF) are gaining popularity, as they gather the advantages of different mass analyzers, providing large amount of structural information. The aim of the study was the development of a selective and sensitive analytical method, based on Solid Phase Extraction (SPE) followed by LC-tandem MS (Q-LIT), for the simultaneous analysis an extended list of 80 pharmaceuticals of major human consumption worldwide in both surface and wastewaters. The analysis was carried out on an Agilent Series 1100 liquid chromatograph coupled to an API 4000 QTRAP mass spectrometer (Applied Biosystems/MSD Sciex, Foster City, CA). Multiple reaction monitoring (MRM) transitions as well

as other compound dependent parameters (declustering, entrance, collision cell exit potential and collision energy), were optimized for each individual compound. In addition, for the purpose of obtaining extra confirmation in the identification of the analytes, Enhanced Product Ion Scans (EPI) were recorded simultaneously, in the same chromatographic run, as the MRM transitions. This was performed by operating the systems in Information Dependent Acquisition (IDA) mode. In a typical IDA experiment, an MS survey scan (Enhanced MS and Enhanced Multi-Charge scan when the third quadrupole operates in ion trap mode and MRM and Neutral loss when it works as a quadrupole), is used to generate a peak list of all ions present, which is subjected to a user defined criteria to filter out unwanted precursor ions. The remaining ions are then submitted for MS/MS. This cycle is repeated through the duration of the acquisition to generate large amount of informative data. The EPI scan was carried out with 30 eV of collision energy (CE) to ensure good fragmentation of all target compounds in the MS/MS scan.

591 Analysis of Pharmaceuticals and Personal Care Products in Wastewater Treatment Plant and Environmental Samples. M. Hamilton, N. Hoover, M. Woudneh, B. Fowler, B. Surridge, Axys Analytical Services Ltd., Sidney, British Columbia, Canada. A method has been developed for the analysis of 73 pharmaceuticals and personal care products in wastewater treatment plant and environmental samples. The analysis procedure uses extraction under acidic and basic conditions to recover a wide range of compounds from both solid and aqueous samples. The extracts are cleaned up by solid phase extraction and then analyzed by a series of four LC/MS/MS runs using a suite of 18 isotopically labeled internal standards for quantification. The development of the extraction, cleanup and instrumental analysis aspects of the method will be described and overall method performance indicators will be presented. Data will be reported for the analysis of POTW influent, effluent and biosolid samples as well as seawater, surface water, groundwater and sediments.

592 Monitoring and environmental processing of pharmaceuticals in a southeastern estuary, Kiawah Island, SC. E.R. Cooper, T.C. Siewicki, L. Reed, W. Pan, National Oceanic and Atmospheric Administration, National Ocean Service, Center for Coastal Environmental Health and Biomolecular Research, Charleston, SC. The development of coastal areas into residential and resort communities in the southeastern United States impacts surrounding coastal ecosystems. Increased population and land use conversion increases demand for freshwater, resulting in conservation measures such as the required use of treated effluent for irrigation. Many contaminants, including pharmaceuticals, may not be removed from effluent via wastewater treatment, making irrigation with treated effluent a potential threat to aquatic organisms. The purpose of this study was to help determine whether pharmaceuticals are a threat to estuarine ecosystems. Four pharmaceuticals, erythromycin, ciprofloxacin, oxytetracycline and simvastatin, were selected for environmental monitoring on Kiawah Island, SC. Sample locations were selected to investigate the effects of sewage treatment and environmental conditions on pharmaceutical residues in effluent as it traveled from the STP to the spray field, stormwater management pond, and ultimately the estuary. Detections of the pharmaceuticals indicate that residues are not fully degraded with wastewater treatment or spray field irrigation. However, these processes do appear to reduce concentrations and limit them from entering the estuary. Pharmaceutical concentrations varied seasonally, which may have been related to human population fluxes on the island. Regression models with variables related to the attenuation of pharmaceutical residues, such as pH and turbidity, best predicted variability in concentrations in the STP and surface waters. Measured pharmaceutical concentrations were well below toxicity thresholds.

593 Bench-Scale Treatability of Industrial Wastewaters: An Anti-fungal Agent as a Case Study. J. McGrath, HydroQual, Mahwah, NJ; E. Kang, Schering-Plough Corp, Union, NJ. During manufacturing of pharmaceutical products, wastewaters are generated which have varying characteristics. These wastewaters are treated either on-site or off-site prior to discharge to a body of water. Treatability studies are generally conducted on wastewaters generated during the developmental stages of the drug, in order to have adequate information for the design of wastewater treatment plant, if necessary, and/or in preparation for the receipt of larger quantity of wastewaters generated during commercial manufacturing. Treatability studies are conducted for two main reasons: 1) to estimate the impact of wastewaters on existing treatment processes, and 2) to evaluate if special treatment is needed for the wastewater. One case study where treatability

studies were performed was on an anti-fungal agent. Given the characteristics of the anti-fungal, it has the potential to accumulate with the activated sludge and possibly impair the performance of the process. Additionally, the sludge generated at the plant is disposed at the local publicly-owned treatment works (POTW), where it is combined with the POTW sludges and composted. Hereto, there is a potential impact on the composting process. Bench-scale evaluations were conducted to determine the impact of the anti-fungal agent on the biological treatment process, simulated for conditions at a Schering-Plough facility, and the municipal compost operations that process the plant's sludges. In addition, method development for the anti-fungal agent in a sludge/soils matrix was done. Based on the observed performance data, it was concluded that the addition of anti-fungal agent did not impact the performance of the activated sludge systems, including the nitrification process. The activated sludge studies indicated that the anti-fungal agent is biodegradable and absorbed into sludge. Based on direct measurements of the active agent, a mass balance suggested that approximately 70% removal was accomplished through the system. Due to negligible vapor pressure, it is assumed that there are no losses via volatilization. The presence of anti-fungal agent in a composting environment did not appear to impact the process. Based on an observed increase in oxygen utilization and reduction in volatile solids, both the control and anti-fungal-spiked compost systems had an active biomass that was stabilizing the waste material.

594 Personal care products in surface water effluent/influent from sewage treatment plants in Winnipeg, Manitoba (Canada). G.T. Tomy, B. Rosenberg, K. Pleskach, Department of Fisheries and Oceans, Winnipeg, Manitoba, Canada; A. Peck, Skidaway Institute of Oceanography, Savannah, GA. Municipal sewage, agricultural and aquaculture waste have all been identified as continuous sources of pharmaceuticals and personal care products (PPCPs) to the environment. Many PPCPs also reach sewage treatment plants (STPs) directly from household disposal. While some of these compounds are efficiently removed during treatment, significant quantities of many PPCPs escape the treatment process unchanged and reach streams or lakes. Because these sources are continuous even relatively labile contaminants are pseudo-persistent in the aquatic environment. There is great uncertainty in the long-term human health and ecological health consequences that may be resulting from exposure to these substances. The city of Winnipeg (Canada), which is home to roughly 650 000 residents, has three STP. In this study we report on levels of a suite of PPCPs, including the antibacterial compounds triclosan and triclocarban, in influent and effluent waters from these STPs to gain a better understanding of the extent of contamination in this region and the effectiveness of the STPs in removing these compounds.

595 Occurrence of Antidepressant Pharmaceuticals in Two U.S. Streams and in Fish Brain Tissue Exposed to Wastewater Effluent. M. Schultz, Department of Chemistry, The College of Wooster, Wooster, OH; E.T. Furlong, National Water Quality Laboratory, U.S. Geological Survey, Denver, CO; D.W. Kolpin, U.S. Geological Survey, Iowa City, IA; H.L. Schoenfuss, Department of Biological Sciences, St. Cloud State University, St. Cloud, MN; L.B. Barber, U.S. Geological Survey, Boulder, CO. Six of the 100 most widely dispensed pharmaceuticals in 2005 were antidepressants, including sertraline (Zoloft), fluoxetine (Prozac), venlafaxine (Effexor), paroxetine (Paxil), citalopram (Celexa), and bupropion (Wellbutrin). Antidepressant pharmaceuticals are widely prescribed, and municipal wastewater treatment disposal is a primary route introducing them to aquatic and terrestrial environments. In-stream studies were performed on two wastewater effluent-dominated streams, Boulder Creek (CO) and Fourmile Creek (IA). Antidepressant pharmaceuticals were present in these streams only downstream of the effluent outfall at nanogram-per-liter concentrations, and extending about 8.4 km downstream from the outfall. Venlafaxine, bupropion, and citalopram were the predominant antidepressants observed in both sets of stream-water samples. The brains of white sucker (*Catostomus commersonii*) also were collected from the two streams and analyzed for the presence of antidepressants. As with the stream-water samples, antidepressant pharmaceuticals were present only in the brains of fish collected downstream of the effluent outfall. Controls (low-head dams) exist upstream of the effluent discharge that effectively separates the fish populations in these stream systems. Fluoxetine, sertraline, and their degradates, at low nanogram-per-gram concentrations, were the principal antidepressants observed in brains, a different analyte profile than what was observed in the stream-water samples. These stream-water results clearly document that wastewater effluent is a point source of antidepressants to the environment. The fish brain results suggest

that while aquatic organisms are exposed to the spectrum of antidepressants in surface water, specific antidepressants are selectively taken up by brain tissues. (Mention of specific equipment or trade names are for identification purposes only and do not constitute endorsement by the United States Geological Survey.)

596 Levels of Synthetic Musk Compounds in Municipal Wastewater for Estimation of Biota Exposure in Receiving Waters. L.I. Osemwengie, Environmental Sciences Division, U.S. EPA, Las Vegas, NV. To test the ruggedness of a newly developed analytical method for synthetic musks, a 1-year monthly monitoring of synthetic musks in water and biota was conducted for Lake Mead (near Las Vegas, Nevada) as well as for combined sewage-dedicated effluent streams feeding Lake Mead. Data obtained from analyses of combined effluent streams from three municipal sewage treatment plants, from the effluent-receiving lake water, and from whole carp (*Cyprinus carpio*) tissue, indicated bioconcentration of synthetic musks in carp (1400 – 4500 pg/g). The same data were evaluated for the prediction of levels of synthetic musk compounds in fish, using values from the source (sewage treatment plant effluent [STP]). This study confirmed the presence of polycyclic and nitro musks in STP effluent, Lake Mead water, and carp. The concentrations of the polycyclic and nitro musks found in Lake Mead carp were considerably lower than previous studies in Germany, other European countries, and Japan. The carp samples were found to have mostly the mono-amino-metabolites of the nitro musks and intact polycyclic musks, principally HHCB (Galaxolide®) and AHTN (Tonalide®). Finally, the determination of sufficiently high levels of Galaxolide® and 4-amino musk xylene in STP effluent may be used to infer the presence of trace levels of other classes of musk compounds in the lake water. To be presented is an overview of the chemistry, the monitoring methodology, and the statistical evaluation of concentrations obtained from the analysis of a suite of these compounds (e.g., Galaxolide®, musk xylene, and amino musk xylene) in an aquatic ecological site. Notice: Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

597 Spatial and temporal analysis of pharmaceutical and chitinase concentrations in the Tennessee River. J.M. Conley, S. Richards, Biological and Environmental Sciences, University of Tennessee at Chattanooga, Chattanooga, TN; S. Symes, S. Kindelberger, Chemistry, University of Tennessee at Chattanooga, Chattanooga, TN. Tennessee currently has the highest per capita prescription drug usage rate in the United States, yet no published studies have analyzed for drugs in Tennessee waters. Composite surface samples were collected upstream and downstream of sewage treatment plants and at the inflow of major tributaries to the Tennessee River to determine the presence and potential sources of pharmaceuticals. Subsurface samples were collected at 21 feet depth to determine differences in occurrence and potential natural degradation. All samples were collected once during each of the four seasons (winter, spring, summer, and fall) to determine yearly variations. Aliquots of each sample were analyzed for pharmaceutical concentrations and chitinase. Chitinase is an enzyme expressed by developing aquatic invertebrates and may be used as a bioindicator of aquatic invertebrate population health. These two measurements will be compared to determine if either total or single pharmaceuticals correlate with chitinase concentrations. The method for the simultaneous quantitation of 14 pharmaceuticals in aquatic matrices was developed utilizing solid phase extraction and ultra-performance liquid chromatography (UPLC) interfaced with an electrospray ionization, triple quadrupole mass spectrometer (MS/MS). This method yielded reproducible quantitation at the low parts per trillion (ng/L) level for all 14 drugs (acetaminophen, caffeine, carbamazepine, sulfamethoxazole, trimethoprim, ranitidine, ciprofloxacin, levofloxacin, sertraline, fluoxetine, norfluoxetine, diltiazem, lovastatin, and atorvastatin). The present simultaneous method pre-concentrates analytes by a factor of 1000 with percent recoveries ranging from 40% to 120% and RSDs below 15%. Percent recoveries were moderately variable due to the broad range of both the polarities and acid-base properties of the target compounds. The end goal of these analyses is to produce a rapid, reliable quantitation of surface water pharmaceutical concentrations and to determine if they pose a potential hazard to aquatic invertebrate populations.

598 Bioaccumulation of the synthetic hormone ethinylestradiol in benthic invertebrates, via water and sediment exposure. D.B. Ève, K.R. Solomon, P.K. Sibley, Environmental Biology, University of Guelph, Guelph, Ontario, Canada; V.K. Balakrishnan, U. Borgmann, Aquatic Ecosystem Protection Research Division, Environment Canada, Burlington,

Ontario, Canada. Environmental exposure to the synthetic hormone ethinylestradiol (EE2) has received considerable attention in the last two decades, during which its estrogenic effects on the reproductive system of aquatic vertebrates were uncovered. In contrast, effects on aquatic invertebrates are poorly documented, despite their important role and contribution to ecosystem structure and diversity. Moreover, studies investigating effects on benthic invertebrates, which can be exposed to pollutants from both water and sediment contamination, are rare, and potential risks to benthic communities are largely unknown. Previous investigations revealed that the midge *Chironomus tentans* and the freshwater amphipod *Hyalella azteca* are somewhat tolerant to EE2 (LC50 ~ 1 mg/L-1 in chronic toxicity tests). Monitoring studies have however detected low levels of EE2 in aquatic systems, implying chronic, sublethal exposure. Moreover, the relative insensitivity of both *C. tentans* and *H. azteca*, and the physico-chemical properties of EE2 suggest that this compound could bioaccumulate in benthic invertebrates, thereby representing a notable source of contamination to their vertebrate predators. In this study, we investigated the bioaccumulation of EE2 in *Chironomus tentans* and *Hyalella azteca*, during a 3-week exposure. The importance of the exposure medium was investigated through a comparison of water and spiked sediment exposure. Our results show that benthic invertebrates accumulated concentration-dependent levels of EE2 from waterborne exposure. Exposure from spiked sediments suggested negligible uptake from the sediments in *Hyalella azteca*. In contrast, *C. tentans* accumulated more EE2 than predicted by water-only exposure, suggesting potential differences between the two species. Results will be discussed in the context of their potential environmental impacts.

599 Importance of Best Science Approaches to Terrestrial Fate, Ecotoxicology, and Risk Assessment Techniques on Military Lands. M.S. Johnson, Health Effects Research Program, U.S. Army Center for Health Promotion and Preventive Medicine, Aberdeen Proving Ground, MD; R.T. Checkai, US Army Chemical Biological Center, Aberdeen Proving Ground, MD; D.A. Anders, US Air Force Center for Environmental Excellence, San Antonio, TX. The U.S. DoD extensively trains, tests, and operates on large tracts of land within and outside the continental United States. This includes testing and firing munitions on more than 9.7 million hectares of ranges that have operated for decades. With increasing human densities surrounding military installations, the relative value of these areas to our national defense and to other natural resources have increased significantly. Testing and training can involve the use of chemical elements and compounds, smokes/obscurants, counter-measure materials, solvents, composites and specialized materiel, nanomaterial, non-lethal suppressants, training surrogates, chemical agent simulants, toxic chemical agents, decontaminants, all potential contaminants within or adjacent to military areas that provide valuable habitat for many species of wildlife. A balance between providing for National defense and protection of natural resources is required. Proactive protection of the terrestrial environment and ecosystems at military installations is in-part achieved by utilizing best-available information on environmental fate and ecotoxicological effects of these materials of importance to the military for both military-unique materials and common industrial chemicals, compounds, and substances that may be used in unique or specialized military applications. This, in turn, requires the use of improved fate, transport, and effect models to help predict risk and manage the areas in a sustainable manner. Here we provide the background for the Session and include a discussion of advancements in approaches for fate and toxicological investigations, models and techniques for contaminant fate, ecotoxicology, and risk assessment, plus provide suggestions for additional research specific to these goals.

600 The Terrestrial Fate of Tungsten at Department of Defense Small Arms Training Ranges. J. Clausen, S. Taylor, Biogeochemical Sciences Branch, US Army ERDC-CRREL, Hanover, NH; A. Bednar, S. Larson, US Army ERDC-EL, Vicksburg, MS; B. Packer, K. Watts, US Army Environmental Command, Aberdeen Proving Ground, MD. The US Army has an interest in understanding the environmental fate of tungsten due to its usage in small and large caliber weapons systems. A study conducted at Camp Edwards, Massachusetts assessed three firing ranges utilized for training with small caliber weapon systems. Surface soil tungsten levels ranged from 82 to 1,534 milligram per kilogram (mg/kg) in the Berm Face, 29 to 932 mg/kg in the Trough, 1.6 to 147 mg/kg at the Firing Point/Range Floor/Target, and 17 to 113 mg/kg behind the berm face. The highest observed tungsten concentrations were observed in surface soil samples (0-5 cm) from the bullet pockets on the berm face. Background surface soil tungsten levels

for Camp Edwards are 1.5 mg/kg. Subsurface soil tungsten levels decreased markedly over a 150 centimeter depth interval, although the concentration of tungsten did not reach background levels. Tension lysimeters were installed at various sampling intervals within the berm face and below the trough to assess pore-water migration of tungsten-laden water. Pore-water tungsten concentrations varied from < 0.05 to 400 mg/L over four sampling events. Five of the lysimeters exhibited an increasing tungsten concentration trend, three a decreasing trend, and the remainder of the 24 total exhibited no trend. Lysimeters installed in background locations indicated ambient tungsten levels of 0.01 to 0.17 mg/L. A monitoring well completed in the aquifer, approximate depth to water of 36 meters, and tens of meters downgradient of one berm face exhibited fluctuating levels of tungsten. The first two sampling events indicated tungsten at 15 and 22 micrograms per liter (ug/L). Tungsten levels increased to 530 ug/L following a period of heavy precipitation. The fourth and fifth sampling event revealed a groundwater concentration of <5 ug/L. Prior to the fourth sampling event soil from the berm face containing greater than 150 mg/kg tungsten was removed. Laboratory experiments conducted to assess the mobility of tungsten revealed that tungsten rapidly goes into solution and that solution concentrations in the 100 ppm neighborhood are sustainable. Tungsten sorption was found to be limited for a low organic sand and gravel material.

601 Soil Lead Risk for Grit Ingesting Birds: A Simple Methodology to Estimate the Number of Grit Size Lead Particles in Soils and Sediment. M. Kierski, C. Menzie, Exponent, Sauk City, WI; E.A. Ferguson, ERDC, U.S. Army Corps of Engineers, Vicksburg, MS. Lead fragments in soil associated with decommissioning of ammunition or firing range operations is a common issue at many military installations including Savanna Army Depot Activity (SVDA), an Army installation in the Base Realignment and Closure (BRAC) Program located in northwestern Illinois. The SVDA had munitions burning and detonation areas and firing ranges which commonly had lead levels above background concentrations and had the potential to contain lead fragments. Lead is known to be toxic to avian receptors. Of particular concern, are birds that ingest grit particles of size classes to aid in the grinding of food for digestion. Though specific shape requirements appear to lessen potential uptake, it is possible that grit ingesting birds have increased exposure to the lead fragments by picking up lead fragments while collecting grit. This study reports a simple methodology to calculate the number of grit-sized lead fragments in soil and sediment that grit ingesting birds may be exposed to. Soil and sediment samples were collected at the Open Burning Ground (OBG) at SVDA and separated into grit-sized particle size classes applicable to specific bird species (i.e., mourning dove, song sparrow and mallard duck). A simple model was used to estimate the number of lead particles in each soil or sediment sample within a particular size class of grit. Numerous soil and sediment samples were collected over the site area to estimate the spatial distribution of grit-sized lead particles. Grit-size lead particles were found to be localized around the former popping furnaces and were not found in other areas of the terrestrial environment of the OBG. Within the aquatic environment next to the OBG, grit-size lead particles were not detected. This information was used by risk assessors and risk managers to determine that there was minimal risk for exposed to lead fragments at this particular site. This presentation will provide the background and model developed to obtain these results.

602 Perchlorate: Significance, Occurrence, and Ecotoxicity in Certain Species. D.A. Anders, TDE, HQ Air Force Center for Engineering & the Environment, Brooks AFB, TX. Ammonium perchlorate is a critical component of solid rocket fuel, and has been used as an explosive propellant for over 200 military applications. Its many domestic uses include fireworks, explosives, roadside warning flares, fertilizers and automobile air bags. Perchlorate has been found surface waters across the US and in both modern and prehistoric groundwaters. It occurs naturally in many desert regions of the world, e.g., nitrate fertilizers mined in Chile contained very high levels of perchlorate. Naturally occurring perchlorate has been found in arid and semiarid regions of the American southwest. Concerns for uptake of perchlorate have been voiced for humans (pregnant women, developing fetuses, children, and the elderly), as well as wildlife and plant populations. After ingestion, perchlorate's effect in humans is competitive inhibition of iodide uptake by the thyroid. Laboratory and field studies of animal ingestion and plant uptake and metabolism of perchlorate are continuing. This presentation will briefly describe the chemistry, characteristics, sources, and uses of perchlorate, its distribution across the US, and will discuss in some

detail routes of exposure and ecotoxicity of perchlorate ingestion/uptake by selected wildlife and plants.

603 Review of Perchlorate Ecotoxicity and Bioaccumulation Data to Support Evaluation of Ecological Risks. L.J. Yoo, K. Nielsen, B. Sample, A. Tsao, C. McCarthy, CH2M HILL, Houston/Dallas/Sacramento, TX; M. Craig, NAVFAC Southeast, North Charleston, SC; M. Johnson, USACHPPM, Aberdeen, MD. Perchlorate salts, used in propellants and munitions, have been found in ground and surface water in and around military installations. Perchlorate interferes with iodide uptake in the thyroid and affects thyroid hormone synthesis in vertebrates. Because thyroid hormones regulate reproduction, growth, metabolism and development, perchlorate exposure may impact survival, growth, and reproduction in wildlife receptors. Current literature describing perchlorate toxicity and bioaccumulation in wildlife receptors was reviewed and summarized. Amphibians appear to be the most sensitive vertebrate species with relatively low concentrations of perchlorate reported to retard metamorphosis, (NOEC 0.023, LOEC 0.06 mg/L). Limited avian data suggests birds (growth inhibition NOAEL 13, LOAEL 26 mg/kg/d) are less sensitive than mammals (acute lethality NOAEL 6.4, LOAEL 32 mg/kg/d). Relatively low levels of perchlorate can affect thyroid hormone levels (~0.02-25 mg/kg-d), however, adverse effects from exposure has not been reported at these levels. Responses in other biota are varied, with plants being more sensitive than earthworms, although neither was highly sensitive (<10 mg/kg = no effect). Aquatic invertebrates are less sensitive than fish and amphibians; effect concentrations were generally greater than recommended chronic water criterion (9.3 mg/L). Bioaccumulation of perchlorate varies between aquatic and terrestrial systems, across receptor groups, and between field and lab studies. The maximum accumulation rate for aquatic invertebrates of 3 kg/L is reported for the Asiatic clam in a water exposure. In fish, lab exposures generated bioaccumulation factor values less than 1 kg/L. In contrast, field study bioaccumulation factors ranged from 1.1 to 50 kg/L with greater accumulation reported in higher trophic level fish. Differences between field and laboratory results suggests the potential for accumulation from multiple sources in a field setting. Aquatic plants bioaccumulate perchlorate with species and study design variability (0.1 - 189 kg/L geometric mean BCF). Generally, perchlorate is not accumulated in terrestrial animals and is eliminated quickly. The effects and uptake data summarized in this review are intended to be applied within ecological risk assessments and support the development of appropriate risk management actions.

604 Fate of depleted uranium (DU) in British weapons test zones: Soil associations and biological assimilation. I.W. Oliver, A.B. MacKenzie, R.M. Ellam, Scottish Universities Environmental Research Centre (SUERC), East Kilbride, United Kingdom; M.C. Graham, J.G. Farmer, GeoSciences, University of Edinburgh, Edinburgh, United Kingdom. Introduction The high density, penetrative power and pyrophoric properties of depleted uranium (DU) make it a highly effective material for military applications including tank-piercing ammunition and heavy vehicle armour. An initial investigation revealed that testing of such munitions at two locations in the UK has led to localized soil contamination and subsequent transfer into biota.¹ As a consequence of the isotopic signature of DU (²³⁵U:²³⁸U isotope mass ratio 0.002), differing from that of natural uranium (ratio 0.0072), its dispersal and environmental fate can be tracked using isotopic techniques. Accordingly, our current research aims to examine the dispersal of DU, its partitioning amongst soil fractions and its assimilation into plants and earthworms at weapons test sites in the UK. Methods Soil, plant and earthworm samples were collected from the immediate vicinity of test firing points and along transect lines extending away from them. Soil samples were subjected to the BCR sequential extraction scheme to determine soil-DU associations while total dissolution of the biological materials was achieved by microwave-assisted acid digestion. The isotopic composition of U in selected BCR extracts and all biological sample digests was determined using Multicollector-Inductively Coupled Plasma-Mass Spectrometry (MC-ICP-MS), employing a recently developed ²²⁹Th/²³²Th external mass bias correction.² Results Sequential extraction data, confirmed by isotopic analysis of extract solutions, indicated that DU was largely associated with the organic fraction in the soils examined, with lesser proportions associated with the residual, reducible and easily extractable fractions. Some variation, however, including that of a depth-related nature within soil profiles, was observed. Initial plant and earthworm results confirm the biological accessibility of DU, with further results expected to reveal the extent to which this bioavailable DU has spread from the firing locations.

605 Dinitrotoluene and Di-n-butylphthalate Exposure and Effects Evaluation for Birds at Badger Army Ammunition Plant. M. Kierski, C. Menzie, Exponent, Sauk City, WI; C. Carroll, SpecPro Inc., Ravenna, OH. Exponent and SpecPro jointly prepared a Baseline Ecological Risk Assessment (BERA) for the Settling Ponds and Spoils Disposal Area Site located at the Badger Army Ammunition Plant (Badger) located near Baraboo, Wisconsin. One part of the first phase of the BERA predicted that nitroaromatic compounds (2,4-Dinitrotoluene, 2,6-Dinitrotoluene, 2-Nitrodiphenylamine, Diphenylamine, Nitroglycerin, and n-Nitrosodiphenylamine) and di-n-butylphthalate exposure to avian species might have reproductive effects on birds using the Site. However, predictions were based on very limited toxicology and exposure data for these compounds. For this reason, field-based exposure and effects studies were performed to collect site-specific data on nitroaromatic compounds and di-n-butylphthalate levels in plants and prey items. These were used to evaluate if exposure on the Site could cause negative reproductive effects in the birds. Biomonitoring of tree swallows, bluebirds, and house wrens was performed to compare reproductive success of insectivorous bird species at the Site and a reference area. A ligature method was used to collect prey items fed to the nestling by the parents. The results showed that nitroaromatic compounds and di-n-butylphthalate did not bioaccumulate in insects or plants at the Site, which filled a major data gap. Reproductive success of the two main insectivorous species studied (bluebirds and tree swallow) did not appear to be affected at the Site in a concentration dependent manner. While there was one Site area where tree swallows had reduced fledging success, the cause was not clear. This information was used to re-evaluate exposure and risk to birds at the Site. Based on these results, the Site does not appear to pose an ecological concern to the insectivorous bird species using the Site.

606 Fate of the Nerve Agent Soman (GD) in Soil: Persistence and Potential Hazard. R.T. Checkai, M.V. Haley, M. Simini, C.T. Phillips, K.L. Matson, Environmental Toxicology, U.S. Army Edgewood Chemical Biological Center, Aberdeen Proving Ground, MD; C.L. Crouse, SAIC, Aberdeen Proving Ground, MD. The fate and persistence of the chemical agent Soman (GD; methylphosphonofluoridic acid 1,2,2-trimethylpropyl ester; a phosphonate nerve agent) delivered onto different soils was investigated. Soil System Units (SSU) were designed and fabricated; atmospheric concentrations of GD above the soil surface were measured, and extractable GD determined. Results showed that in soil environments surface-controlled reactions can predominate over bulk solution hydrolysis, persistence of GD in soil may be expected for at least the days-to-months, that potentially life-threatening atmospheric levels of GD may be successively displaced from soil into the overlying atmosphere in response to small (0.3mm) additions of moisture (e.g., rainfall). Successive GD displacements from soil, causing subsequent reoccurrences of GD in overlying atmosphere, previously had not been documented. GD displaced from soil into overlying atmosphere was not stoichiometric with respect to moisture levels applied to soil. GD-contaminated soil may present a potential hazard to unprotected individuals even when classic "All Clear" conditions exist. Investigation of GD extractability showed that longer contact times with soil constituents resulted in less GD being extracted (24-hr extractions of GD using isopropanol yielded recoveries) from: sand of 90-100% when GD was in contact $\leq$ 24hrs, 45% with 48hrs contact, and 16% with 72hrs contact; recoveries from Montmorillonite clay were approximately 40% when GD was in contact $\leq$ 48hrs, decreasing to approximately 30% with 72hrs contact. Investigation of soil factors affecting persistence showed: Coarse sand yielded highest levels of GD displacement from additions of soil moisture, measured as GD in the atmosphere above the soil surface; successive displacement of GD from the coarse and medium sands, and sandy loam soil, persisted over the days-to-weeks timeframe. Montmorillonite clay yielded lower individual-levels of GD displacement from moisture additions, but yielded continuing appreciable levels of atmospheric GD over the weeks-to-months timeframe. The potential toxicity of unextractable residual-GD in soil is unknown.

607 Are QSAR Models Effective in Predicting Environmental Effects of Emerging Military Materials with Limited Physicochemical Data? E. Bennett, I. Linkov, Intertox Inc., Cambridge, MA; J. Clausen, ERDC-CRREL, Hanover, NH. Both the military and industry are continuously researching and developing new materials. Reliable, up-front environmental toxicity information is essential before making a decision and investment to synthesize, formulate, scale-up, test, and manufacture a new material for use in both military and civilian applications. Environmental exposure assessment

tools are available for predicting a material's chemical/physical properties and environmental effects (i.e. QSARs). In order to use QSARs properly, we must better understand the importance differing structures and variations in the input values play in providing useful fate and transport and toxicity information. This presentation reports sensitivity analyses using EPI SuiteTM, one of the most widely used QSAR model for predicting environmental properties of emerging materials. We selected a set of materials that have very different structures and properties were analyzed using EPI SuiteTM Analysis was done for materials with largely uncertain properties as well as for a PCB and a pesticide, for which more information is available. The presentation reports comparison of modeling endpoints and literature-derived values to determine the sensitivity to structural and numeric variations, summarizes models confidence limits and usability for emerging materials assessment.

608 Overview of Emerging Pollutants Issues. E. Ohanian, US EPA, Washington, DC. The possible significant health and ecological impacts of emerging pollutants, such as pharmaceuticals and personal care products (PPCPs) and endocrine disrupting compounds (EDCs) in water are prompting considerable media attention, Congressional interest, and public concern. As the number of media and research reports of intersex fish and deformities in amphibians continues to increase, there is mounting Congressional interest in identifying the causes, and addressing the implications of the occurrence and effects of these compounds on the environment and human health. To address these concerns, the Agency is working to develop water quality criteria for appropriate compounds, as well as fill a number of critical information gaps, including improving analytical capabilities for measuring EDCs and PPCPs, evaluating the relative effectiveness of various drinking water and wastewater treatment technologies, and assessing human and ecological risks. This presentation will go over some of the issues related to addressing these concerns and provide 1) a broad overview of EPA efforts to reduce emerging pollutants in the environment, 2) regulatory frameworks related to emerging pollutants, and 3) federal agency activities and research plans. These include intramural and extramural biological and toxicological research, screening programs, monitoring programs, ecological and human health assessments, and treatment and remediation efforts. In addition, interagency efforts, such as the Pharmaceuticals in the Environment workgroup and the Endocrine Disruptors in the Environment workgroup and their products will be presented.

609 Pharmaceuticals in the Environment: Opportunities for International Collaboration. M.R. Embry, ILSI Health and Environmental Sciences Institute, Washington, DC. The detection of human and veterinary pharmaceuticals in the aquatic environment has gained increased international attention in the last decade by scientists, regulators, and the public concerned about potential risks to the environment and human health. Although there are numerous regulations in place for the environmental risk assessment of pharmaceuticals, guidelines and practices can vary among agencies internationally, such as the US Food and Drug Administration and the European Medicines Agency. As a first step to integrating national guidance, the US National Science and Technology Council established a Working Group on Pharmaceuticals in the Environment to facilitate dialogue and collaboration between and among US Federal agencies involved in evaluating the issues pertaining to pharmaceuticals in the environment. From an international perspective, however, it is necessary to address these issues by evaluating, documenting, and communicating the similarities and differences between and among international agencies; identifying conceptual and informational gaps in knowledge; and focusing on the scientific issues that should be collaboratively evaluated.

610 Understanding the Occurrence, Fate, and Effects of Emerging Contaminants in the United States. D. Kolpin, U.S. Geological Survey, Iowa City, IA; E.T. Furlong, M.R. Burkhardt, S.D. Zaugg, National Water Quality Laboratory, U.S. Geological Survey, Denver, CO; M.T. Meyer, U.S. Geological Survey, Lawrence, KS; L.B. Barber, U.S. Geological Survey, Boulder, CO; V.S. Blazer, National Fish Health Research Laboratory, U.S. Geological Survey, Kearneysville, WV. Research is documenting with increasing frequency that many "emerging contaminants" (ECs) such as pharmaceuticals, hormones, and fragrances that have not historically been considered as environmental contaminants are present across the world. These emerging contaminants (ECs) are commonly detected in municipal, agricultural, and industrial wastewater sources. Since 1998, the United States Geological Survey (USGS) Emerging Contaminants Project (<http://toxics.usgs.gov/regional/emc/index.html>) has been conducting "source to receptor" research on this rapidly

advancing topic. The primary objectives of this project are to: 1) develop the analytical tools required for detecting ECs in the environment, 2) document the environmental occurrence and concentration of ECs, 3) characterize contaminant sources and their potential pathways into the environment, 4) determine processes and factors that affect the transport and fate of ECs, and 5) assess the potential deleterious effects of ECs and complex mixtures of ECs on aquatic and terrestrial organisms. To carry out these research objectives, an interdisciplinary team of scientists has been assembled. The overall mission of this USGS research is to provide reliable scientific data and information on ECs needed by regulators, resource managers, industry, and the public to make sound decisions about the use, disposal, and general management of these chemicals.

611 Panel Session on Addressing Emerging Contaminant Risk. E. Ohanian, D. Eignor, J. Beaman, O. Conerly, US EPA, Washington, DC. This panel session will be designed to provide a healthy dialogue between presenters and the audience to address issues in emerging pollutant risk. Topics such as regulatory guidelines, stewardship efforts and evaluation of aquatic life risk will be discussed. The panel will consist of EPA Office of Water presenters (prior 4 presentations) and will hopefully encourage a thought-provoking session among participants focused on improvements and new approaches to this difficult problem. Topics will include: Office of Water Regulatory Tools to Address Emerging Contaminants, Regulatory Tools and Voluntary Stewardship Efforts to Address Pharmaceutical Disposal, and Water Quality Criteria for Emerging Contaminants.

612 Overview of Regulatory Tools and Voluntary Stewardship Efforts to Address Pharmaceutical Disposal. I. Ruhuy, US EPA, Las Vegas, NV. This presentation will provide an overview of current federal regulatory guidance for pharmaceutical disposal, currently funded pilot programs for take-back pilot studies, and state programs. The EPA Office of Water's role is to protect our Nation's watersheds and drinking water supplies against chemicals in our waterways. Therefore, current regulations and stewardship efforts to control pharmaceuticals in waterways is of premier importance to our office. The Federal guidelines for the proper disposal of prescription drugs released by the White House Office of National Drug Control Policy in February 2007 will be presented. The guidelines recommend disposal of prescription drugs by removing the drug from its container, mixing with an undesirable substance (coffee grounds and kitty litter), and then placing in a trash receptacle in a sealed container. Current drug take-back pilot studies sponsored by the Office of Children's Health Protection (OCHP) will be presented and an overview of state efforts to address pharmaceutical disposal will also be addressed.

613 USEPA Office of Water Regulatory Tools to Address Emerging Contaminants in Drinking Water. O. Conerly, US EPA, Washington, DC. Where surface water is used as a public water supply, an additional multi-barrier system of public health protection measures apply to assure that our cities, towns, and communities have clean and safe water to drink. Under the Safe Drinking Water Act and EPA's national drinking water program, the Agency has issued numerous public Health Advisories and established Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) for many contaminants in drinking water. MCLGs are used in conjunction with information on validated analytical methods, available treatment technologies, and associated costs and benefits to develop enforceable MCLs or "standards" that apply to millions of water systems across the nation. There are two mechanisms, (the Six Year Review Process, the Contaminant Candidate List), EPA relies upon to keep existing standards up to date, and to identify future contaminants (including emerging contaminants) that may warrant more in depth research and possible drinking water regulation. In addition to these mechanisms, EPA's Office of Water has a program to collect monitoring data on unregulated contaminants from a subset of water systems throughout the country. This presentation will provide an overview of regulatory tools that EPA's Office of Water may be able to use to address various emerging contaminants in drinking water.

614 USEPA Office of Water Regulatory Tools to Address Emerging Contaminants in the Aquatic Environment. D. Eignor, US EPA, Washington, DC. The presence of emerging contaminants in the environment, their potential effects on aquatic life, and the implications for their effects on human health are topics of great interest around the world. The EPA Office of Water's role is to protect our Nation's watersheds and drinking water supplies against chemicals (including emerging contaminants) in our waterways. Our mission is to better understand the physiological effects of exposure to

water-related contaminants in terms of metabolic pathways, modes of action, and dose response relationships. We work within a national framework of protecting human health and the aquatic environment, using technology and watershed-based implementation -- all driven by a strong emphasis on sound science, transparency, public information, and partnerships. This framework reflects requirements established by Congress under the Clean Water Act (CWA), the Safe Drinking Water Act (SDWA), and the Food Quality Protection Act (FQPA). EPA uses this regulatory framework to understand, manage and reduce hazards posed by emerging contaminants in our waters. Using CWA tools such as water quality criteria and effluent guidelines, EPA and its partners significantly reduce the levels of contaminants entering drinking water plants. This presentation will provide an overview of regulatory tools that EPA's Office of Water may be able to use to address various emerging contaminants in the aquatic environment.

615 Exposure of aquatic populations to a potent estrogen: what are the risks? K. Kidd, Biology, University of New Brunswick, Saint John, New Brunswick, Canada; P. Blanchfield, K. Mills, M. Paterson, C. Podemski, D. Findlay, V. Palace, Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, Manitoba, Canada. A whole-lake study was conducted from 1999-2006 at the Experimental Lakes Area in northwestern Ontario to determine whether the potent synthetic estrogen ethynylestradiol (EE2) affects freshwater food webs. Surface waters of the experimental Lake 260 were maintained at EE2 concentrations of ~5-6 ng/L through weekly additions during the summers of 2001 to 2003. Microbial, algal, zooplankton, benthos and fish populations were sampled in this lake in the two years before and after dosing and in the three years of EE2 additions, and compared to reference lake data. No effects of EE2 on abundance or community composition were observed for lower-trophic-level organisms during EE2 amendments. In contrast, the lake trout, white sucker, pearl dace and fathead minnow responded at the biochemical and tissue level to the EE2 additions through increased production of vitellogenin and delayed gonadal development in both males and females. The population of the shortest-lived fish species, the fathead minnow, collapsed after the second summer of EE2 additions due to a loss of young-of-the-year; of the four, this species was the first to show population-level impacts of the estrogen although the longer-lived species also showed some impacts of EE2 on size-frequency distributions and abundances. Results indicate that life history strategies play an important role in determining the risks that estrogen and their mimics pose to fish species in impacted environments.

616 Water Quality Criteria for Emerging Contaminants: Options and Opportunities. J. Beaman, US EPA, Washington, DC. Endocrine disruption remains one of the most controversial contemporary environmental issues of our time. While the desired level of protection is ultimately a societal choice, endocrine toxicity has been shown to cause a wide spectrum of adverse effects in aquatic organisms. Many chemicals named as actual or potential endocrine disruptors come from a class of compounds collectively known as "pharmaceuticals and personal care products" (PPCPs). Since these compounds are designed for human use, their toxicity must be low, and their potency (in the case of pharmaceuticals) must be high. The combination of low potential acute toxicity, coupled with high potency and organ system-specific modes of action, may cause detrimental effects to sensitive aquatic species and/or life-stages when these compounds reach surface waters. The Clean Water Act (CWA) provides for a foundation of water quality standards that are based on scientifically-defensible water quality criteria. While the current criteria derivation paradigm has enabled development of chemical criteria for compounds with endocrine disrupting properties (e.g., nonylphenol, tributyltin), the physicochemical and toxicological attributes of many PPCP compounds make derivation of CWA §304(a) criteria difficult or impossible. Examples illustrating the current criteria derivation paradigm will be presented, as well as issues and options for emerging pollutants, such as endocrine disrupting chemicals.

617 Application of a Solid-Phase Microextraction-Based Technique in Measuring Hydrophobic Organic Chemicals in Sediment Porewater. E.Y. Zeng, H. Xia, Z. Yang, State Key Laboratory of Organic Geochemistry, Guangzhou Institute of Geochemistry, Guangzhou, China; D. Tsukada, K.A. Maruya, Southern California Coastal Water Research Project, Costa Mesa, CA; H. Xia, Z. Yang, Graduate School, Chinese Academy of Sciences, Beijing, China. A prototype sampler based on solid phase microextraction (SPME) was developed to measure freely dissolved porewater concentrations of 13 target hydrophobic organic chemicals (HOCs). Precalibrated SPME

fibers within the samplers were exposed either dynamically or statically via direct burial within laboratory-prepared sediment slurries. Time series batch experiments were conducted to establish the times to equilibrium for the analytes with 7- μ m and 100- μ m PDMS coatings. Under dynamic conditions, extraction reached equilibrium within one month for all analytes with these two coatings. In contrast, the time to equilibrium increased to four months with the 7- μ m coating under static conditions, and even 180-d exposure was insufficient to reach equilibrium for the two most hydrophobic analytes, PCB 153 and 180 with 100- μ m coating. From SPME-derived porewater concentrations, the specific sorption coefficients of the spiked sediment were calculated, and were compared with the estimates of a QSAR model. To illustrate the distinct pattern of extraction kinetics under static conditions, the amounts of PCB 153 and 180 obtained with 7- μ m and 100- μ m coatings were fitted separately with a standard one-compartment diffusion model. Preliminary results showed that (1) moderate agitation greatly accelerated SPME extraction kinetics by enhancing mass transfer between the sorbed and the dissolved phases; (2) desorption and/or mass transfer in bulk sediment appeared to be the rate-limiting factors for static extraction if the pool of freely dissolved HOCs in the porewater became partially depleted by fiber uptake; and (3) a simple theoretical model can not fully describe the distribution of HOCs in sediment because a multitude of confounding factors plays a role. Overall, the SPME-based sampler is simple, sensitive and cost-effective for measuring freely dissolved concentrations of HOCs in sediment porewater, and the robust physical and anti-fouling design and deployment strategy should ensure its survival in most sedimentary environments, thus making field sampling feasible. Keywords: Solid-phase microextraction; Sediment porewater; hydrophobic organic chemicals; Time to equilibrium; Extraction kinetics

618 Solid Phase Micro Extraction for Measuring Pore Water Concentrations of Organic Contaminants. S. Rajagopalan, A.W. Jackson, Civil and Environmental Engineering, Texas Tech University, Lubbock, TX; T.A. Anderson, The Institute of Environmental and Human Health, Texas Tech University, Lubbock, TX. Use of Solid Phase Micro Extraction (SPME) fibers for quantifying pore water concentrations of freely dissolved organic compounds has simplified sampling and analytical processes. One of the potential uses of such sampling devices is for the collection of high-resolution spatial concentration profiles in natural systems in order to study the fate, transport, and toxicity of anthropogenic compounds. Previous methods using dialysis samplers or peepers have been limited in both sensitivity and resolution. Samplers with higher resolution (~1 cm) typically have poorer sensitivity due to volume limitations. While sensitivity can be increased by increasing the depth of the sampler this will also cause an increase in equilibration time that typically ranges from days to weeks. Regardless, detection limits for poorly soluble compounds are still higher than desirable. SPME fibers are a potential solution to these limitations. Numerous studies have demonstrated the sensitivity and efficacy of these fibers for measuring concentrations of a variety of compounds in real systems. Use of these fibers would allow finer resolution, much higher sensitivity for hydrophobic compounds, and faster equilibration times. In a series of studies we investigated the use of SPME fibers to determine vertical concentration profiles of three different compounds of environmental relevance including RDX, 17 α -ethynylestradiol (17 α -EE), and naphthalene. Optimum SPME fiber type was determined for each compound as well as partitioning studies and kinetic studies on contaminant equilibration. SPME fibers exhibited a linear uptake relationship and reached steady state equilibrium within 7 days in completely mixed systems. A sampling (peeper) study was conducted in artificial wetlands to estimate the potential of using SPME fibers as passive samplers for high resolution vertical profiling of the pore water concentrations of all three compounds. A traditional peeper was used to compare profiles obtained from both methods. The peeper had 13 chambers that were 75 mm x 10 mm x 10 mm and were 10 mm apart with DDI and SPME fiber in alternate chambers. The peeper chambers were covered using a 0.45 μ m porous Tuffryn (Pall Corporation) membrane. The fiber concentrations and predicted pore water were well correlated ($r^2 = 0.90$) in the case of RDX.

619 Development and Testing of a Field Deployable SPME Sampler for Sediment Pore waters. D.D. Reible, A.E. Skwarski, X. Lu, B. Drake, W. Sarchet, Civil, Architectural and Environmental Engineering Department-EWRE, University of Texas at Austin, Austin, TX. A field-deployable solid phase microextraction (SPME) sampler was developed for the in-situ assessment of pore water concentrations of hydrophobic organic compounds

including PCB and PAHs. SPME has become a standard approach for extracting organic analytes from aqueous samples, however the opportunity exists to use SPME for measuring in-situ pore water concentrations in sediments if appropriately strengthened and enough time is provided for equilibration. Demonstration and evaluation of this approach for the application of in-situ SPME devices is the goal of this paper. Testing has been conducted both in the laboratory and in preliminary field trials. The testing has included studies of fiber-water partition coefficients, equilibration time, vertical resolution, detection limits and comparisons of SPME measured pore water concentrations to contaminant accumulation in benthic deposit feeders. The direct measurement of the contaminant which is freely dissolved has also been shown to be an effective tool for determining the bioavailable fraction and predicting bioaccumulation of partitioning contaminants. The presentation will focus on the use of SPME to predict bioaccumulation in sequential dilution exposure experiments in the laboratory and in field exposures but will also summarize the results of the various operational parameter tests. The results further support the use of pore water as an indicator of bioaccumulation in benthic organisms as well as the use of SPME to measure pore water concentration.

620 A Comparison of Diffusion Sampler Equilibration Rates Using Teflon (PTFE) and Tuffryn Membranes. W.A. Jackson, Civil and Environmental Engineering, Texas Tech University, Lubbock, TX; T. Anderson, The Institute of Environmental and Human Health, Texas Tech University, Lubbock, TX; T. Johnson, E. Glaza, C. Kiehl-Simpson, Parsons, Liverpool, NY. Passive samplers, including dialysis samplers or peepers, have numerous applications. Typically they are used to evaluate the spatial distribution of the "truly" dissolved phase in saturated soils and sediments. Benefits of the samplers over traditional pore water evaluation methods can include higher spatial resolution, reduced sample processing, lower sampling impact, reduced sampling artifacts, and potentially better estimates of the dissolved phase. Equilibration time has been shown to be a function of the sampler geometry, specifically the ratio of the volume to surface area, the porosity of the sediment or soil, and the compound being evaluated. The impact of membrane type has been largely ignored as an equilibration parameter. The objectives of this study were to evaluate the equilibration times required using a Teflon membrane compared to a traditional Tuffryn membrane for a variety of compounds including Cl, SO₄, BTEX, chlorobenzene, dichlorobenzenes, naphthalene, and Hg. Studies were conducted using bottle style samplers (~8 ml) inserted into real contaminated sediments within 250-ml Teflon bottles. Sediments were obtained from 4 different locations from a lake bottom at sediment depths ranging from 0.3-6 m. Bottles and associated samplers were sacrificed over a 4-8 week period. Studies were conducted using both 0.45 μ m Teflon and Tuffryn membranes. VOCs equilibrated at similar rates for both membranes at all three sites tested. Laboratory equilibration times varied for the VOCs from 5-33 days (average of 13 ± 10 days) and 16-49 days (average of 28.5 ± 11 days) for the Teflon and Tuffryn membranes, respectively. Cl and Hg equilibration rates were very different for the two membrane types. Laboratory equilibration times using the Teflon membrane were >250 days for Cl and 104 days for Hg. Laboratory equilibration times using the Tuffryn membrane were 9 - 19 days (average of 12 ± 4) for Cl and 6.3-7.3 days (average of 6.8 ± 0.7 days) for Hg. These results indicate that membrane type can be a critical parameter in discrete sampling studies.

621 Estimating bioavailability of veterinary antibiotics: comparing passive samplers to traditional aquatic invertebrate assays. K. Henderson, A. Jessick, J. Coats, Entomology, Iowa State University, Ames, IA; T.B. Moorman, USDA-ARS, National Soil Tilth Laboratory, Ames, IA. Veterinary antibiotics are commonly used as feed additives in livestock production for growth promotion and disease prevention. These pharmaceuticals are often excreted by the livestock in urine and feces, and enter the environment via manure application. Understanding the bioavailability of pharmaceuticals in environmental matrices is particularly important considering they are often in an active form. In this study, the bioavailability of radiolabeled sulfamethazine in surface water microcosms was evaluated using C8-Empore™ extraction disks as passive sampling devices and *Lumbriculus variegatus* in a bioassay. The disks and worms were incubated in treated water at several time points. At the end of the study, the disks and worms were extracted and uptake of radioactivity was determined. Bioconcentration factors were calculated based on surface area to allow for comparison between disks and worms.

622 Using PSDs to Assess the Biological Availability of Contaminant Residues in Soil. T.A. Anderson, B. Zhang, Environmental Toxicology, Texas Tech University, Lubbock, TX; W.A. Jackson, Civil & Environmental Engineering, Texas Tech University, Lubbock, TX. The fraction of a chemical available to soil-dwelling organisms is not simply related to the concentration of the chemical(s) in the soil determined through rigorous extraction methods. Sorption is one of the most predominant factors controlling contaminant movement and bioavailability in soils. As time progresses, sorption becomes seemingly irreversible in that the bound contaminant is no longer free or available in solution (a process often referred to as 'aging'). These two processes, sorption and aging, although inter-related, have caused the most problems when attempting to determine the bioavailability of contaminants associated with soils. Hazard assessments of chemicals and regulations for soil cleanup rarely take into account such processes. Several approaches have been used in order to assess the aging phenomenon. In addition, alternative approaches for determining the fraction of a chemical in soil that is available have been proposed. For organochlorine pesticides, uptake rates into passive sampling devices (PSDs) and maximum concentrations were observed to positively correlate with uptake rates and maximum concentrations in earthworms for different soil types (sandy loam, silt loam). The uptake kinetics of 2 RDX metabolites (MNX and TNX) into PSDs, and the ability of PSDs to serve as surrogates for evaluating bioavailability of RDX metabolites were also investigated. A linear relationship between MNX and TNX uptake into PSDs and uptake into earthworms was observed. Correlation coefficients were > 0.90 in almost all test soils. These data indicate that PSDs may be used as a surrogate for soil organisms such as earthworms and provide a simple chemical test for assessing the bioavailability of contaminants in soils.

623 Estimation of Contaminant Fate and Transport in Saturated Soils using Passive Samplers. S. Rajagopalan, A.W. Jackson, Civil and Environmental Engineering, Texas Tech University, Lubbock, TX; T.A. Anderson, The Institute of Environmental and Human Health, Texas Tech University, Lubbock, TX. Passive dialysis samplers (peepers) have been widely used for monitoring dissolved constituents in saturated sediments. Peepers are rigid structures, which can hold volumes of water separated from the environment by porous membranes to monitor dissolved constituents in saturated environments. One of the potential uses of such sampling devices is for the collection of high-resolution spatial concentration profiles at relatively low cost. Tracer studies using 100 g/L Br⁻ were done to estimate the transportation times of chemicals through saturated play sand in 5 gallon buckets by diffusion only. The peeper chambers were 25 mm x 7 mm x 20 mm and were 8 mm apart. First three chambers were filled with the Br⁻ tracer, while the rest of the chambers had DDI water. The peeper chambers were covered using a porous Tuffryn (Pall Corporation) membrane (0.45µm pore size). Multiple peepers were setup to study the transport of Br⁻ at different time points. Further studies using deuterated chemicals to estimate the fate and transport of dissolved constituents in saturated sediments by sorption and diffusion are to be done.

624 Development of a Dynamic Food Web Bioaccumulation Model with Monte Carlo Analysis of Uncertainty and Sensitivity. C. Ng, K.A. Gray, Chemical and Biological Engineering, Northwestern University, Evanston, IL; K.A. Gray, Civil and Environmental Engineering, Northwestern University, Evanston, IL. In our previous work, we constructed a seasonally resolved, stage-structured model of PCB bioaccumulation in Calumet Harbor, a highly altered food web in southern Lake Michigan which is dominated by invasive species. With this model, which could give us "snapshot" predictions of steady-state PCB concentrations in species of a given size in a given season, we discovered a number of surprising bioaccumulation patterns. We found that shifts in the round goby diet led to a decrease in PCB concentration with size, counter to conventional notions regarding bioaccumulation. These shifts occurred at both short (seasonal) and long (species lifetime) time scales. The high PCB concentrations predicted in the food web's top predator, the smallmouth bass, were consistent with empirical data and appeared to be primarily due to consumption of smaller round gobies. Finally, we used our model to explore unexpected effect of a new exotic species, the quagga mussel, on contaminant accumulation in the harbor: a 3-fold decrease in PCB concentrations in the round goby. The results of our "snapshot" model led to a number of questions concerning the time-dependent evolution of PCB concentrations in a food web undergoing change at a number of different time scales, with both gradual and abrupt consequences (e.g., ontogenetic shifts, species introductions). For example, how long would an increase in round

goby PCB concentration due to seasonal egg consumption persist? Would the fast growth rate of young round gobies counterbalance the effect of egg consumption? In order to answer these fundamental questions regarding the Calumet Harbor food web, and design a tool to probe possible ecological scenarios, we have constructed a dynamic version of our original Calumet Harbor model, using existing species' bioenergetic models to predict the accumulation of PCBs in round gobies as a function of time. Here, we use Monte Carlo uncertainty and sensitivity analysis to probe the ecological parameters of greatest importance in determining the dynamics of PCB bioaccumulation in an important invasive species in the Great Lakes. Our new model gives insight into how ongoing environmental change such as species introductions and climate variability may affect contaminant accumulation and, ultimately, human health.

625 Sediment Dredging at Superfund Megasites: Assessing the Effectiveness. K. Gustavson, Board on Environmental Studies and Toxicology, National Academy of Sciences, Washington, DC. Decisions about whether to dredge at contaminated-sediment sites have proved to be among the most controversial at Superfund megasites. In response to controversies regarding the efficacy of dredging at remediating contaminated sediments, the Committee on Sediment Dredging at Superfund Megasites was convened by the National Research Council of the National Academies. In brief, the committee was charged with evaluating the effectiveness of dredging of contaminated sediments at Superfund megasites, including short-term and long-term changes in contaminant transport and ecologic effects. Overall, the committee was charged to strive to develop recommendations that would facilitate scientifically based and timely decision-making for megasites in the future. The committee concluded that sediment dredging can be effectively implemented to remove contaminants from aquatic systems, but technical limitations often constrain its ability to achieve expected outcomes. Dredging has had systematic difficulties in achieving short-term surface sediment cleanup levels. However, under some conditions dredging can achieve cleanup levels and aid recovery of biota at contaminated sediment sites. The committee emphasized the need for monitoring to establish whether or not the remedial action was having its intended effect, but determined that monitoring at most Superfund sites has been inadequate to determine whether dredging has been effective in achieving remedial objectives. The committee also expressed the need to make the monitoring data from remedial projects publicly available so independent evaluations of remedial effectiveness can be conducted. To improve future decision making the committee recommended that adaptive management approaches be implemented in the selection and implementation of remedies where there is a high degree of uncertainty about the effectiveness of the remedial action. EPA should compare the expected net risk reduction associated with each remedial alternative, taking into account the range of risks and uncertainty associated with each alternative. EPA also needs to improve site tracking, implementation of monitoring and adaptive management, and support research to examine the relationship between the remedial actions, site conditions, and risk reduction. This presentation will summarize the findings of the NRC report.

626 Monitoring of Remedy Effectiveness in Contaminated Sediments Management. M.S. Greenberg, U.S. EPA-ERT, Edison, NJ. Remedy effectiveness for environmental cleanup generally means meeting risk reduction goals in a cost effective and time-appropriate manner. The success of the selected remedy at a contaminated sediments site will be determined through evaluation of the data collected during the short- and long-term monitoring programs. Effectiveness measures include contaminant levels in sediment, bathymetry, mass of contaminant removed, volume of sediment removed, confirmation of cap placement, contaminant concentrations in fish/shellfish, toxicity testing, and ecological community surveys. This presentation will summarize the results of post-remedial monitoring data from selected contaminated sediment sites where a remedy (e.g., monitored natural recovery, capping, dredging) has been implemented and will provide an overview on upcoming monitoring activities at Superfund sites where the remedy is currently undergoing design or implementation.

627 Effectiveness of Remediation of PCB-Contaminated Sediments in the Grasse River, Massena, NY. J.P. Connolly, J.D. Quadrini, Quantitative Environmental Analysis, LLC, Montvale, NJ; L.J. McShea, Alcoa Inc., Pittsburgh, PR. Alcoa Inc. conducted the Remedial Options Pilot Study (ROPS) in 2005 to obtain site-specific information related to the implementation and effectiveness of potential remedial alternatives for addressing the PCB-containing sediments in the lower Grasse River. The

ROPS consisted of four components: 1) removal of debris and sediment from an 8-acre portion of the main channel, followed by capping; 2) removal of debris and sediment from a 0.5-acre area along the northern shoreline, followed by capping; 3) placement of a thin-layer cap over sediments in an approximate 0.5-acre area along the southern shoreline; and 4) construction of an armored cap in a 1-acre portion of the main channel. The ROPS also included an intensive monitoring program aimed at assessing the effects of the construction activities on the river system and surrounding communities. Dredging and dredging-related activities included boulder and debris removal, dredging via hydraulic auger, sediment processing, water treatment, and disposal. Despite significant efforts to remove the targeted sediments, residual sediments with elevated PCB concentrations remained throughout much of the work area. These residual sediments were capped using mechanical equipment. PCB releases downstream of the work area occurred during the project and increases in fish tissue PCB levels were observed during monitoring in fall 2005 after about 3 months of dredging and debris removal, although the fish recovered from the release by the fall of 2006. Dredging operations in the northern near shore area were successful in removing approximately 1,600 cubic yards of sediments in this area, leaving relatively low residual PCB concentrations. The residual sediments were capped using mechanical equipment. Thin-layered and armored capping were implemented in the southern near shore and main channel areas, respectively. Water column data indicated that PCB releases during cap construction were minimal. Post-remediation monitoring conducted in 2006 showed that the effectiveness of the various remedies was maintained for the most part and that new material had deposited on the caps.

628 Post Remediation Monitoring at sediment sites remediated under the Great Lakes Legacy Act. S. Ireland, M. Tuchman, U.S. Environmental Protection Agency, Chicago, IL. The Great Lakes Legacy Act (GLLA) was signed into law in 2002 authorizing \$270 million in funding over 5 years, beginning in fiscal year 2004, specifically to assist with sediment remediation in the Great Lakes Areas of Concern (AOC). As of June, 2007, U.S. EPA's Great Lakes National Program Office (GLNPO) has completed three sediment remediation projects and two are ongoing. Pre- and post-remediation data will be presented for two of the completed projects as well as the plans for the remaining sites. Confirmation sampling for these two sites demonstrated that sediment remediation goals had been achieved. The first completed site was the Black Lagoon located in the Detroit River AOC in Trenton Michigan. This remediation project resulted in the removal of 115,000 cubic yards of contaminated material which removed 470,000 pounds of contaminants from the waterbody. Upon completion of the mechanical dredging the bottom was covered with sand and stone to further protect fish and wildlife from any remaining contamination in the river. Sediment chemistry and sediment toxicity were collected and analyzed prior to the remediation and efforts are underway to collect data this summer to evaluate the ecological health post remediation. The second sediment remediation project accomplished under the GLLA was Newton Creek/Hog Island Inlet in the St. Louis River AOC in Superior, Wisconsin. This project removed 46,000 cubic yards of contaminated material. This project was remediated "in the dry" by isolating the area from Lake Superior and pumping out the water allowing the sediment to be excavated by traditional construction equipment. Sediment chemistry, sediment toxicity, and benthic community data were collected pre and post remediation. The evaluation of this data was not completed prior to the submission if this abstract, but will be presented.

629 Effectiveness of Remediation at a Toxic Hot Spot Site in San Francisco Bay. U. Vedagiri, C. Marks, H. Loso, URS Corporation, Oakland, CA. This presentation describes the effectiveness of remedial actions and subsequent monitoring undertaken at an offshore site contaminated with PCBs, PAHs and metals in San Francisco Bay. An area of concern (AOC) was defined within the 120-acre offshore area, based on potential risks to human health and ecological receptors associated with the upper 3 ft of sediments. The AOC was 3 acres and included intertidal and subtidal areas. The remedial action for the AOC included excavation and removal of shallow sediment, installation of an engineered cap, and mitigation of a saltmarsh wetland. The engineered cap included 3 sections: a shoreline slope cap, an intertidal cap and a submerged/subtidal cap. Monitoring of cap integrity and the success of the saltmarsh has occurred over 5 years. The effectiveness of the remedial actions in achieving risk reduction by elimination of exposure pathways and isolation of sediments, and by enhancing habitat quality and wetland function is evaluated for this award-winning project

630 Presence and potential exposure of fish populations to persistent organic pollutants at a remediated site in Sydney, Australia. C. Rawson, R. Lim, Environmental Sciences, University of Technology, Sydney, Broadway, New South Wales, Australia; C. Rawson, R. Lim, Institute for Water and Environmental Resource Management, Broadway, New South Wales, Australia; L. Tremblay, Landcare Research, Lincoln, New Zealand; M. Warne, Centre for Environmental Contaminants Research, CSIRO Land and Water, Glen Osmond, South Australia, Australia; E. Laginestra, Sydney Olympic Park Authority, Sydney Olympic Park, New South Wales, Australia; J. Chapman, Department of Environment and Climate Change, Sydney South, New South Wales, Australia. Sydney Olympic Park is a remediated site that was heavily contaminated with high levels of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), organochlorine pesticides and dioxins. The current study aimed to investigate the residual presence of these groups of persistent organic pollutants (POPs) in the sediment and overlying waters of a number of water bodies in Sydney Olympic Park using chemical analysis, EROD activity by cytochrome P4501A (CYP1A) induction in the H4IIE cell line and hepatic CYP1A in populations of the mosquitofish, *Gambusia holbrooki*, inhabiting the waters of the Park. Dioxin equivalencies in extracted water samples were low (<0.12 nM eqTCDD to 10.307 nM eqTCDD) with the highest readings from a site receiving storm water runoff. Extracted sediment ranged from <20 ng/kg eqTCDD to 1.2 µg/kg eqTCDD. Both water and sediment values were low compared with values from remnant water bodies in Sydney and Homebush Bay. Sediment chemistry showed PAH levels in unremediated Homebush Bay sites up to 10 times greater (19.36 mg/kg) than those from remediated water bodies. Hepatic EROD induction was significantly ($p < 0.05$) higher in fish from unremediated sites than those from remediated sites. Both groups were within the range measured in fish from other urban water bodies in the Sydney region (2158–22026 pmol resorfin/min/mg protein). While remediation has reduced the concentrations of POPs in the study sites it is clear that some sites require ongoing monitoring with others requiring investigation into continuing contaminant input in light of migratory bird and endangered aquatic taxa inhabiting the Park.

631 A Framework for Using Lakewide Background Tumor Prevalence in Delisting Decisions on Great Lakes Areas of Concern. P.C. Baumann, Field Station, OSU, U.S. Geological Survey, Columbus, OH; D.R. Smith, Leetown Science Center, U.S. Geological Survey, Kearneysville, WV. Areas of Concern (AOCs) in the Great Lakes were designated using Beneficial Use Impairments (BUIs), one of which concerned the prevalence of tumors in fish. This BUI could be delisted if the prevalence of fish tumors "did not exceed rates at unimpacted control sites". Since many AOCs have undergone remediation, such as the dredging of contaminated sediment, developing the methodology to determine tumor prevalence at "unimpacted control sites" has become crucial. We believe that a consistent framework for determining background prevalence or criteria should be developed for each of the Great Lakes. Using Lake Erie as an example, we propose a framework that uses historical and recent data to determine the statistical distributions of liver tumor prevalence in adult brown bullhead within sites, classified along a gradient of sediment contamination with polynuclear aromatic hydrocarbons (PAHs). The statistical distributions can then be used to determine thresholds of tumor prevalence for listing or delisting AOC's. Thresholds and distributional assessments can be incorporated in a structured decision analysis to account for risks of incorrectly listing or delisting due to uncertainties in sample data. As a first step in the development of this framework we present an example dataset in which we control for age effects by including age as a model covariate. We discuss tradeoffs associated with listing decisions under data uncertainties and the implications for effective sampling designs.

632 Novel statistical and experimental approaches to evaluate effectiveness of remediation in a metal-polluted stream: validating thresholds of recovery. W.H. Clements, B. Noon, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, CO; D. Sonderegger, H. Wang, Department of Statistics, Colorado State University, Fort Collins, CO. Although a long-term perspective is often necessary to evaluate effectiveness of remediation and recovery in aquatic ecosystems, natural variation in population dynamics and community composition complicates our ability to quantify impacts of anthropogenic stressors. We used a spatially extensive survey of 79 Colorado streams and a meta-analysis of 16 microcosm experiments to identify ecological thresholds of metal contamination, defined as the metal concentration that, when exceeded, resulted in pronounced changes in benthic community structure.

To estimate ecological thresholds, data were analyzed using both traditional (piecewise regression) and derivative-based (locally weighted polynomial regression; SiZer) statistical approaches. To validate and test the ecological significance of these thresholds, we examined long-term (1989-2007) changes in heavy metal concentrations and benthic communities in the Arkansas River, a mining-impacted stream in central Colorado. In 1992, three years after we began this research program, state and federal agencies initiated a large scale restoration program designed to improve water quality in the Arkansas River, thus providing a unique opportunity to quantify recovery thresholds. Results showed that experimentally derived estimates of toxicity were generally much greater than recovery thresholds and therefore inadequate to protect stream ecosystems. In contrast, ecological thresholds derived from spatially extensive data provided a good estimate of recovery thresholds for benthic communities.

633 Societal cost-benefit analysis for soil remediation in the Netherlands. A.V. Wezel, Chemical water quality and health, KIWA Water Research, Nieuwegein, Netherlands; R. Franken, E. Drissen, R. van den Berg, Netherlands Environmental Assessment Agency, Bilthoven, Netherlands; K. Versluijs, National Institute for Public Health and the Environment, Bilthoven, Netherlands. This societal cost-benefit analysis for soil remediation operations in the Netherlands, distinguishes four options for future investments. In the zero option government funding will be terminated. Because –legal- incentives do not change, private parties continue with remediation. Besides, three policy options are distinguished with government-finance. Soil remediation does deliver benefits to human health, the drinking-water supply, housing, perceptions and the ecosystem. Much of the Netherlands population is concerned about soil contamination. The benefits for health, drinking-water supply and housing are expressed in monetary terms. To what extent the benefits weigh up to the money spent depends partly on the –value-taxed discount rate chosen. Use of the current discount rate of 4% means a slightly negative balance whatever the policy option chosen. Focusing on non-material benefits, such as ecology, can cause the scales to tip in another direction. By using a lower discount rate future benefits, such as health and drinking-water supply, are considered more important. If the discount rate drops to 2% or less, all policy options may lead to a positive balance. Particularly the health benefits that are veiled in uncertainty may be a reason for applying a surcharge and, in turn, a higher discount rate; in this case, all the options will lead to a net negative balance. This analysis was carried out for the whole soil remediation operation; however, weighing up costs and benefits on remediation components or for individual sites will produce other results. The net benefits of soil remediation on an individual site are – excluding historical causes and type of contamination particularly dependent on the soil use and population density.

634 REACH 'Basics of the regulation'. M. Crane, C. Watts, Watts & Crane Associates, Faringdon, United Kingdom; A. Fasey, Protection Through Knowledge Ltd., Hampshire, United Kingdom. The advent of REACH in the European Union has global implications for the way in which chemicals are manufactured, exported and used. The effects of these regulations go far beyond the usual Health, Safety and Environment functions of most corporations, with potentially serious impacts on the ability to market and use a range of business-critical substances. It is therefore essential that the manufacturers, importers and users of chemicals understand the basics of the regulations, can identify what needs to be done to protect their business, and know when they need to act. They will also need to develop clear strategies that allow them to co-operate effectively with a range of other parties, including competitors. This presentation provides a strategic overview of the most critical elements of REACH, and identifies appropriate ways for corporations to protect their business interests whilst complying with the regulations over the coming years.

635 REACH 'European Industry perspective'. W. De Wolf, Human and Environmental Sciences - Europe, DuPont, Mechelen, Belgium. REACH will require many companies to change their approach from product based thinking towards substance based thinking. The first step for many of them towards that change is to compile substance inventories across products to allow estimation of annual tonnages imported or marketed in Europe. Another step in the business process to prepare for REACH is to change the hazard information gathering, evaluation and data sharing process. In future, this will take place in Substance Information Exchange Fora, so called SIEFs. This SIEF process will be used to identify potential hurdles and challenges that industry will be confronted with, and possible solutions will be discussed. Furthermore, to gather information relevant for the exposure assessment the

technical community will need to learn to communicate in clear and simple language with industry managers within their own company, as well as within the supply chain. Although there are some parts of REACH that do not require fundamentally different approaches, it will require a mindset change in many areas. REACH is no more business as usual!

636 Implications of REACH for Multi-National Corporations Focus on substances. M. Herwig, GE. Implications of REACH for Multi-National Corporations Focus on substances

637 REACH: Confidentiality, data sharing and consortia – How to work together and protect your Intellectual Property. P. Jones, Hammonds, Manchester, United Kingdom. REACH is an unusual piece of legislation, introducing the concept of the compulsory sharing of information and co-operation amongst competitors. It is therefore essential that companies are aware of what they are obliged to share, how to take steps to protect their intellectual property and how to co-operate advantageously in consortia without exposure to liability and potential litigation. This includes understanding the European competition rules that will govern how competitors interact. This presentation will give practical and strategic guidance on how to protect company intellectual property whilst working co-operatively with competitors as well as how to exploit the data-sharing opportunities that REACH brings. This presentation will also look at the implications of REACH on researchers, including how the sometimes diverging interests of publication of research and confidentiality can be practically balanced against the background of REACH.

638 Exposure Scenarios under REACH. F. Verdonck, M. Vangheluwe, P. Van Sprang, EURAS, Gent, Belgium. In REACH, the exposure assessment is required for substances meeting the criteria for classification as dangerous or assessed to be a PBT or vPvB substance and is a prerequisite for conducting a risk characterisation. The development of the exposure scenario (ES) and the exposure assessment process is of an iterative nature. An initial, worst-case assessment is first conducted after which refinements and risk management measures are made until no risk has been estimated or further refinements are not necessary. In this presentation, an overview of the tools available to develop an ES will be given for occupational, consumer and environmental exposure (based on the latest draft RIP 3.2.2). In addition, several options for the registrant will be given on how communication through the supply chain can support the ES development. Finally, the usefulness of an intelligent data collection tool will be illustrated to identify and rank the most important parameters (physico-chemical properties, emission estimates, etc...) and risk management measures (of technical, organisational, economical... nature) influencing the local and regional risk characterisation.

638.1 US EPA tools and databases: Opportunity for industry to reapply to support REACH Compliance. L. Libelo, U.S. EPA, Washington, DC. US EPA tools and databases: Opportunity for industry to reapply to support REACH Compliance

638.2 Interfaces Between REACH, Classification and GHS. W. Adams, Rio Tinto, Magna, UT; C.A. Pittinger, BBL Sciences, Cincinnati, OH. REACH legislation in the EU entered force on June 1, 2007 and requires substances undergoing Registration to be assessed in terms of their hazard classification and the information be included as part of the Chemical Safety Report (CSR). Additionally, legislation is pending that would adopt major portions of the United Nation's Globally Harmonized System for Classification and Labeling of Chemicals (GHS). This legislation will provide guidance on hazard classification of chemical substances impacting both the need for Authorization and hazard statements in Material Safety Data Sheets. GHS is intended to standardize requirements for classification and labeling across the global chemical industry, and deliver a globally-consistent hazard communication system. The immediate onus on industry is to gain consensus across industrial sectors for "self-classified" chemicals according to human health, physical-chemical, and environmental endpoints, to minimize differences in data interpretation and decision rationale. The classification process will require industry to re-evaluate toxicological and environmental data and the need for new data for many substances. Often, professional judgment will be required to justify classification decisions on a weight-of-evidence approach, placing a strain on technical resources and introducing the potential for different classifications for the same substance. During the international transition periods from existing systems to GHS, companies will likely have to logistically juggle several MSDS systems simultaneously, and in

multiple languages. To meet these hurdles, new or expanded IT systems and MSDS-authoring services to link corporate functions involving marketing, purchasing and HSE must be deployed. The transition to GHS will have broad corporate ramifications that may not be readily evident.

639 Uptake and trophic transfer of selenium in aquatic model food chains. D. Wallschläger, J. Charters, Environmental & Resource Sciences Program, Trent University, Peterborough, Ontario, Canada; M. Garton, Great Lakes Environmental Center, Traverse City, MI; D. McIntyre, Great Lakes Environmental Center, Columbus, OH. Selenium accumulates in aquatic food chains, and may cause deformities and reproductive effects in higher organisms, such as water fowl and predatory fish. Efforts are underway to regulate selenium in aquatic ecosystems based on tissue concentrations encountered in organisms, so it is of primary importance to identify and quantify the factors that influence the uptake of selenium from the water or sediment into the food chains, as well as its transfer between trophic levels. In this study, we assess selenium accumulation in fish at the top of simple aquatic food chains as a function of time and selenium exposure. The concentrations of selenium in bluegill sunfish (*Lepomis macrochirus*), exposed to selenium via water and their diet, the blackworm (*Lumbriculus variegatus*), was monitored in controlled laboratory experiments over a period of 180 days. Exposure consisted of six different combinations of water/diet selenium concentrations, where the dietary selenium concentration was adjusted by feeding yeast of varying selenium concentrations to the worms. Total selenium concentration and selenium speciation in the exposure waters were monitored by hydride generation-atomic fluorescence spectrometry (HG-AFS), and selenium speciation was periodically checked by anion exchange chromatography-inductively-coupled plasma-mass spectrometry (AEC-ICP-MS). Total selenium concentrations in fish and worm tissues were also determined by HG-AFS after digestion with concentrated HNO₃, and normalized to dry weight basis. The kinetics of Se uptake and accumulation in bluegill will be presented, and discussed in relation to the exposure concentrations.

640 The Use of Passive Algae Diffusion Samplers (PADS) to determine bioaccumulation of selenium in the environment. D.B. Simmons, Watershed Ecosystems Graduate Program, Trent University, Peterborough, Ontario, Canada; A. McDonald, D. Wallschläger, Environmental Resource Sciences, Trent University, Peterborough, Ontario, Canada. Passive sampling devices containing algae as a biological indicator organism were developed in order to obtain site-specific information about bioconcentration of selenium in the field. These devices were tested downstream of effluent discharge from a uranium milling operation in northern Saskatchewan that contains a selenium gradient. Passive Algae Diffusion Samplers (PADS) consisting of pure cultures of *Chlorella vulgaris* grown in semi-solid medium contained within a semi-permeable membrane were constructed to float and withstand turbulence. They were then shipped to the site and deployed at three different sites with three different exposure levels including a control site with no detectable selenium exposure. PADS were then removed from site, shipped back to our laboratory at Trent University, Peterborough, ON and analyzed for total selenium using inductively-coupled-plasma mass-spectrometry (ICP-MS) after microwave digestion. Bioconcentration factors calculated in *Chlorella vulgaris* from field data will be presented and compared to results found in the lab and previous studies. We will also discuss the potential of these devices for effective use in the field to assess site-specific criteria and confirm long term models.

641 Selenium accumulation in *Artemia franciscana* under conditions relevant to the Great Salt Lake, Utah. M. Grosell, R. Gerdes, RSMAS, University of Miami, Miami, FL. *Artemia franciscana* is the largest aquatic predator in the Great Salt Lake (GSL) and serves as one of the principle food sources for the high number of waterfowl relying on the GSL habitat. Considering the well documented avian reproductive effect arising from ingestion of selenium contaminated food, the present study set out to determine selenium accumulation rates in *Artemia* from both water-borne and dietary sources. Selenium accumulation rates and steady state concentrations are being modeled from measurements of uptake kinetics from the water, ingestion rates and assimilation efficiencies as well as selenium elimination rates. Both uptake and depuration of selenium as well as media selenium concentrations are measured using a Se-75 isotopic approach which avoids the matrix related analytical challenges otherwise associated with selenium measurements in saline environments. The GSL native algae, *Dunaliella viridis*, are being cultured in the presence of elevated media selenium concentrations to provide a natural diet for studies of *Artemia* selenium assimilation from the diet. The algae *D. viridis* displays a biphasic pattern of

selenium accumulation when cultured in the presence of 2 µg/l selenate. Rapid accumulation during the initial 6 days of culturing peaking at 120 µg Se/g dry weight is followed by an apparent depuration phase leading to steady state concentrations of ~20 µg Se/g dry weight. This biphasic pattern of selenium accumulation suggests homeostatic control of selenium in *D. viridis*. Algae grown to steady state with respect to selenium concentrations will be fed to *Artemia* to determine ingestion rates and assimilation efficiencies at different dietary selenium concentrations. Selenium accumulation in *Artemia* from the water displays saturation type kinetics at low ambient selenium concentrations and is inversely correlated with salinity of the exposure medium. The ultimate goal of these studies is to construct a model which will allow for prediction of steady state selenium concentrations in *Artemia* from the GSL based on recorded concentrations of selenium in the GSL water and *Artemia* diet.

642 Characterizing the toxicity of pulsed selenium exposure to *Daphnia magna*: latent mortality and potential of tolerance development. T.C. Hoang, Environmental Studies, Florida International University, North Miami, FL; T.C. Hoang, S.J. Klaine, Biological Sciences, Clemson Institute of Environmental Toxicology, Pendleton, SC. The acute toxicity of selenium (Se) to aquatic biota has been studied extensively for decades. However, most studies have used a constant concentration aqueous exposure of Se to an invertebrate species. Since constant concentration exposure of toxicants to invertebrates is unusual in the environment, episodic exposure or pulsed exposures may represent true risk to aquatic biota more accurately. This research was designed to characterize the toxicity effects of pulsed Se exposures to *Daphnia magna*. Selenium exposure was varied during a 21-d chronic toxicity test to examine the effects of exposure concentration, duration, and recovery on survival, growth, and reproduction of *D. magna*. While *D. magna* did not die during exposures, latent mortality was observed. Latent mortality increased with exposure concentration and duration. Hence, standard toxicity test using continuous exposures would underestimate Se toxicity. Risk assessment method using results of continuous exposure would underestimate risk of Se to biota. For double-pulse exposures, cumulative mortality on day 21 was higher when time interval between pulses was shorter. With the same total exposure time, continuous exposure caused higher toxicity than did pulsed exposures due to recovery and tolerance development in *D. magna* after earlier pulses. The recovery of *D. magna* after pulses were stopped also resulted in no effects on growth and reproduction of surviving *D. magna*. Based on these results, risk assessment for Se should take latent effects and the effect of recovery in to account.

643 Critical Review of Selenium Bioaccumulation and Bioconcentrations Factors for Freshwater Fish. M. Wacksman, N. Weinberg, ARCADIS, Portland, ME; A. Pawlisz, ARCADIS-BBL, Tampa, FL; J. Staveley, ARCADIS, Durham, NC; T. Purcell, API, Washington, DC. Selenium in the aquatic environment has natural and anthropogenic origins. Released selenium readily cycles in the environment and some forms of this essential metal bioaccumulate and biomagnify in biota, including fish. Knowledge regarding the propensity of selenium to enter and remain in fish is critical in understanding its biological fate, toxicity, and derivation of site-specific water quality standards. This presentation describes the methodology used to retrieve existing bioaccumulation (BAF) and bioconcentration (BCF) factors for selenium as well as the approach used to calculate new values using ambient water and whole fish data reported in monitoring studies. As part of the methodology, the authors present a modified Klimisch approach to assess the quality/applicability of the data. Some of the key ranking criteria considered included the type of tissue analyzed, measured concentrations, time of exposure, and the exposure route. Other factors considered were selenium forms, uptake modifying factors, species, size, trophic level, food web structure, and water body type. Over 400 publications were initially identified, with 26 being eligible for analysis based on the presented criteria. A tabulated listing of these studies is provided along with Klimisch ranking and key information. Of the 26 selected publications, nine reported BAF and BCF values. An additional eleven BCF and BAF values were calculated from the remaining reports. Overall, the results indicate that BAF and BCF vary considerably and that the selection of appropriate BAFs or BCFs must consider site-specific factors. The application of the obtained values is discussed in terms of the derivation of site-specific water quality criteria for this metal.

644 Selenium exposure histories derived from analysis of selenium in otoliths of rainbow trout (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*) from an area impacted by coal mining in Alberta's eastern slopes. V.P. Palace, Fisheries and Oceans, Freshwater Institute,

Winnipeg, Manitoba, Canada; C. LeVasseur, N. Halden, Department of Environment, University of Manitoba, Winnipeg, Manitoba, Canada; G. Sterling, Fish and Wildlife Division, Alberta Sustainable Resource Development, Edson, Alberta, Canada. Examining the potential effects of contaminants on wild fish is often limited by the ability to determine if fish are indeed exposed to the effluent being evaluated. Measuring contaminants in muscle or visceral tissues of the fish can be useful, but depuration, metabolic transformation and mobilization of contaminants among tissues dictates that these measures are only indicative of recent exposure. Otolith, inner ear bones in fish, are metabolically stable and have been used for ageing fish because of the regular accumulation of calcium carbonate in daily and annual growth rings. Recent evidence suggests that these rings can also provide a permanent record of exposure to some elements that fish are exposed to in industrial effluents. Microchemical analysis of the growth rings is typically accomplished by laser ablation inductively coupled mass spectrometry (LA-ICP-MS). Until now, divalent cations which can substitute for calcium during the assembly of the otolith structure (eg. Zn, Mn, Mg, and Sr,) have been studied. More recently, we have used LA-ICP-MS to analyze elements incorporated in the mineral and protein matrix of the otolith, including Se, which behaves as an anion in the environment and in biological tissues. LA-ICP-MS was used to analyze selenium in otolith annual growth rings from rainbow trout and brook trout that were captured from reference streams and from streams with elevated selenium downstream from coal mining activity. Results illustrate important differences in exposure patterns between the two species.

645 Effects of Selenium Discharges from Coal Mining in Western Canada. P.M. Chapman, Golder Associates, North Vancouver, British Columbia, Canada; R. Berdusco, R. Jones, Elk Valley Coal Corporation, Calgary, Alberta, Canada. Investigations into the effects / impacts of selenium released from coal mining are being conducted in both British Columbia and Alberta (Canada). The findings of an expert Selenium Science Panel in 2005 in Alberta serve as a guide to necessary studies. Four categories of investigations have been and are being conducted: effects; monitoring; other studies; and management. Studies conducted to date have determined an absence of impacts to fish (cutthroat trout) and water birds (American dipper and spotted sandpiper) living in the predominantly lotic (flowing water) areas of the Elk River Valley, BC. There is disagreement regarding impacts to fish (rainbow trout) in Luscar Creek, Alberta, but impacts do not appear to be occurring to water birds downstream of the Alberta mines. In the less common but more at risk lentic (still water) areas of the Elk River Valley, an absence of Se-related impacts has been determined for red-winged blackbirds, eight species of waterfowl, longnose sucker and Columbia spotted frog. An effects study on cutthroat trout living in a lentic environment partially confirmed the findings of the previous lotic study with this same species, specifically that cutthroat trout have a relatively high tolerance to Se. Although the two cutthroat trout effects studies also resulted in some contradictory findings, there are no indications of impacts from Se. Monitoring studies indicate increasing concentrations of Se in waters downstream of the BC coal mines but no corresponding increase in fish muscle Se concentrations. Similar increases in water column concentrations are occurring downstream of the Alberta mines. Biogeochemical studies are being conducted into Se release and cycling as part of ongoing management activities. A management decision framework has been developed that provides a means to integrate present and future information to effectively manage Se releases from the coal mines to ensure environmental protection.

646 Canadian Regulatory Assessment Of Ecological Risk and Adaptive Management Requirements for Selenium In A Uranium Mill Effluent. D.A. Wismer, M.H. McKee, Environmental Risk Assessment, Canadian Nuclear Safety Commission, Ottawa, Ontario, Canada. This study evaluated ecological risk in order to determine the need for mitigation and environmental performance measures for treated uranium mill effluent at a site in northern Saskatchewan, Canada. We integrated several studies which provided (1) hazard predictions from site ecological risk modelling (2) larval deformity rates among laboratory cultured fertilized eggs of field-captured fish; (3) observational data on fish relative abundance and environmental concentrations (water, sediment, macrophyte, fish and muskrat tissues); (4) site-specific selenium and molybdenum water quality objectives for environmental protection based upon local and regional environmental concentration data. Hazardous conditions were estimated from field, laboratory and modelling studies to be of sufficient total duration (40 to 60 years), spatial extent (10 to 15 km) and biological scope (birds, mammals,

benthic invertebrates, large and small-bodied fish) to require mill operational controls for environmental protection and recovery. Tissue-based water quality performance objectives were determined for a lake situated 10 km downstream of the mill for exposure of fish to selenium (0.0005 mg/L) and muskrats to molybdenum (0.050 mg/L). Site ecological model predictions of rates of recovery of water, sediment, plant and animal tissue concentrations were required to determine the sample size necessary to test recovery performance. The integrated approach combining four types of studies was sufficiently robust to allow acceptance of the conclusion of significant risk and need for mitigation by independent reviewers (9 scientific peer reviewers) and a regulatory decision-making tribunal. It was important to provide an explicit listing of lines of evidence (spatial, biological receptor) and associated confidence (predicted and/or observed) as well as uncertainties.

647 Using ecosystem-scale and biodynamic modeling to forecast implications of different selenium guidelines. S.N. Luoma, T. Presser, US Geological Survey, Menlo Park, CA. Ecosystem-scale modeling is a stepwise approach that combines existing knowledge (both generic and site-specific) about Se loadings, concentrations, speciation, transformations, bioaccumulation and trophic transfer to forecast the fate and effects of Se under different environmental conditions. Forecasts from the model can be used to evaluate different proposals for guidelines or criteria (water-based, tissue-based or tissue-to-water conversions). An advantage of the stepwise approach is that it confronts knowledge uncertainty directly by constructing scenarios for different feasible circumstances. For example, the model can be used to show the outcome of different choices for saltwater criteria: 1, 2, 5 and 75 ppb. Then the range of Se loadings to a specific bay or estuary can be determined to meet the different outcomes. The particulate Se concentrations that are chosen to evaluate the dissolved guidelines are developed from transformation constants that are either site-specific or typical of similar habitats. Uptake by invertebrates from two different food webs are estimated from biodynamic models for types of animals typical of the site, and tissue concentrations are compared to tissue guidelines base upon toxicity tests. Tissue concentrations in different predators are forecast from the existing field data. The results show that protection provided by a guideline is highly dependent upon environmental conditions. Transformation constants and food web-type are critical in determining what animals are threatened and when. The method provides a framework for site-specific analysis of the implications of Se contamination scenarios.

648 Estrogen receptor "hijacking" by AhR-agonists and dioxin-like PCB congeners 126 and 77 in fish. A. Arukwe, A.S. Mortensen, Dept. of Biology, Norwegian University of Science and Technology (NTNU), Trondheim, Norway. Aryl hydrocarbon receptor (AhR) agonists are known to have anti-estrogenic properties. The anti-estrogenicity of AhR agonists are believed to be mediated through crosstalk between the estrogen receptor (ER) and AhR. In salmonid, this crosstalk is bidirectional and can be observed as alterations in gene and protein expression patterns. In the present study, we show that the strong AhR and dioxin-like PCB congener 126 produced estrogenic responses (ER-hijacking) in salmon hepatocytes. ER-hijacking, a phenomenon that was recently described in mammalian system occurs when the AhR-Arnt complex binds directly to the ER and induces transcription of ER controlled genes. Salmon hepatocytes isolated by two-way perfusion techniques were exposed to PCB126 (0.001, 0.01 and 0.05 μ M) and the ER agonist nonylphenol (NP) at 5 and 10 μ M, singly and also in combination. A second experiment was performed using cultured hepatocytes and 1 μ M PCB-77 with sampling at 12, 24, 48 and 72 h after exposure. The third experiment was performed with PCB126 at the above named concentrations in the presence and absence of ICI (ER-antagonist). The mRNA expressions were analyzed by quantitative PCR using gene specific primers of genes involved in the AhR pathway (AhR α , AhR β , Arnt, AhR-repressor, CYP1A1, UGT and a proteasome unit) and genes regulated by ER (ER α , ER β , Zr-protein, Vtg and vigilin). While NP alone induced the expression of genes controlled by ER, anti-NP actions of PCB126 were only observed in the expression patterns of ER α and ER β . Interestingly, the expression levels of ER-isoforms, Zr-protein and Vtg significantly increased in cells treated with PCB126 and 77 alone and these effects were reduced in the presence of ICI in a time-specific manner. Exposure of cells to PCB126 or PCB77 alone, induced AhR mediated transcription of CYP1A1, Ugt and Arnt, and NP inhibited these gene responses. These results strongly indicate that ER-hijacking is part of our recently postulated complex interactions between the ER and AhR in salmon. We believe that these results, especially the estrogenic actions of

PCB126 and 77, despite being novel, will assist to further unravelling the mechanisms involved in ER-AhR crosstalk.

649 Wastewater treatment effluents can hinder DNA repair processes in exposed zebrafish. G. Mayer, E. Notch, University of Maine, Orono, ME. Natural phenolic steroid estrogens and the semi-synthetic pharmaceutical estrogen, 17 α -ethinylestradiol, have been detected in the aquatic environment in quantities sufficient to elicit altered physiological processes in fish. Pharmaceutical estrogens enter the aquatic environment primarily via wastewater treatment facilities as excretory products or after improper disposal of unused prescriptions. Numerous investigations throughout the past several years have implicated pharmaceutical estrogens in altered reproductive status of aquatic fauna including unwarranted vitellogenesis and many other reproductive abnormalities. In addition to altering reproductive endpoints, aquatic estrogens are known mutagens and tumor promoters. Currently, little to no data exists that explains the role of estrogens in neoplastic transformation. We exposed zebrafish (*Danio rerio*) to effluents from three wastewater treatment plants in Maine that use differing treatment types. Estrogenicity was analyzed by in vitro reporter assays (luciferase production), examined via analysis of known biomarkers of estrogen exposure in vivo (vitellogenin and CYP1A1 mRNA abundance), and these endpoints were correlated with zebrafish hepatic DNA repair parameters (nucleotide excision repair gene expression and activity) after exposure to wastewater effluent. Results of this and corollary studies suggest waterborne estrogens in wastewater effluent can hinder DNA repair capacity in exposed fish and implicate aquatic estrogens as co-factors in environmental carcinogenesis.

650 Short-term exposure of the fathead minnow (*Pimephales promelas*) to a pyrethroid insecticide: Implications for growth, behavior, and predation risk. E. Floyd, San Diego State University/UC Davis, San Diego, CA; J.P. Geist, Technische Universität München, Freising, Germany; I. Werner, University of California, Davis, Davis, CA. Pyrethroids are highly toxic to fish, yet little information exists regarding their sublethal effects on aquatic organisms. The objective of this study was to determine the effects of short-term (4 h) exposure to sublethal levels of the pyrethroid esfenvalerate [(S)- α -cyano-3-phenoxybenzyl-(S)-2-(4-chlorophenyl)-3-methylbutyrate] on food consumption, growth, behavior, and predation risk in larvae of the fathead minnow (*Pimephales promelas*). For the determination of growth rates, 8-d old fathead minnows were exposed to five esfenvalerate treatments (control, solvent control, 0.1 μ g/L, 0.7 μ g/L, 1.5 μ g/L), then transferred to uncontaminated water and held for 7 d. Unconsumed food and abnormal swimming behavior were monitored daily. For predation experiments, 10 fathead minnows from each treatment were transferred to 2.5-gallon aquaria immediately following 4-h exposures; each aquarium contained one juvenile threespine stickleback (*Gasterosteus aculeatus*). Sticklebacks were allowed to feed for 45 minutes, after which the number of minnows remaining was recorded. Fish exposed to 0.7 μ g/L and 1.5 μ g/L exhibited impaired swimming and feeding ability 24 hours after exposure, and had reduced growth compared to fish exposed to 0.1 μ g/L and controls. Predation risk was significantly higher in fathead minnows exposed to 0.7 μ g/L and 1.5 μ g/L esfenvalerate than in control fish. These results demonstrate that larval fish can experience significant growth impairment, as well as increased predation pressure and thus reduced evolutionary fitness, even after short-term exposures to sublethal concentrations of esfenvalerate.

651 Reproductive behaviors link biochemical and morphological changes in fathead minnows exposed to 17 α -ethinylestradiol. J.D. Salierno, A. Kane, Center for Environmental and Human Toxicology, University of Florida, Gainesville, FL; J.D. Salierno, A. Kane, Epidemiology & Preventive Medicine; & Dept Veterinary Medicine, University of Maryland, College Park, MD. Ecologically-relevant indicators of endocrine disruption in fish must be linked with measures of reproductive success. The ability of male fathead minnows, *Pimephales promelas*, to compete for, maintain, and defend a spawning substrate is paramount to reproductive success. This study quantified alterations in male fathead minnow reproductive behaviors after exposure to environmentally-relevant concentrations (0, 10, 20 or 40 ng/L) of 17 α -ethinylestradiol (EE2) for 21 days. A video-based behavioral quantification system examined changes in male-male competitive behaviors (i.e., chasing and head butting), and ability of males to maintain spawning substrates (i.e., nibbling and scrubbing). Behaviors analyzed included time under the spawning substrate, frequency of substrate cleaning, and conspecific aggression. Plasma hormone levels (11-KT, T, and E2), vitellogenin (VTG), secondary male characteristics (tubercle count and dorsal nape pad rank),

gonadal-somatic index (GSI), and gonad histology were also evaluated. Exposure to 40 ng/L EE2 decreased the ability of exposed males to compete with control males for spawning substrates ($p = 0.09$). Further, exposed males displayed reduced frequency of substrate cleaning activities as well as chasing male competitors ($p \leq 0.05$). 11-KT, T, and E2 were lower, and VTG was notably higher, in EE2-exposed males compared with control males ($p \leq 0.03$). EE2 exposure in males was also associated with reductions in tubercles, lower GSI and gonadal maturity ranks, number of resorbed tubercles, and presence of an ovipositor ($p \leq 0.001$). These data reveal alterations in male reproductive behavior that coincide with decreased hormone levels and secondary sex characteristics. Behavioral endpoints to discern potential ecological consequences in fish exposed to low concentrations of EDCs may provide sensitive and functional indices of exposure.

652 Effects of Environmentally Relevant Levels of Diazinon on the Olfactory Function and Behavior of Chinook Salmon in Two-Choice Maze Systems. D.B. Powell, R.C. Palm, ProFishent, Inc., Redmond, WA. Although it has been well documented that the sense of smell is necessary for imprinting and homing in anadromous fish species, other potentially critical roles for olfaction, such as predation avoidance, are poorly understood. It is possible that some common watershed contaminants could negatively affect juvenile salmonid populations by disrupting their ability to detect natural alarm substances, conceivably increasing susceptibility to predation. To investigate this, controlled laboratory two-choice maze tests were used to evaluate the olfactory function of juvenile chinook salmon (*Oncorhynchus tshawytscha*) following immersion treatments of 0, 1, 10, or 100 micrograms/L of the organophosphate pesticide Diazinon. Randomly selected groups of salmon were exposed to Diazinon for two hours, followed by as much as a one-hour recovery period in clean water. Salmon were then transferred to the pre-choice zone of a simple, two-choice maze with parallel streams of water. After 2 minutes, a dilute scent composed of either L-serine or chinook skin extract was pumped into the water supply of the pre-selected "alarm-scented" arm. An identical, parallel arm that received unscented water provided an alternate place to which fish could swim after both gates were opened. The position of each fish was recorded in a digital photograph after a ten-minute decision period. The gates leading to each arm were then quickly lowered and the salmon counted to confirm their positions in scented, unscented, and "pre-choice" areas of the maze. Certain aspects of maze design, test procedures, and animal husbandry appeared to be important to achieve accurate and unbiased results. The order of pesticide exposure levels were randomly assigned for each scent type. The data suggest that olfactory function in chinook salmon, as measured by the ability to distinguish and respond to putative alarm scents, are not affected by environmentally relevant water-borne doses of Diazinon.

653 Acute and Sublethal Toxicities of Rotenone in Juvenile Rainbow Trout (*Oncorhynchus mykiss*): Swimming Performance and Oxygen Consumption. W. Cheng, PWGSC, Public Works and Government Services of Canada, Halifax, Nova Scotia, Canada; T.P. Farrell, Department of Zoology, University of British Columbia, Vancouver, British Columbia, Canada. Rotenone, a natural insecticide and piscicide, was shown to have an extremely small margin between no lethality (5.0 μ g/L) and 100% mortality (6.6 μ g/L) for static-renewal 96-hour toxicity tests with juvenile rainbow trout (*Oncorhynchus mykiss*). Dissolved organic carbon (DOC) at concentrations of 3.0 and 4.0 mg/L significantly increased the rotenone 96-hour LC50 (median lethal concentration) from 5.80 μ g/L (CL 5.51 to 6.10) to 6.55 μ g/L (CL 6.28 to 6.83) and 7.75 μ g/L (CL 7.29 to 8.24), respectively, probably as a result of rotenone adsorption onto DOC, which decreased its bioavailability. Using concentrations of 0, 3.0, 4.0, and 5.0 μ g/L rotenone and exposure periods of 2, 4, 6, 12, 16, 24, and 48 hours, the threshold concentration of rotenone for impairment of critical swimming performance (Ucrit) was 3.0 μ g/L ($P = 0.029$), with no further impairment at higher concentrations and no time-dependent effect on Ucrit. Using continuous measures of oxygen uptake for 48 hours before and 48 hours during rotenone exposure (0, 1.5, 2.5, 3.0, and 3.5 μ g/L), rotenone significantly decreased peak active oxygen uptake at all rotenone concentrations tested without affecting routine oxygen uptake. Fish were individually chased and then placed in rotenone concentrations of 0, 1.0, 3.0, 4.0, 5.0, and 6.0 μ g/L to monitor initial post-exercise oxygen uptake (Mo2Max) and excess post-exercise oxygen consumption (EPOC) during a 40-minute recovery period. Rotenone significantly decreased Mo2Max ($P = 0.002$) after exposures to 4.0 and 5.0 μ g/L, but not 6.0 μ g/L, without affecting EPOC. Rotenone, exhibits very steep dose-response curves for both lethal and sublethal metabolic effects, such that the margins between mortality

and threshold sublethal effects extremely small. Only prudent application of rotenone for selective killing and detailed knowledge of thresholds of toxicity for both selected and non-target species will allow the continued use of this toxic compound.

655 Effects of Dietary Methylmercury on Serum Hormone Levels in Goldfish (*Carassius auratus*). K. Crump, N. Basu, E. Zhao, D. Lean, V. Trudeau, Biology, University of Ottawa, Ottawa, Ontario, Canada. Methylmercury (MeHg) exposure can impair reproduction in teleost fish, yet the mechanisms involved remain largely unexplored. Adult female goldfish (*Carassius auratus*) were fed *ad libitum* one of three environmentally relevant dietary concentrations of MeHg: 0.02 (control), 0.89 (low), and 8.78 (high) $\mu\text{g Hg g}^{-1}$ dry weight (dw). After four weeks, mean carcass total mercury concentrations were 0.04, 0.51, and 4.89 $\mu\text{g Hg g}^{-1}$ dw. Neuroendocrine tissues accumulated mercury to concentrations of 0.05, 0.46, and 7.78 $\mu\text{g Hg g}^{-1}$ dw in the hypothalamus and 0.09, 0.56, and 6.65 $\mu\text{g Hg g}^{-1}$ dw in the pituitary. To examine the effects of MeHg at the hypothalamic-pituitary level, the *in vivo* luteinizing hormone (LH) release response was assayed in subsets of mercury fed fish at 6 h post i.p. injection with either saline (0.6% NaCl) or a salmon gonadotropin releasing hormone analog (GnRH; 10 ng g^{-1} body weight in 2 $\mu\text{L g}^{-1}$ body weight). Goldfish fed the low MeHg diet had decreased levels of serum testosterone (91 % lower, $P < 0.001$) compared with those fed the control diet. Upon GnRH-stimulation, circulating levels of testosterone increased to equivalently elevated levels in control and treated goldfish. Basal serum LH levels were also significantly decreased (75 % lower, $P < 0.001$) in fish fed the low MeHg diet compared to control but levels were comparable between treatments under GnRH-stimulated conditions. Pituitary LH content was neither affected by MeHg diet nor GnRH-stimulation. These results suggest that in addition to previously reported alterations in gonad steroidogenic activity, environmentally relevant levels of MeHg can alter basal pituitary function. It remains to be elucidated whether this is a direct effect at the hypothalamus and/or pituitary or a secondary result of decreased positive feedback resulting from suppressed testosterone. Funded by NSERC.

656 Predator Avoidance by Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) Following Exposure to Sublethal Levels of Diazinon. D.B. Powell, R.C. Palm, ProFishent, Inc., Redmond, WA. The organophosphate Diazinon is a commonly applied pesticide in many agricultural areas of the United States, including some watersheds that contain salmon populations listed as threatened or endangered by the U.S. Endangered Species Act. Although a significant number of toxicological studies have examined the lethal impact of organophosphates on fish, very few have investigated possible sublethal effects on piscine sensory functions such as olfaction. It has been postulated that olfaction may play a key role in protecting juvenile outmigrating salmon from fish predation through the detection of chemical alarm substances, thus permitting the timely initiation of avoidance behavior. To investigate this possibility, controlled laboratory predation tests were conducted using rainbow trout (*Oncorhynchus mykiss*), a natural predator of juvenile salmon. Randomly selected groups of juvenile chinook salmon were exposed to nominal Diazinon concentrations chosen to mimic (1 and 10 $\mu\text{g/L}$) or exceed (100 $\mu\text{g/L}$) environmentally relevant pulses that have been observed in river systems adjacent to farm lands. Sets of control and exposed salmon received a water soluble, putative natural alarm substance, chinook skin extract, during and after transfer to a protected section of a predation trough containing submerged cover. An opaque divider was then removed to allow predators access to the area containing both the control and Diazinon-exposed fish. Each predation trial was terminated when approximately 50% of the prey had been consumed. The results suggest that immersion exposure to environmentally relevant levels of Diazinon does not have a detrimental effect on the ability of juvenile chinook salmon to avoid fish predation.

657 The effects the insecticide, bifenthrin, in estuarine organisms. M.H. Fulton, P. Pennington, H. Harper, Y. Sapozhnikova, K. Chung, Marine Ecotoxicology Branch, NOAA, NOS, NCCOS, CCEHBR, Charleston, SC. Bifenthrin is a synthetic pyrethroid insecticide that is widely used in agricultural and urban environments. Like other insecticides, bifenthrin has the potential to contaminate water bodies and cause adverse effects to aquatic organisms. The objective of this study was to examine the lethal and sublethal effects of bifenthrin in model estuarine organisms using standard laboratory bioassays as well as a simulated salt marsh mesocosm. Test species included grass shrimp, *Palaemonetes pugio*, clams *Mercenaria mercenaria* and sheepshead minnows, *Cyprinodon variegatus*. Laboratory static renewal bioassays were performed in each species and mortality was assessed at 24

and 96 h. The experimental design for the mesocosm study was a 28 day exposure with weekly dosing. Sublethal endpoints assessed in the grass shrimp included glutathione, lipid peroxidation, and catalase. Aqueous bifenthrin concentrations in the mesocosms were quantified using GCMS. Results from the laboratory bioassays indicated that bifenthrin was highly toxic to grass shrimp with 24 and 96 h LC50s of 0.038 $\mu\text{g/L}$ and 0.020 $\mu\text{g/L}$, respectively. Sheepshead minnows were less sensitive with LC50s of $>25.0 \mu\text{g/L}$ and 19.8 $\mu\text{g/L}$ at 24 and 96 h, respectively. Juvenile clams were the least sensitive species with both 24 and 96h LC50s $> 100 \mu\text{g/L}$. Results from the mesocosm study again indicated that the grass shrimp was the most sensitive species tested with an estimated LC50 of 0.128 $\mu\text{g/L}$ after 28 days of exposure. No significant effect on survival was observed in either the fish or clams at 0.2 $\mu\text{g/L}$ (the highest concentration tested). No significant effects were observed for any of the sublethal endpoints. Given the sensitivity of grass shrimp to this insecticide, additional work will be needed to determine the levels of bifenthrin that may be entering estuarine environments.

658 Toxicity of the Organophosphate Dichlorvos to Grass Shrimp (*Palaemonetes pugio*) and Oysters (*Crassostrea virginica*). J. Weinstein, Biology, The Citadel, Charleston, SC; M. Bolton-Warberg, College of Charleston, Charleston, SC; L.D. Coen, S.C. Department of Natural Resources, Charleston, SC. One commonly used mosquito control agent is the organophosphate, naled (Dibrom[®]). The major breakdown product of naled is dichlorvos. The lethal and sublethal effects of dichlorvos were examined on two widely distributed and ecologically-important estuarine invertebrate species, the grass shrimp, *Palaemonetes pugio* and the Eastern oyster, *Crassostrea virginica*. In grass shrimp, adults (LC50=0.06 mg/L) were more sensitive to dichlorvos compared to larvae (LC50=0.15 mg/L). Both tested life stages for grass shrimp were more sensitive to dichlorvos than juvenile oysters (LC50=31.6 mg/L). Acetylcholinesterase (AChE) inhibition was evident in both species; however, grass shrimp again were more sensitive than oysters. The most notable decreases in AChE activity in both species occurred at concentrations above those considered ecologically-relevant. In field experiments, both species were deployed in cages in unsprayed ($n = 2$) and sprayed ($n = 3$) sites and water samples collected pre- and post-spraying. Quantifiable dichlorvos levels were measured at the two narrowest creek treatment sites following mosquito spraying suggesting that overspray can occur and there was evidence of a sublethal AChE response at these same sites. Experiments however, at the widest creek, revealed no measurable dichlorvos or sublethal responses. Results from this research suggest that grass shrimp are more sensitive to dichlorvos than oysters. Spraying near small tidal creeks may have measurable impacts on resident species, while larger (wider) creeks appear to be capable of buffering organisms from transient fluxes of mosquito control agents that may enter the system.

659 Stress and the male crab: Limb regeneration and molting under chronic methoprene exposure in *Uca pugnax*. T. Stueckle, J. Likens, C.M. Foran, Biology, West Virginia University, Morgantown, WV. Application of insect growth regulators for wetland mosquito control remains controversial in that there is the potential for disruption of normal development and growth processes in non-target adult crustaceans. Concerns include application of methoprene and its resulting breakdown products which mimic an endogenous crustacean hormone and retinoids, respectively. Our primary objective was to evaluate the effect of a chronic methoprene exposure (0 – 1000 $\mu\text{g/L}$) on male and female *U. pugnax* limb regeneration and molting. After single limb autonomy, limb growth and molt stage was monitored every two days. The dorsal carapace was collected 6 days post-molt to determine protein and chitin content. Post-molt male crabs lost more weight per body volume than females, possibly due to their disproportionate sized cheliped. Methoprene exposed crabs displayed a lower percent gain in body weight compared to controls. Neither sex nor methoprene affected basal limb growth duration, but male crabs exposed to 0.1 $\mu\text{g/L}$ methoprene took significantly longer to proceed through proecdysis than females at that concentration. Methoprene did not significantly alter exoskeleton extractable protein or chitin content. However, variability in overall protein content, primarily due to variable water-soluble protein (arthropodin) expression, increased with exposure at 1.0 $\mu\text{g/L}$. Male crabs also exhibited a significantly elevated frequency of abnormal limb formation at 1.0 $\mu\text{g/L}$ while females displayed no trend. Our findings suggest that chronic methoprene exposure affects post-molt biomass and exoskeleton quality. Furthermore, adult male *U. pugnax* possess greater sensitivity to methoprene during limb regeneration and molting than females.

660 Development and Validation of Sensitive Insect Bioassay Procedures for Detection of Cry3Bb1 and Cry1Ab Biological Activity in Field Collected Soils. S.L. Levine, G.M. Mueller, S. Dubelman, Regulatory, Monsanto, Saint Louis, MO. To assess the environmental fate of the of the Cry3Bb1 and Cry1Ab proteins in soil, insect bioassays with sensitive species have been developed and validated. Activity of the Cry3Bb1 protein is restricted to the order Coleoptera and activity is evident within the family Chrysomelidae. Activity of the Cry1Ab protein is restricted to the order Lepidoptera. The Colorado potato beetle (CPB, *Leptinotarsa decemlineata*) and the European cornborer (ECB; *Ostrinia nubilalis* (Hübner)) were chosen to assess Cry3Bb1 and Cry1Ab activity, respectively, because of their relative ease to rear and high sensitivity to the respective proteins. These bioassays utilized soil-diet incorporation methodology and larval insects were incubated for 7-days. A novel approach was used to determine the limit of detection (LOD) for these assays, and the LOD was primarily a function of the sensitivity of the insect and the number of replicates that could feasibly be tested for each sample. The LOD estimates for the Cry3Bb1 protein in fortified soil samples was dependent on soil type and ranged from approximately 5 to 10 ug/g soil. The LOD estimates for the Cry1Ab protein in soil were dependent on soil type and ranged from approximately 0.033 to 0.049 ug/g soil. Estimated LOD values correlated with clay and organic carbon content, with the lowest LOD estimates for low clay and low organic content sandy-soils. However, for the purpose of validation, the maximum value from the LOD range was validated as a conservative global LOD for detection of Cry3Bb1 activity in soil. These assays are currently being used to assess the environmental fate of the Cry3Bb1 and Cry1Ab proteins in different soil types that have been cultivated with Cry3Bb1 and Cry1Ab producing corn varieties for three consecutive growing seasons.

661 The Role of Sumithrin in the 1999 Long Island Sound Lobster Die-Off. M. Levin, S. De Guise, Pathobiology and Veterinary Science, University of Connecticut, Storrs, CT; B. Brownawell, Marine Sciences Research Center, Stony Brook University, Stony Brook, NY. An unusual mortality event in the fall of 1999 was observed in Long Island Sound (LIS) lobsters (*Homarus americanus*) resulting in the reduction of up to 99% of lobster landings. The die-off corresponded in time with the application of pesticides for the control of mosquitoes that carried West Nile virus, an emerging disease in North American at that time. In order to determine the possible implications of sumithrin application as a direct or contributing factor in the die-off, studies were conducted to determine the effects of experimental exposure to sumithrin on the health of lobsters. Lobsters were exposed in 20-gallon tanks for 5 or 28 days, and the direct toxicity and sub-lethal effects on the immune system were determined. The 96-hour LC50 upon single exposure and 28-day LC50 upon repeated (weekly) exposure, were greater than 1.0 µg/L, the highest concentration tested. No modulation of immune function was detected following either the single or repeated exposures. Water concentrations of sumithrin decreased rapidly over the 5-day single sumithrin exposure, with a half-life of less than 2 hours, with similar decay rates for all concentrations tested. A modeling exercise suggested the maximum concentrations of pyrethroids (sum of resmethrin and sumithrin) reaching the bottom waters of Long Island Sound was 0.082 µg/L, a concentration within the range of those tested in this study and that did not induce significant increases in mortality or deleterious effects on lobster immune functions. Overall, the weight of evidence suggest that sumithrin did not directly or indirectly play a role in the lobster die-off because (1) sumithrin was not detected in randomly tested lobsters sampled during the die-off, (2) the half life of sumithrin is very small in sea water, (3) the highest sumithrin concentration tested was below the maximum concentration modeled to have been present in LIS during the lobster die-off, and (4) the maximum modeled concentration did not correlate with the location of dead lobsters. The results on the toxicity of pesticides will be useful in risk assessment and will help in making informed decisions on further use of pesticides for application around LIS.

662 Analysis of the Decline of Puget Sound Pacific Herring Stocks: Toxics, Urbanization, Climate Change or Disease? W.G. Landis, P.T. Bryant, Inst. Env. Tox, Western Washington University, Bellingham, WA. Pacific herring historically has been an important fishery in the Puget Sound-Georgia Strait region. The decline of the Cherry Point Pacific herring stock (CPPHS) has been determined to be due to factors not related to the spawning area. Patterns of increase and decline in predicted population size in the simulations suggest that fishing moratoriums or other management actions had little

effect. The analysis demonstrates that the causative agent for the decline of the CPPHS existed in the 1974-1975 timeframe with effects persisting until 2004. Puget Sound spawning stocks at Squaxin Pass, Discovery Bay and Port Gamble also have been sampled since the mid 1970s until 2004. These stocks also demonstrate a collapse in the age structure as seen in the Cherry Point stock during the same period, although the sites range the entire Puget Sound region. Genetic data demonstrated that the Cherry Point and the remainder of the Puget Sound herring stocks are two genetically distinct populations. The results of the analysis of the criteria for causality indicate that the timing of the warming Pacific Decadal Oscillation (PDO) corresponds closely to the change in age structure resulting in a declining population, but a confounder is the corresponding urbanization in the region. A proximate causative mechanism may well be the change in the distribution of pathogens as suggested by Hershberger et al. due to the warming but confounded by other factors. Simulations on how toxicants could affect these patterns are currently being performed and a Bayesian network approach is being implemented to update the analysis of causality of the fishery decline.

663 Fipronil and metabolites in residential runoff in California. L. Oki, D. Haver, J. Kabashima, Department of Plant Sciences, University of California, Davis, CA; J. Gan, S. Bondarenko, Department of Environmental Sciences, University of California, Riverside, CA. The use of fipronil is rapidly increasing in California as a popular insecticide for controlling termites and ants. The reported use of fipronil in CA was just a few lbs in 2000, but reached over 70,000 lbs in 2005. Fipronil is known for its aquatic toxicity to certain aquatic invertebrates. For instance, the LC50 of fipronil is only 0.14 ppb for Mysid shrimp and 0.32 ppb for Grass shrimp. In addition, degradation of fipronil produces three metabolites that all have higher acute toxicities than fipronil. In a large statewide monitoring study, runoff water samples are being collected from residential areas on a regular basis in Sacramento County and Orange County. A GC-MS (NCI) method is used to analyze concentrations of fipronil, fipronil sulfide, fipronil sulfone, and fipronil desulfinyl. At two sites in Sacramento County, fipronil and its three metabolites are consistently found in the runoff. At two sites in Orange County, fipronil and metabolites are present at levels much higher than the LC50 for Mysid shrimp. This is the first finding of fipronil and its metabolites in urban runoff. Given the increasing use of fipronil for landscape maintenance and structural pest management, this finding may have significant implications for water quality protection in urban and coastal watersheds.

664 Occurrence and Bioavailability of Urban-Use Insecticides in Estuarine Environments. K.M. Kuivila, K.L. Smalling, US Geological Survey, Sacramento, CA. Insecticides are applied in urban settings for a variety of uses, such as gardens, golf courses, lawns, and structures. If applications are in watersheds adjacent to estuarine ecosystems or their tributaries, these insecticides can be transported into the estuarine environment and taken up by organisms. In two studies of urban-influenced estuarine ecosystems in California (Stege Marsh and Bodega Bay), insecticides were analyzed in the embryos of shore crabs (*Hemigrapsus oregonensis* and *Pachygrapsus crassipes*) as an indicator of occurrence and bioavailability. Three different classes of insecticides were detected: organophosphates (chlorpyrifos and malathion), pyrazoles (fipronil) and pyrethroids (bifenthrin, cyfluthrin, permethrin, and tau-fluvalinate). The watershed for Stege Marsh, an estuarine saltmarsh in northern San Francisco Bay watershed, is 95% urban. Crab embryos collected in Stege Marsh had detectable concentrations of bifenthrin, chlorpyrifos, fipronil, three degradates of fipronil (fipronil desulfinyl, fipronil sulfide, and fipronil sulfone), and permethrin. Maximum lipid-normalized concentrations in the crab embryos ranged from 0.10 to 0.54 ppm. Near Bodega Bay on the California coast, crabs were collected in a watershed with a suburban community and golf course. Insecticides detected were bifenthrin, cyfluthrin, malathion, and tau-fluvalinate, with maximum concentrations ranging from 0.24 to 13.5 ppm. A new study is focusing specifically on inputs from a golf course on Kiawah Island, South Carolina, and is beginning with analysis of insecticides in water and sediments. Bifenthrin concentrations in a drain on the golf course green reached 126 ng/L in the water while downstream bed sediments had concentrations up to 0.43 ng/gm, dry weight. These results demonstrate that insecticides are transported from urban-use settings into estuarine and coastal environments and are available to concentrate in biota, such as crab embryos.

665 Fate factors and emission flux estimates for emerging contaminants in surface waters. H.T. Trinh, P. Adriaens, C.M. Lastoskie, University of Michigan, Ann Arbor, MI. Pharmaceuticals, personal care

products, hormones, and wastewater products are identified as emerging environmental concerns because of their potential for endocrine disruption at a very low chronic exposure level. Lately, research has been conducted on the environmental occurrences of these emerging contaminants in water, soil, sediment and biota in European nations and the United States. This work reports an emission and fate assessment to characterize the potential environmental and health impacts of thirty compounds listed in the National Reconnaissance of the United States Geological Survey (USGS, 1999-2000) as the most frequently detected organic wastewater contaminants in U.S. streams and rivers. Analysis of the environmental fate and surface water concentrations of the thirty compounds was carried out using Level II and Level III multimedia fugacity models for a 1000 km² model environment, the size of a typical county in the eastern United States. The compounds are categorized into three groups based upon the sensitivity of their predicted surface water concentrations to uncertainties in their physicochemical property values and landscape parameters. It is observed that for one subset of compounds, conventional treatment strategies may be ineffective for their removal from wastewater effluents. The environmental fate factors, mass distributions and loss pathways of the compounds are strongly affected by their mode of entry into the environment. From a comparison of surface water concentrations predicted by the fugacity models and the concentrations measured in the USGS reconnaissance, emission rate ranges for the thirty contaminants into U.S. streams and rivers are inferred.

666 Use of biomarkers to assess contaminant-associated health effects in birds of the Great Lakes. K. Grasman, Biology, Calvin College, Grand Rapids, MI; G. Fox, Canadian Wildlife Service, Ottawa, Ontario, Canada. Severe reproductive and population-level effects of organochlorine pollutants were first observed in fish-eating birds (gulls, terns, and herons) of the Great Lakes during the late 1960s and early 1970s. Shortly thereafter, the Canadian Wildlife Service, and later other agencies and academic laboratories, initiated health effects studies examining the cellular and physiological bases of impacts at higher levels of biological organization. Over the last three decades their collective work has assembled one of the largest regional and temporal databases on biomarkers in wildlife. The purpose of this presentation is to describe the methods and findings of these biomonitoring studies in several species of colonial waterbirds. During the 1970s, numerous physiological alterations were observed in adult herring gulls (*Larus argentatus*) at Great Lakes sites contaminated with organochlorines. These effects included enlarged thyroid glands, reduced hepatic concentrations of retinoids, and elevated hepatic concentrations of carboxylated porphyrins. During the 1980s and 1990s, these physiological indicators improved as organochlorine concentrations decreased, but alterations in these biomarkers are still observed at many of the most contaminated colonies. During the 1990s and 2000s, associations have been found between polychlorinated biphenyls and immunological impacts in several species. The phytohemagglutinin skin response, a measure of T lymphocyte function, is suppressed in preflightling herring gulls, Caspian terns (*Sterna caspia*), and black-crowned night herons (*Nycticorax nycticorax*) at contaminated colonies. Other immune alterations observed in herring gulls include reduced antibody responses, altered proliferation of lymphocytes, and atrophy of the thymus and bursa of Fabricius (maturation sites for T and B lymphocytes, respectively). Other biomarkers found to be associated with contaminants in Great Lakes birds include plasma protein profiles, plasma clinical chemistry, histology of gonads, liver, and kidney, and genomic indicators. In summary, biomonitoring studies in fish-eating birds of the Great Lakes have demonstrated the utility of health effects biomarkers, and contaminant-associated health effects continue in these birds at many sites during the 2000s.

667 Assessing risk from dioxin-like compounds in Great Lakes birds: Is EROD a useful biomarker? J.A. Head, S.W. Kennedy, National Wildlife Research Centre, Environment Canada, Ottawa, Ontario, Canada; S.W. Kennedy, Department of Biology, Centre for Advanced Research in Environmental Genomics, University of Ottawa, Ottawa, Ontario, Canada. Ethoxyresorufin-O-deethylase (EROD) induction is a well-documented biochemical response to dioxin-like compounds. The development of a high throughput assay for measuring EROD activity has made this biomarker a common choice for assessing exposure to and effects of dioxin-like compounds in avian wildlife. A major limitation associated with EROD is that the sensitivity of the response can be extremely variable among individuals and across species. In this talk, I will review EROD data for Great Lakes fish-eating birds, and will describe our research into environmental and genetic

factors contributing to variability in the EROD response. Our work highlights strengths and weaknesses of EROD as a biomarker of exposure, effect, and species sensitivity to the toxic effects of dioxin-like compounds.

668 Use of Bioaccumulation Models to Aid in the Interpretation of Avian Bioaccumulation Monitoring Datasets for Persistent Organic Contaminants. K.G. Drouillard, GLIER, University of Windsor, Windsor, Ontario, Canada. Avian bioaccumulation models have been developed and calibrated for several organic contaminants including PCBs, PBDEs and mercury in model species. These tools allow for stage-specific and in some cases full lifecycle interpretation of contaminant residues. While most avian biomonitoring programs rely on statistical interpretation of databases generated, bioaccumulation models can greatly facilitate the interpretation of such data. Common examples where bioaccumulation models can be used to shed light on particular problems include i) establishing steady state bioaccumulation times for different contaminants; ii) deducing the relative contribution of contaminant exposures at breeding and over-wintering sites, ii) chemical dilution in juveniles during rapid growth and iv) identifying sensitive life stages where contaminant residues become maximized in animal tissues. This study presents a generalized two compartment bioaccumulation model developed and calibrated for PCBs in birds and presents case studies of its use to interpret biomonitoring data sets as exemplified through the Great Lakes herring gull egg biomonitoring program.

669 Avian contaminant monitoring in the Grand Calumet River / Indiana Harbor Canal. D.W. Sparks, U.S. Fish & Wildlife Service, Bloomington, IN; D.S. Henshel, School of Public and Environmental Affairs, Indiana University, Bloomington, IN. It became obvious by 1990 that the avian monitoring efforts (described by others in this symposium) were sorely needed in southern Lake Michigan where significant sources of pollution were contaminating the Great Lakes but were not being studied. Southern Lake Michigan was not represented in CWS Great Lakes wide herring gull monitoring program, an unfortunate data gap. In the early 1990s, dozens of herring gulls nested within the midst of many thousands of ring-billed gulls on the lakefront of several steel mills. Samples from these herring gulls were provided to the CWS for a few years but developing access to these areas was difficult and has not been sustained as it should. Herring gulls are excellent representatives of Indiana Harbor and the overall southern Lake Michigan condition but this was not enough to address the avian impacts occurring in the GCR/IHC. Although significant avian resources were utilizing this area, access limitations hindered understanding of wildlife use and delayed monitoring efforts. At a more local level, the common knowledge that the GCR/IHC was severely polluted seemed to encourage the continued lack of needed monitoring. The small area and urban nature of regional contamination also contributed to neglecting monitoring on the part of wildlife agencies. The next issues that had to be overcome included what species should be studied and where are the best representatives of the area located? We evaluated the following avian species as monitoring targets: black-crowned night heron, great blue heron, peregrine falcon, nesting waterfowl, wintering diving ducks, green herons, and red-winged blackbirds. Although a great deal of information was gained from these efforts, in the end the studies of colonies of barn swallows nesting on bridges over the GCR/IHC has proven to be the most effective method of assessing avian effects of contaminated sediments. These swallows are present in sizable numbers, are easily monitored, bioaccumulate contaminants as readily as piscivores and are descriptive of the local environment. Changes in the bridge construction techniques are reducing barn swallow nesting sites, however they remain an excellent biomonitoring species where present. We will discuss the interrelatedness of monitoring these species and recommendations for future monitoring efforts.

670 Evaluating Great Lakes food web change using fish-eating birds and impacts on contaminant accumulation. C. Hebert, A. Idrissi, Environment Canada, National Wildlife Research Centre, Ottawa, Ontario, Canada; C. Weseloh, Environment Canada, Canadian Wildlife Service, Downsview, Ontario, Canada; M. Arts, Environment Canada, National Water Research Institute, Burlington, Ontario, Canada. In the Laurentian Great Lakes, anthropogenic activities have resulted in frequent alterations to natural food webs. However, it is often difficult to quantitatively evaluate how food webs have changed. To address this problem there is a need to improve our ability to define food web structure as well as detect and understand the implications of trophodynamic change. This requires the development, validation and application of ecological tracers that can provide insights into

the movement of energy, nutrients and contaminants through food webs. In this study, we examine the utility of two groups of naturally-occurring intrinsic tracers (stable nitrogen isotopes and fatty acids) to provide such information in a predatory seabird, the herring gull (*Larus argentatus*). For the Great Lakes, retrospective stable nitrogen isotope analysis of archived herring gull eggs indicates that there have been temporal declines in gull trophic position. These declines are related to changes in gull diet composition inferred from egg fatty acid concentrations. These two groups of ecological tracers provide corroborating evidence that gull trophic position is related to the degree to which aquatic foods, namely fish, are consumed. Temporal changes in fish abundance have influenced the composition of the gull diet and may have affected exposure to biomagnifying contaminants. Use of different ecological tracers in concert has improved our understanding of routes of energy and contaminant flow.

671 Temporal trends of polychlorinated naphthalenes, polychlorinated dibenzo-p-dioxins and dibenzofurans, and dioxin-like polychlorinated biphenyls in Lake Ontario lake trout (1979-2004). S. Gewurtz, L. Shen, Department of Chemistry, Brock University, Toronto, Ontario, Canada; S. Gewurtz, R. Lega, P. Crozier, E. Reiner, L. Shen, P. Helm, Ontario Ministry of the Environment, Toronto, Ontario, Canada; G. Tomy, Fisheries and Oceans Canada, Winnipeg, Manitoba, Canada; M. Whittle, Fisheries and Oceans Canada, Burlington, Ontario, Canada; C. Marvin, Environment Canada, Burlington, Ontario, Canada. Polychlorinated naphthalenes (PCNs), polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs), and dioxin-like PCBs (DL-PCBs) are classes of highly toxic compounds. Of these chemicals, PCNs have been the least well studied and their temporal trends have yet to be measured in any environmental media in the Laurentian Great Lakes. Here we evaluated the temporal trends of PCNs, PCDDs, PCDFs, and DL-PCBs in Lake Ontario lake trout (*Salvelinus namaycush*) collected between 1979 and 2004. Concentrations of the sum of each of these three compound classes have decreased since the late 1970s. Elimination rate constants (k_2), calculated as the slope of the least squares regression line between the lipid normalized concentration and year, for PCNs that had two pairs or three adjacent carbons unsubstituted with chlorine were not significantly different from zero, which indicated that these congeners had not declined in the fish. This was not surprising considering these PCNs are known to be metabolized by vertebrates. In contrast, the k_2 values for PCNs that did not have adjacent carbons unsubstituted with chlorine generally increased (i.e. the rate of concentration decline increased) with hydrophobicity and degree of chlorination. This pattern differed from what was previously found for non dioxin-like PCBs where the rate of contaminant decline generally decreased with hydrophobicity. Differences in the rate of decline of individual PCN congeners was not due to changes in either the source or formulation of PCNs over time since an opposite pattern was found in a Lake Ontario sediment core collected in 2004 where the proportion of the less chlorinated and more chlorinated PCN compounds decreased and increased over time, respectively. Instead, we hypothesize that the PCN pattern in fish was due to dechlorination of higher chlorinated congeners, PCN 74 and 75, to lower chlorinated ones through metabolic biotransformation. PCNs contributed between 5 to 10% of total dioxin-like activity in the fish.

672 Current threats to Great Lakes bird populations: What have we learned to face the future. K.A. Grasman, Biology, Calvin College, Grand Rapids, MI; W.W. Bowerman, Forestry and Natural Resources, Clemson University, Clemson, SC. Avian species are excellent sentinels of environmental change. As this session has shown, a number of new techniques were developed in the Great Lakes region using birds to indicate effects at the individual, population, and ecosystem levels. Collectively, these methods assist ecologists and toxicologists to understand and assign causality among multiple stressors. New and emerging compounds may become threats to avian populations of the Great Lakes. The impacts and threats from future global problems such as global warming also pose unknown effects for these populations. This talk will focus on what emerging threats exist and how the techniques that were developed in the Great Lakes will be used to determine which stressors are impacting these populations as these problems occur in the future.

674 An isotope dilution GC/MS/MS method for steroid hormones in water. W.T. Foreman, J.L. Gray, C.E. Lindley, US Geological Survey, National Water Quality Laboratory, Denver, CO; L.B. Barber, US Geological Survey, National Research Program, Boulder, CO. The presence of steroid

hormones in the environment has received increasing scrutiny due to their potential to disrupt vertebrate endocrine-signaling pathways at part-per-trillion concentrations. An isotope dilution method for 6 androgens, 9 estrogens, and 2 progestins plus cholesterol and coprostanol in water samples was developed that uses 13 deuterium-labeled surrogate analogs added prior to sample extraction. Steroids were isolated on a C18 disk and eluted with methanol. Polar interferences were removed with a Florisil solid-phase extraction column, and the steroids were derivatized with N-methyl-N-(trimethylsilyl)trifluoroacetamide (MSTFA) and analyzed by gas chromatography with tandem-quadrupole mass spectrometry. Estimated detection levels range from 0.4–2 ng/L, with higher levels for cholesterol and coprostanol because of blank limitations. Mean ($n=8$) absolute recoveries of isotope surrogates ranged from 50–105% in tested natural-water samples. Surrogate-corrected recoveries of analytes ranged from 78–110%, with <15% relative percent deviation. Individual spiked samples with low (<50%) absolute surrogate recoveries consistently had surrogate-corrected analyte recoveries of greater than 80%. The trimethylsilyl derivatives of the analytes and surrogates exhibited weeks-to-months stability in MSTFA, except for progesterone (and its analog), which had a half-life of 3.5 days at room temperature. Application of this method to various water types (surface and ground waters; municipal and confined animal feeding operation wastewaters) will be presented.

675 Experiences in Analysis of PCPPs and Steroids / Hormones in POTW BioSolids. R. Grace, M. Hamilton, B. Fowler, M. Woudneh, M. Scheible, S. Leahy, AXYS Analytical Services Ltd., Sidney, British Columbia, Canada. For two years AXYS Analytical Services Ltd. has been developing analytical methods suitable for the trace measurement of PCPPs and Steroids / Hormones in POTW influents, effluents, and biosolids. The objective of this work in biosolids was to produce analytical methods of high accuracy and reproducibility while measuring target analytes in the ng/g concentration range. Robust methods have been developed for the measurement of these compounds. Each method employs internal standard quantification using an extensive suite of labeled compounds. LC/MS/MS is used to analyze 73 PCPP compounds while GC/MS is used for the determination of 30 steroids and hormones. Both low resolution and high resolution MS protocols will be described for the steroids / hormones analysis. Application of these methods to the analysis of POTW biosolids provided significant learning experiences in dealing with complex sample matrices and minimizing their effects on the quantification of a wide range of compounds. The goals of the method development included reliable detection of target analytes in this complex matrix and accurate quantification of analytes present. An overview of the entire analytical process will be provided prior to discussion of results. The presentation will discuss appropriate sample extraction and clean-up procedures, instrumental methods, and quality control protocols designed to reduce sample matrix effects and increase selectivity and sensitivity when quantifying target analytes. Concentrations of steroids, hormones and PPCPs in a variety of POTW biosolid matrices will be reported.

677 New Strategies to Apply LC/MS/MS for the Quantitation and Confirmation of Endocrine Disrupting Compounds, Pharmaceuticals and Personal Care Products (EDC and PPCP). A. Schreiber, Applications Group: Applied Markets, Applied Biosystems / MDS Sciex, Toronto, Ontario, Canada. Endocrine disrupting compounds (EDC) and pharmaceuticals and personal care products (PPCP) are environmental contaminants of growing concern. In order to properly assess the effects of such compounds on our environment, it is necessary to accurately monitor their presence in the environment. The diversity of chemical properties of these compounds makes method development challenging. Experimental and Preliminary results The method in this work was developed on a hybrid triple quadrupole linear ion trap mass spectrometer (4000 Q TRAP LC/MS/MS system) fitted with an ESI and a combined ESI-APCI source. A Shimadzu Prominence HPLC with a Phenomenex C18 reversed phase column was used for chromatographic separation. An eluent of water and acetonitrile with formic acid was used. All compounds were detected in Multiple Reaction Monitoring (MRM) mode and Information Dependent Acquisition (IDA) experiments were used to trigger Enhanced Product Ion (EPI) spectra. These spectra were searched automatically against a mass spectral library of EDC and PPCP. The mass spectral library was generated by injection of standards of investigated compounds using standardized Collision Energies (CE) of 20, 35, and 50. In addition a CE of 35V with a Collision Energy Spread (CES) of 15V was used. Water samples collected in the inlet and outlet of water treatment plants were prepared using Solid Phase Extraction (SPE) and then analyzed

by LC/MS/MS. The standardized collision energies used to produce the library were also used to acquire the analytical data of water samples. Up to a hundred endocrine disrupting compounds, pharmaceuticals, and personal care products were quantified and confirmed by library searching. Detection and quantitation of all compounds was achieved down to low part per trillion levels (ng/L). In addition different water samples were analyzed on a hybrid triple quadrupole time of flight mass spectrometer (Q STAR Elite LC/MS/MS system) fitted with an ESI source. Data acquired with high resolution and high mass accuracy (<5ppm) were processed using principle components analysis (MarkerView software).

678 Methods for the Analysis of Illicit Drugs in Wastewater.

A.M. Peck, R. Heltsley, J.R. Kucklick, National Institute of Standards and Technology, Gaithersburg, MD; A.M. Peck, Skidaway Institute of Oceanography, Savannah, GA; K. Lippa, M.M. Schantz, National Institute of Standards and Technology, Charleston, SC. Compared to prescription and over-the-counter medications, the environmental fate and effects of illicit drugs have received relatively little attention. We have developed an isotope dilution liquid chromatography-tandem mass spectrometry (LC-MS/MS) method for the analysis of cocaine and twelve major cocaine metabolites, ecstasy and three primary ecstasy metabolites, methamphetamine, and amphetamine in wastewater. Filtered samples (100 mL to 1 L) were extracted using 500 mg Oasis MCX solid-phase extraction cartridges. Filters were extracted by shaking with 2.5 % ammonium hydroxide (v/v) in dichloromethane/methanol (1:1 v/v). The method has been applied to influent and effluent samples collected over two weeks from a large wastewater treatment facility (18 million gallons per day; MGD). All cocaine metabolites were detected in wastewater influent. Concentrations of the primary cocaine metabolite, benzoylecgonine, in composited influent samples ranged from 6670 ng/L to 8750 ng/L and was about three times higher in concentration than cocaine. Fewer cocaine metabolites were detected in wastewater effluent, and all compounds were found in significantly lower concentrations than in influent. The concentrations of norbenzoylecgonine (45.2 ng/L to 72.8 ng/L) and ecgonine (18.3 ng/L to 49.6 ng/L) were the highest among cocaine metabolites in effluent. The removal of these compounds during wastewater treatment was estimated from the daily average influent and effluent concentrations (removal = $1 - [\text{effluent}]/[\text{influent}]$). Average removal ranged from 64.4 % to > 99 % for all compounds. Most compounds were removed by treatment with greater than 90 % efficiency.

679 Use of Polar Organic Integrating Samplers to Determine

Pharmaceuticals and Other Emerging Organic Contaminants in Surface Waters. E.T. Furlong, S.L. Werner, National Water Quality Laboratory, US Geological Survey, Denver, CO; D.A. Alvarez, Columbia Environmental Research Center, US Geological Survey, Columbia, MO; J.S. Tertuliani, Ohio Water Science Center, US Geological Survey, Columbus, OH; M. Caughey, Illinois State Water Survey, Champaign, IL. The presence and distribution of pharmaceuticals, components of personal-care products, and other compounds associated with the discharge of treated wastewater have been extensively documented in surface-water systems, but effectively monitoring the potential long-term exposure of aquatic biota in these systems to these anthropogenic waste indicators poses challenges. The presence of multiple discharges within a watershed, variations in the composition and volume of discharge, and changes to the hydrologic characteristics of the watershed can result in substantial variation of pharmaceutical concentrations in space and time. Polar organic chemical integrative samplers (POCIS) complement discrete sample analyses by passively sampling polar organic compounds over extended (30-day) exposures, allowing detection of compounds that are present sporadically or episodically in a watershed. Extracts of POCIS from 28 deployments in Midwestern streams were submitted to specific HPLC/MS and HPLC/MS/MS analyses of a range of pharmaceuticals, including analgesics, acidic pharmaceuticals, antimicrobials, diuretics, and antidepressants. Of 43 pharmaceuticals assayed in POCIS extracts, 12 were not detected, and 15 were detected in greater than 20 percent of extracts. Concentrations ranged from less than detection to 240 ng/extract for simvastatin; the median concentration for most pharmaceuticals ranged between 0.2 and 20 ng/extract. Absolute concentrations cannot yet be determined from POCIS sampler results because an understanding of uptake rate kinetics is still developing; however, the pattern of detections in samplers downstream of wastewater discharges was qualitatively similar to the patterns of detections observed in discrete water samples collected downstream of discharges. As an added benefit of deploying POCIS, the ability to assay these extracts

with exploratory mass spectrometry techniques, which permit the tentative identification of additional compounds, also will be discussed.

680 Environmental Occurrence of Irgarol 1051 Metabolites (M1, M2, M3 and M4) in Coastal Waters from the United States. P. Gardinali, C. Maxey, Chemistry & Biochemistry and SERC, Florida International University, Miami, FL. The environmental fate of Irgarol 1051 is one of the few topics where a clear debate is still on-going. Irgarol 1051 residues (1-4,000 ng/L) have been globally documented. Past reports have always considered "M1", the des-cyclopropyl product formed by photo degradation, the major metabolite of Irgarol 1051 in natural waters. M1 is almost always present in surface waters where Irgarol is detected at levels usually lower than the parent compound. Recent studies however, have shown the presence of high concentrations of "M1" (up to 24,000 ng/L) and two previously undetected metabolites "M2" (20,200 ng/L) and "M3" (390 ng/L) in surface waters from the Pearl River and coastal areas of Hong Kong with very little of the parent compound present on the water samples (<1,400 ppt). Based on these premises our initial goal was to produce an analytical method that will allow for the simultaneous detection of all Irgarol metabolites in coastal waters using LC/MS-MS. This study also reports the first occurrence of CA30-0156 (M4, Irgarol sulfone), a previously identified photolysis product of Irgarol 1051, in coastal waters from the United States. 'M4' (2-sulfomethy-4-tert-buthylamino-6-cyclopropylamino-s-triazine), characterized from authentic standards by LC-MS/MS, was detected in 86% of the water sample analyzed (107/125) from marinas in US waters at concentrations ranging from ND (<3 ng/L) to 137 ng/L (7.4 ng/L average). An LC/MS method that targets Irgarol 1051 and all its metabolites was used to screen all samples collected in the 2006 monitoring program. Of all metabolites analyzed for (M1, M2, M3 and M4) only M1 and M3 and M4 were detected in the samples. In contrast to other reports and likely due to its reactivity, M2 was never found in any environmental setting within the US.

681 Perfluorinated Chemicals (PFCs) in Artic Samples: Analytical Challenges and Solutions. R. Grace, B. Surridge, D. Hoover, AXYS Analytical Services Ltd., Sidney, British Columbia, Canada; B. Kelly, J. Blair, M. Ikononou, Institute of Ocean Sciences, Department of Fisheries and Oceans, Sidney, British Columbia, Canada. Previous analytical work focused on reporting concentrations of PFCs in samples from the Eastern Hudson Bay area. Samples included sediment, fish, macro algae, and Beluga whales (liver, muscle, blubber, milk and blood). A single method was used for extraction and LC/MS/MS analysis of 21 analytes (perfluorocarboxylic and sulfonic acids and perfluorosulfonamides) for all biota samples. Method improvements have been identified for specific classes of tissues and will now be discussed. Chromatographic interferences for the C4 carboxylic acid (PFBA) prevented definitive detection in macro algae samples during routine monitoring. Modified chromatographic conditions, inclusion of a confirmatory MS/MS parent-daughter transition, and addition of ¹³C-labeled analogue for PFBA allowed for increased confirmation of detections in macro algae samples. Improved method performance for the perfluorosulfonamides will be presented. Application of this improved method and results for the analysis of various tissue samples from biota from eastern Hudson Bay will be reported.

682 Naphthenic Acid Analysis by Capillary HPLC / High Resolution Mass Spectrometry and Application to Remediation of Oil Sands Process Water. J.W. Martin, X. Han, M. Bataineh, Division of Analytical & Environmental Toxicology, University of Alberta, Edmonton, Alberta, Canada; P.M. Fedorak, A.C. Scott, Biological Sciences, University of Alberta, Edmonton, Alberta, Canada; M. Gamal El-Din, K. Ikehata, H. Fu, Civil and Environmental Engineering, University of Alberta, Edmonton, Alberta, Canada; M. MacKinnon, Syncrude Canada Ltd, Edmonton, Alberta, Canada. Large volumes of toxic aqueous tailings, containing high concentrations of naphthenic acids (NAs), are produced in northern Alberta by the rapidly expanding oil sands industry. NAs are a complex mixture of cyclic and non-cyclic saturated carboxylic acids with the general formula of $C_nH_{2n}ZO_2$, where Z is a negative even integer specifying the number of cyclic rings in the molecule. Because of their persistence and contribution to aquatic toxicity, there is an urgent need to understand why NAs resist biodegradation and to propose alternative remediation techniques. Therefore, we applied a new HPLC / high resolution mass spectrometry method to study how cyclicity, carbon number, and alkyl branching affect NA recalcitrance to biodegradation. Microbial degradation studies were conducted with Syncrude tailings pond water and a commercial mixture of NAs. The commercial NAs degraded very quickly, with half lives ranging from 1 to 8 days, whereas NAs

in tailings water degraded slowly with half-lives ranging from 44 to 237 days - a fact that we attribute to our parallel observations that tailings water NAs were more highly branched than the commercial NAs. Nonetheless, in both NA mixtures the same general structure-persistence relationship was observed based on Z, whereby the rate of biodegradation decreased in the following order: $Z=0 > Z=-2 > Z=-4 > Z=-6 > Z=-8$, indicating that increased cyclization increases recalcitrance to biodegradation. A possible solution to increasing industry demands for water in Northern Alberta may be to treat the tailings water by advanced oxidation to enable release to natural environments. Ozonation structure reactivity relationships were complementary to biodegradation, such that the most biologically persistent fraction was preferably destroyed. Implications and future research needs for these emerging contaminants will be discussed.

683 Flux of PCBs into the riparian zone from contaminated sediments using gas chromatography and stable isotope analysis. J. Gallagher, S. Klaine, Biological Sciences, Clemson University, Pendleton, SC; D. Walters, U.S. EPA, Cincinnati, OH; W. Bridges, Applied Economics and Statistics, Clemson University, Clemson, SC. The fate of PCBs in the aquatic environments of Twelvemile Creek and Lake Hartwell (South Carolina) is well characterized, but the fate of PCBs at the aquatic-terrestrial interface is poorly resolved. The objective of this research was to measure achiral and chiral PCBs in soil, sediment, aquatic insects and tetragnathid spiders to determine the pathways of flux from contaminated sediments to the riparian zone. The sediment, soil, and tissue samples were collected spatially and temporally throughout Twelvemile Creek and PCBs were extracted and quantified using sonication and gas chromatography, respectively. Stable isotope analysis ($\delta^{13}C$, $\delta^{15}N$) was used in conjunction with the PCB analysis to better characterize PCB movement into the Twelvemile Creek riparian zone. We hypothesized that PCB concentrations would decrease with distance downstream from the PCB source. PCB concentrations varied within and between sites with no downstream trend. Based on previous research, $\delta^{13}C$ of aquatic insects and tetragnathid spiders varied spatially depending on local geomorphology and were depleted at sand-bed compared with rock-bed sites. In addition, $\delta^{15}N$ gradually became enriched downstream. We conclude that aquatic insects are the primary vectors of flux from the aquatic to terrestrial ecosystem resulting in significant accumulation of PCBs in the riparian food web.

684 Effect-Directed Strategy to Identify Previously Unrecognized Toxic Chemicals in Hudson River Sediments. S.J. Lupton, D.S. Aga, T.D. Wood, Chemistry, The State University of New York at Buffalo, Buffalo, NY. Over a span of 30 years, ceasing in the 1970's, as much as 1.3 million pounds of polychlorinated biphenyls (PCBs) were released into the upper 40 miles of the Hudson River. In addition, the Hudson River receives runoff from agricultural waste and human sewage sources which may contribute a variety of wastewater organic compounds, especially those thought to be endocrine disruptors. These chemicals include pharmaceuticals, plasticizers, fire retardants, and detergent metabolites. The high concentrations of these compounds that persist in sediment raise a concern for human health due to fish consumption and for aquatic wildlife in the river and surrounding watershed. Metabolites and degradation products from weathering, hydrolysis, and photolysis of these chemicals are also a potential threat. It has been seen in previous studies that the toxicity or biological response from sediment extracts and fractions does not correspond to the concentrations of known toxic chemicals in the extracts and fractions. For this reason, an effect-directed approach was applied to sediment cores from the upper 40 miles of the Hudson River to identify previously unrecognized toxic chemicals. This approach utilized a combination of analytical techniques including CALUX-based bioassay, accelerated solvent extraction (ASE), gas chromatography mass spectrometry (GC-MS), liquid chromatography tandem mass spectrometry (LC-MS/MS) and high resolution Fourier Transform ion cyclotron resonance mass spectrometry (FT-ICR). Through these techniques we are able to determine toxicity of sediment extracts, identify compounds in extracts and quantify compounds in extracts. The approach also gives information on whether mixtures of certain compounds found in the extracts behave synergistically, antagonistically, or additively.

685 Optimization of PCB Dechlorination with Palladized Magnesium in Marine and Freshwater Sediments. E. Hadnagy, K.H. Gardner, I. Calante, University of New Hampshire, Durham, NH. PCB contamination in sediments remains a significant problem in many rivers, harbors, and estuarine areas in the US and around the world. In this work, PCB dechlorination by palladium-coated magnesium (Mg/Pd, 0.01%

by weight Pd) has been demonstrated in PCB-contaminated marine and freshwater sediments from New Bedford Harbor, MA; the Housatonic River, MA; and the Hudson River, NY. Experiments were also conducted in pure solvent systems (10% methanol in distilled water). Laboratory experiments simulating in-situ treatment methods revealed that the dechlorination reaction was very rapid, with most of the dechlorination occurring within the first few hours. Congener specific analysis of treated samples showed that the highly chlorinated congeners were dechlorinated and thus their sorption was not limiting the reaction. Experiments conducted with single PCB congeners BZ 194 and 204 in pure solvents demonstrated the formation of lower-chlorinated PCB congeners, indicating that dechlorination was occurring. The dechlorination kinetics were highly dependent on the type of sediment. For the Housatonic River (sandy, low organic carbon), the majority of PCB dechlorination occurred within the first hour, whereas for the Hudson River and New Bedford Harbor (silty/clayey with high organic carbon), in the second hour. The smallest mass of Mg/Pd able to achieve dechlorination greater than 50% was 0.5% of wet sediment weight, which lowers the treatment cost, as it is highly dependent on the amount of Mg/Pd used. Experiments investigated the use of both non-polar and polar solvents to enhance dechlorination of PCBs in New Bedford Harbor sediment by making the contaminant more available to the Mg/Pd surface. The use of two non-polar and biodegradable citrus based solvents, d-limonene and Citrus Burst 2, proved to be inefficient in increasing PCB dechlorination when compared to water. Other tested solvents included hexane, methylene chloride, acetone, methanol, ethanol and isopropanol. The polar protic solvents methanol, ethanol and isopropanol aided dechlorination to the greatest extent (the other solvents did not cause any improvement compared to water). Currently, bioaccumulation tests are being conducted using solid phase microextraction fibers to assess the bioavailability of PCBs remaining in the sediment after treatment and the reduction in bioavailability due to treatment. Results of these studies will be presented.

686 Development of Preliminary Remediation Goals Using a Food Web Model. J. Toll, N. Judd, E. Duffield, S. Replinger, F. McNair, L. Saban, Windward Environmental LLC, Seattle, WA. An updated version of the Gobas food web bioaccumulation model was applied to the Lower Willamette River (Oregon) to characterize relationships between the chemical concentrations present in sediment, water, and tissue. The primary purpose of the food web model (FWM) was to derive initial preliminary remediation goals (iPRGs) for hydrophobic organic chemicals (e.g. PCBs) in sediment. Sediment iPRGs are specific concentrations of chemicals in sediment associated with target tissue concentrations based on human health and ecological target risk estimates. A probabilistic approach was used for general model calibration and for sensitivity and uncertainty analyses. Once all model parameters had been defined, a probabilistic approach was again used to select sediment iPRGs. Sediment iPRGs were selected from distributions of model-predicted chemical concentrations in tissue and the corresponding model input concentrations for chemicals in sediment. Assumptions of relationships (or lack thereof) between water and sediment chemical concentrations were important in determining iPRGs. In some cases, assumed contributions from water alone (i.e., sediment chemical concentration equal to zero) resulted in predicted tissue concentrations in excess of risk-based targets, and iPRGs for sediment could not be determined. Future model applications will focus on characterizing the uncertainty of FWM derived PRG estimates and describing the relationship of water and sediment chemical concentrations.

687 Biogeochemical Changes beneath a Sediment Cap. D.D. Reible, N.W. Johnson, L.E. Katz, Civil, Architectural, and Environmental Engineering, The University of Texas at Austin, Austin, TX. The placement of a cap over contaminated sediment changes sensitive biogeochemical conditions in the underlying environment. These changes can have important effects on the fate and transport of underlying contaminants. The objective of this research is to characterize the geochemical changes induced by cap placement and interpret the results in light of mercury fate and transport. Lab-scale river simulator cells reproduced in-situ conditions for a range of geochemical environments. Millimeter-scale dissolved oxygen, reduced manganese (Mn^{2+}), reduced iron (Fe^{2+}), and dissolved sulfide (HS^-) profiles were measured as a function of time. Geochemical profiles achieved steady state conditions within 3-4 weeks of cap placement. Oxygen was depleted and reduced iron and manganese migrated into the cap layer within 1-2 weeks. Dissolved sulfide also was observed in the cap layer above sulfate dominated sediment. These shifts in biogeochemical conditions, especially that of sulfide,

suggest that a cap could significantly alter the fate of mercury in underlying sediments. A one dimensional, unsteady diagenetic model was used to simulate the dynamics of observed changes for each type of sediment and was coupled to a mercury biogeochemical model that includes mercury-sulfide speciation, mercury bioavailability, and methylation by sulfate reducing bacteria. Model results predict how the location and extent of mercury methylation will be affected by the placement of a sediment cap.

688 Site characterization of contaminated sediment in portion of the Kinnickinnic River, Milwaukee, WI. X. Zhang, M. Burzynski, Wisconsin Department of Natural Resources, Madison, WI. The Kinnickinnic (KK) River is a typical urban river in the City of Milwaukee, Wisconsin. It joins the Milwaukee River and Menomonee River before discharges to Lake Michigan via the Milwaukee Outer Harbor. Sediment in the KK River between Becher Street and Kinnickinnic Avenue, approximately 1 mile upstream from Lake Michigan, is contaminated primarily with PCBs and PAHs. Site characterization was carried out in 2002 and 2003 as part of a sediment remediation project. With the consideration of site specific information and existing data, long sediment cores were collected to define the spatial extent of contamination. Maximum concentrations of 36ppm and 244ppm were detected in sediment for PCBs and PAHs, respectively. Historical bathymetric survey data was used for sediment dating purpose to construct the temporal records of PCBs and PAHs in sediment. Significant deposition of PCB and PAH contaminated sediments occurred during the 1960s-1970s. Attempts were made to identify potential sources. Uncertainties related to field sampling and laboratory analyses were evaluated to assist decision making for sediment remediation. High uncertainties were associated with PAH concentration.

689 Integrated Model Linkage Analysis for Contaminated Sediment TMDLs in San Diego Bay. B. Chadwick, P. Wang, C. Katz, SPAWAR Systems Center San Diego, San Diego, CA; K. Schiff, Southern California Coastal Water Research Program, Costa Mesa, CA; S. Carter, Tetra Tech, San Diego, CA; C. Gorham-Test, San Diego Regional Water Quality Control Board, San Diego, CA. A number of sites in San Diego Bay have been listed for TMDLs based on impairments related to contaminated sediment. Three of these sites are co-located with the discharges of small creeks that drain the adjacent urban-industrial watersheds. In order to develop the linkage analysis for the TMDLs at these sites, an integrated model system is being applied that connects the watershed loading with the fate and transport of particles in the receiving Bay water. The land-based contaminant loads, along with the freshwater inflows, are simulated using the LSPC watershed model, and the LSPC predicted freshwater inflows and contaminant loads at the mouths of the three creeks are linked to the CH3D model which simulates the hydrodynamics and fate and transport of these contaminants in San Diego Bay. For the present study, CH3D is implemented to account for fate and transport of particle-borne contaminants emanating from the three watersheds and discharging into San Diego Bay. From the measured data, three particle size categories (clay, silt and sand) are obtained, and settling velocities based on the particle sizes are used in the CH3D model. TSS loadings from the two storms of Feb 28 and Mar 11 of 2006 are estimated using both the LSPC model predictions and the field measurements as loading terms. Results for the CH3D model are presented based on simulations that start 24 hours before the storms and extend until the particles either have settled to the bottom or been flushed out of the creek mouth regions. The outcome of the effort is used to predict the fraction of the discharged particles that are likely to impact the impaired sediment zone, thus providing an estimate of the linkage between the source and the impairment.

690 Bioassay Testing of Baltimore Harbor Sediments Spiked with Cr(VI). J.C. Baummer, K.J. Watlington, E.J. Bouwer, W.L. Goodfellow, W.L. McCulloch, Ecotoxicology, EA Engineering Science and Technology, Sparks, MD; K.J. Watlington, A.M. Graham, Geography and Environmental Engineering, Johns Hopkins University, Baltimore, MD. Sediments collected from many locations around the Baltimore Harbor exhibit toxicity and are classified as "impaired". The complex nature of sediment toxicity has made it extremely difficult to establish cause-and-effect relationships for specific contaminants in the Harbor. This study was designed to determine if there is a relationship between toxicity in Baltimore Harbor sediments and chromium concentrations in the sediment. This was accomplished by spiking indigenous sediment samples with Cr(VI) and subsequently conducting amphipod bioassay toxicity tests. Whole sediment samples were used in the bioassays, and emphasis was placed on ingestion as the exposure route. Both acute (10 day) and chronic (28 day) toxicity studies were performed using the amphipod,

Leptocheirus plumulosus. Survival was used as an endpoint for the acute toxicity studies, while survival, growth and reproduction were used for the chronic study endpoints. Three different concentrations of Cr(VI) were spiked into the sediments to determine if increased addition of Cr(VI) to sediment caused acute or chronic toxicity to the amphipods. Spiking concentrations ranged from 250 to 3000 µg/g, spanning environmentally relevant concentrations as well as slightly higher concentrations. Based on the sediment chemistry in the Baltimore Harbor, it was hypothesized that toxic Cr(VI) would be rapidly reduced to less toxic Cr(III). Results of the sediment toxicity tests indicated that in all but one sediment sample, additional chromium did not significantly impact survival, biomass and reproduction of *L. plumulosus* as compared to baseline (unspiked) sediment. Further characterization of water and sediment chemistry supported these results. Analysis of chromium speciation in the water column indicated that both Cr(III) and Cr(VI) were at detection limit concentrations for all samples except for the sample exhibiting toxicity. Cr(III) and Cr(VI) water column concentrations for this sample were 74.0 µg/L and 1050 µg/L respectively. Experiments were also conducted to understand the rates of Cr(VI) reduction in Harbor sediments and the mechanisms responsible for this Cr(VI) reduction.

691 The chemistry and toxicity of sediments mantling Sydney Harbour, Australia. G. Birch, S. McCreedy, Geosciences, Sydney University, Sydney, New South Wales, Australia; E. Long, ERL Environmental, Salem, OR. Past and present stormwater discharge and historical poor-industrial practice have resulted in highly contaminated sediment over extensive areas of Sydney Harbour. The chemistry and toxicity of these sediments were investigated in a 3-tiered, hierarchical approach to assess sediment degradation. An initial chemical investigation showed some of the highest concentrations of heavy metals, organochlorines and polycyclic aromatic hydrocarbons of any capital port in sediments of embayments near central Sydney. Sediment quality guidelines (SQG) were used as a preliminary test of possible biological harm in the second tier of investigation. Assessment of chemical mixtures indicated that sediment in a small part (~2%) of the harbour had a high probability of being toxic (probability ~ 75%), however sediment in almost 25% of the port was estimated to have a medium (~50%) probability of being toxic. The SQG assessment enabled careful stratification of the harbour for concurrent chemical and ecotoxicological analyses, which reduced cost and time commitments in the final tier of assessment. Tests of amphipod survival in whole sediment and tests of microbial metabolism (Microtox®) and sea urchin egg fertilisation and embryo development in pore waters generally increased with increasing chemical concentrations, but amphipod response was lower than predicted due to the relatively low sensitivity of the indigenous amphipod (*Corophium* sp.) used. Areas previously predicted, using SQGs, to be most at risk were highly toxic in the combined chemistry/toxicity investigation and sediment from the most un-impacted areas of the port were toxic in at least one ecotoxicological test, which matched the earlier assessment using SQGs. SQGs over predicted toxicity in one bay (Iron Cove), which was contaminated with poorly bioavailable pyrogenic PAHs and under-predicted toxicity in another area contaminated with high concentrations of copper.

693 Cooperative Natural Resource Damage Assessments under the Oil Pollution Act of 1990: The Responsible Party Perspective. A.N. Davis, Environmental Practice Group, LeBoeuf, Lamb, Greene & MacRae LLP, Hartford, CT. NRDA's under OPA 90, where the RP and federal, state and/or tribal natural resource trustees undertake the critical steps of the NRDA process (injury assessment; damage calculation; restoration planning, scaling and implementation), can be implemented cooperatively and cost-effectively. While the OPA 90 statutory and regulatory provisions allow and, by their very design, mitigate in favor of a collaborative approach (and against the adversarial approach that has historically been typical of CERCLA clean up matters), there is no formula for a 'successful' cooperative NRDA. While every oil spill differs, there are a number of fundamental issues that frequently arise that can be anticipated and dealt with up front. Based on experience in numerous oil spills, large and small, there are challenges (which need not be road blocks) which can arise, including: avoiding redundant efforts and duplication of costs; differing goals (expedited assessments can be cost-effective on the front-end, but can grossly exaggerate the injury in favor of expedience which ultimately costs the RP/its insurers significantly more on the back end); differing levels of agility/ability in terms of experts/resources that can be tapped; imbalances in experience of technical working group members; differing expectations on the 'path forward' (e.g., that the parties must agree on a precise injury calculation vs. a range where the 'point spread' can be bridged

with properly scaled restoration); and resource groups that are 'out of step' with the other resource groups. Strategies for a successful cooperative NRDA include: workable formal MOAs for complex spills (and simplified guiding principles for small spills); ensuring that the process is technically driven, and having the right people (technical and legal) on both sides of the table who can negotiate fairly and build consensus; using joint experts and best available/multiple lines of evidence (including ephemeral data which is collected 'early and often'); and ensuring that transport, fate and effects modeling, where appropriate to be used, is done (whether cooperatively or in parallel) in a transparent and reproducible manner that is calibrated with other lines of data. A successful, cooperative NRDA is one which ensures fairness of process and outcome to all stakeholders within the OPA 90 statutory and regulatory construct.

694 Considerations for Cooperative Natural Resource Damage Assessment. T.M. Penn, Assessment and Restoration Division, NOAA, Silver Spring, MD. The Oil Pollution Act (OPA) and the Superfund law (CERCLA) require the trustees to assess and restore natural resources injured by the release of oil or other hazardous materials. The trend in damage assessment is for trustees and responsible parties to work together to quantify injuries from contamination and plan and implement restoration. There were national and regional workshops among stakeholders on cooperative assessments beginning with a national workshop in San Diego in 2004. The workshops highlighted the benefits of cooperative assessment and identified specific tools to facilitate cooperation. Based on the author's experience with these discussions and a number of assessments conducted under OPA and CERCLA in southeastern U.S., this paper extends the earlier discussions to identify some of the challenges that remain with cooperative assessments and offers considerations for addressing those challenges. Two issues that continue to confront the trustees and responsible parties (RPs) in cooperative assessment are choices about data collection and the ability of their representatives to make decisions about the assessment. The choices of what data to collect and how they are to be used are key factors that influence cooperative assessment success. In some cases the trustees and RPs conducted the wrong study, failed to take advantage of existing data or ongoing data collection, or did not collect data when they should have – all of which led to increased assessment costs or delays in reaching settlement or both. On the contrary, in other cases trustees and RPs conducted the right study or made efficient use of existing information. Factors that influence wise data collection decision-making include the type of incident, knowledge of and access to existing data and other data collection efforts, understanding which unknown parameters are important to quantify for assessing injury, and a variety of other issues like trust, communication, and a common goal of what needs to be restored. A related factor for success is that educated principals should be the trustee and RP decision-makers throughout the process. Educated principals who understand the needs of injury assessment and restoration scaling and focus on the end result of restoration can separate issues from non-issues, expediting the assessment and restoration and reducing process costs.

695 West Coast Joint Assessment Team Recommendations for Conducting Cooperative Natural Resource Damage Assessments. R.C. Helm, Environmental Contaminants, US Fish and Wildlife Service, Arlington, VA; A. Mike, Energy Technology Company, Chevron USA, Richmond, CA; J. Yamamoto, Office Spill Prevention and Response, California Department of Fish and Game, Sacramento, CA; M. Cramer, Emergency Response, ConocoPhillips, Houston, TX; D. Doty, Department of Fish and Wildlife, State of Washington, Olympia, WA; D. Helton, Damage Assessment Response and Restoration, National Oceanic and Atmospheric Administration, Seattle, WA; C. Hebert, Environmental Contaminants, US Fish and Wildlife Service, Portland, OR; C. Gorbics, Environmental Contaminants, US Fish and Wildlife Service, Carlsbad, CA. The purpose of this presentation is to discuss the development of the West Coast Joint Assessment Team (JAT) and present the salient points of the Team's recommendations for conducting cooperative natural resource damage assessments. The West Coast JAT's cooperative damage assessment document provides guidance to state and federal natural resources trustee agencies (Trustees) and parties responsible for oil spills or other pollution events (Responsible Parties) on how to: 1) initiate a cooperative natural resource damage assessment (NRDA) during an oil spill, and 2) move from the initial chaotic phase of response to a cooperative injury assessment as soon as possible. Although this document focuses on marine oil spills, the concepts expressed here could be used for any other incident requiring a NRDA. This

document summarizes the goals, key elements, and boundaries of cooperative assessments, with the objective of educating both trustees and responsible parties on the guiding principals for a successful cooperative assessment as envisioned by the West Coast Joint Assessment Team. The West Coast JAT is an ad hoc group of representatives from various state and federal trustee agencies, spill response organizations, and representatives from the oil industry, including major and independent oil companies and oil transportation companies. The JAT was formed in 1996 to explore avenues for conducting cooperative NRDAs in the event of an oil spill. The JAT meets three times a year to discuss a variety of topics related to conducting cooperative assessments including collection of ephemeral data, injury assessment, NRDA case histories, recent developments in NRDA, available resources, and many more.

696 Cooperative Assessment Agreement. C.D. Baker, Law Department, United States Steel Corp., Pittsburgh, PA. A project should be undertaken to develop a written form of agreement between Public Trustees and Responsible Parties for a cooperative/coordinated assessment of natural resource damages. The goal of the project is to develop a basis for collaboration to foster estimating the appropriate scale and type of restoration to compensate the public for natural resource injury and reach a settlement. This goal can be attained with the help of a form agreement that identifies critical elements in the cooperative assessment process, such as: 1. Methodology for determining Baseline, 2. Commitment to determining causation and evaluating severability of injuries, 3. Methodology for determining service losses as an element of damages, 4. Commitment to determining restoration goals, 5. Covenant for sharing expenses, 6. Mechanism for decision-making, and 7. Streamlined site evaluation with joint decision-making on scope of significant studies. Too often, the parties fail to engage in a cooperative assessment because agreement is not easily attained with regard to these methods and practices for conducting the assessment. If a joint trustee/industry task group is mobilized to work on developing a form agreement that can be utilized in most sites, the chances of reaching agreement on how to conduct a cooperative assessment would be significantly improved.

697 Cooperative Natural Resource Damage Assessments: Getting Around the Obstacles. S. Jawetz, Beveridge & Diamond, P.C., Washington, DC. The basic elements of a cooperative natural resource damages assessment (CNRDA) are well understood, but relatively few CNRDAs have occurred with respect to hazardous substance sites under the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund) and comparable state laws. Most practitioners agree that hazardous substance sites present challenging technical and legal issues, making cooperation more difficult. As an abstract matter, however, technical and legal issues should rarely cause CNRDAs to fail, because most NRD claims at hazardous substance sites are ultimately resolved through negotiation in any event. Nonetheless, CNRDAs at Superfund sites must overcome several structural hurdles. These include the lack of an accepted national model memorandum of agreement to use as a template, difficulties in setting appropriate timelines for completion, overburdened trustee agency staff that are unused to working cooperatively with private parties, and a lack of standard methods for establishing baseline and quantifying service losses for many categories of resource injury (particularly in urban or industrialized areas). These hurdles must typically be addressed on a site-specific basis through perseverance, negotiation, the provision of substantial resources by the involved private parties, and a willingness on the part of all parties to be creative and take risks. The formation of small technical working groups on particular issues that meet often and exchange written materials and other communications on a regular and confidential basis is one method of increasing the level of collaboration and enhancing the chances of a successful CNRDA. An early focus on the collaborative identification of potential high-value restoration projects is another method of increasing the apparent value of the process to the parties and reducing the impact of disagreements over technical issues. This presentation will provide examples of obstacles, institutional and otherwise, that have hindered progress at particular Superfund sites, and examples of mechanisms that have promoted the progress of CNRDAs and related claims resolution efforts.

698 Opportunities for Cooperation in Natural Resource Damage Assessments. J. Carlucci, Office of the Solicitor, U.S. Dept. of the Interior, Washington, DC. Federal statutes provide the framework of an adversarial legal claim for assessing natural resource injury caused by hazardous substances or oil and determining appropriate restoration. Nevertheless, opportunities exist throughout the assessment process, for natural resource trustees and

potentially responsible parties to cooperate to achieve faster, more efficient, more cost effective restoration of injured resources. However, sometimes the 'shadow' of potential legal claims and defenses makes it difficult to structure a cooperative process at the outset. This discussion will focus on taking advantage of cooperative opportunities that can arise at all sites in order to build trust that can lead to a cooperative resolution of claims, and successful natural resource restoration.

699 Hanford Site Risk Assessments. J.T. Markwiese, R.T. Ryti, Neptune and Company, Los Alamos, NM; R. Bauer, Fluor-Hanford, Richland, WA; S. Weiss, J. Thomson, Washington Closure, Richland, WA. The Hanford Site, occupying an area of over 1,500 km² (586 mi²) near Richland Washington, became a Federal facility in 1943 when the U.S. Government took possession of the land to produce nuclear materials for defense purposes. Its present-day mission is to clean up the radioactive and hazardous wastes generated during previous years. Cleanup is facilitated through the Tri-Party Agreement as overseen by the US Department of Energy, the US Environmental Protection Agency and the Washington State Department of Ecology. In an effort to expediently characterize and remediate the thousands of waste sites at Hanford, the Tri-Parties initiated the bias for action strategy by implementing Interim Action Records of Decision, in which remediation proceeded until field screening and verification sampling demonstrate that the interim cleanup goals have been met. These interim goals allowed for timely management of a huge number of contaminated sites but the bias-for-action strategy does not meet the stringent requirements of a baseline risk assessment under Superfund; consequently, post-remediation risk assessments are required to document protectiveness to human health and the environment before the final Records of Decision can be issued. Areas targeted for data collection and assessment of ecological and human health risks include the interior of the Hanford Site (approximately 195 km²; 75 mi²) and former nuclear reactors and support and research facilities along approximately 32 km (20 mi) of the Columbia River shoreline. The risk assessment effort involves input from a diverse group of interested organizations, including several Tribes and other Natural Resource Trustees, and supports end-state remedial action decision-making and provides information to evaluate potential human health and ecological risks across the Hanford Site.

700 EPA Involvement in Risk Assessment at Hanford. L.E. Gadbois, Region 10, Environmental Cleanup Office, US Environmental Protection Agency, Richland, WA. The US Department of Energy manages a large nuclear waste site in Washington State called Hanford. Commensurate with the amount of waste is the number of stakeholders and organizations with interests in how cleanup is performed. One step of cleanup which brings many of these interests to the table is risk assessment. Participants have varied knowledge levels of the site, risk assessment, and mechanics of cleanup. Time with stakeholders must be balanced between studying contaminant data, learning about the physical and biological environment, understanding the needs and interests of the participants, and producing a risk assessment that is both useful and responsive. The US Environmental Protection Agency is involved in cleanup oversight as a regulatory agency at Hanford. Risk assessments are a key element of cleanup decision making by EPA. EPA has a very inclusive process for risk assessments which solicits stakeholder involvement. At Federal Facilities such as Hanford, EPA is a user but not performer of the risk assessment. In this talk some of EPA's challenges in ensuring sufficient risk assessment information is available will be discussed.

701 A Regulatory Perspective of Risk Assessment at the Hanford Site. D. Delistraty, Washington State Dept. of Ecology, Spokane, WA; E. Rochette, J. Yokel, J. Price, Washington State Dept. of Ecology, Richland, WA. Two recent risk assessments at the Hanford Site are the River Corridor Baseline Risk Assessment (RCBRA) and the Central Plateau Ecological Risk Assessment (CPERA). These assessments are complex with large spatial areas, aquatic and terrestrial habitats, nonradionuclide and radionuclide contaminants, numerous ecological receptors, and multiple human exposure scenarios. From a regulatory standpoint, we observed pros and cons with the methodology after a three year assessment period. On the positive side, assessments adopted an open forum with multiple stakeholder input, a weight of evidence approach (e.g., literature review, contaminant analysis in abiotic and biotic media, lab toxicity bioassays, histopathology, field surveys, modeled exposure), analytical suites to assist with identifying contaminants, and a website format to post RCBRA data. On the negative side, the following method deficiencies compromised the utility and reliability of assessments: difficulties in tracking comment resolutions and document revisions over

a protracted period; a fragmented approach to spatially assessing risk (e.g., waste site by waste site, judgmental sampling locations); minimal evaluation of temporal variation (cross sectional study design); loss of data due to sampling and analysis errors (e.g., changes in sample locations, porewater collection, plant bioassays, lab problems); combining data from multiple sources (variable data quality); statistical limitations (e.g., nonrandom sampling, small sample sizes, use of max vs. UCL for exposure, nonconservative non-detect method); no modeling of ecological population dynamics (focus on individuals vs. populations); limited analysis of key contaminants (e.g., PCB congeners vs. Aroclors); problems with reference site selection (e.g., use of borrow pits); lack of consensus in weighting lines of evidence; exclusive use of deterministic vs. probabilistic methods; and an inadequate uncertainty analysis (e.g., exposure, effects, risk characterization). These deficiencies may be addressed during the risk management step by recommending modifications to current work (e.g., collection of supplemental data) or making environmentally conservative decisions (e.g., partial, deferred, or more protective decisions).

703 Risk Assessment at the USDOE Hanford Nuclear Site with an Ecologically-Based Tribal Human Health Subsistence Exposure Scenario. B. Harper, S. Harris, Confederated Tribes of the Umatilla Indian Reservation, Pendleton, OR; B. Harper, Oregon State University, Corvallis, OR. The risk assessment challenges at the US Department of Energy's Hanford Nuclear Facility in southeastern Washington State are manifold. The 570 mi² Hanford Site includes 4 NPL sites with hundreds of individual radioactive and chemical waste sites and football field-scale radioactively contaminated buildings. Some 200 square miles of contaminated water, about half of which is above drinking water standards, is or may eventually discharge into the Columbia River. Radioactive soil and groundwater will remain hazardous for tens of thousands of years. Due to this scale and complexity, no spatially and temporally satisfactory sitewide risk assessment has ever been done. A method for visualizing long-term risk profiles will be presented. The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) retains Treaty-reserved rights to access and use the site to support a subsistence lifestyle. This lifestyle has more intense environmental contact than the conventional suburban lifestyle. The CTUIR developed a subsistence exposure scenario following scientific and cultural rules of evidence, and includes exposure parameters for all the conventional exposure pathways as well as a subsistence diet. The first application at Hanford is underway. Methods for evaluating longterm risk and holistic risk will be described.

704 Human Health Risk Assessment Framework for the Hanford 100 and 300 Areas. R. Perona, J.T. Markwiese, R. Ryti, L. Jenifer, Neptune and Company, Los Alamos, NM; S. Weiss, T. Jill, Washington Closure, Richland, WA. The main objective of the 100 Area and 300 Area River Corridor Baseline Risk Assessment is to evaluate the adequacy of soil remediation efforts at individual waste sites. The assessment employs a suite of exposure scenarios to provide risk managers with information on how potential risks may vary as a function of exposure intensity under a variety of conditions. These scenarios include: Hypothetical Native American User Scenario Hypothetical Rural Residential Scenario Hypothetical Resident Monument Worker Scenario Hypothetical Industrial / Commercial Worker Scenario Hypothetical Recreational Use Scenarios: Avid Hunter, Avid Angler, and Casual User applications This assessment represents the first attempt to implement the Native American scenario published in 2004 by the Confederated Tribes of the Umatilla Indian Reservation. In addition to the traditional exposure pathways related to soil and groundwater media, the Native American scenario also addresses potential exposures via use of the sweat lodge. Exposures via various home-produced and wild foodstuffs are incorporated in some of the exposure scenarios. Environmental data integrated in the risk assessment include cleanup verification data for over 160 waste sites, groundwater monitoring well data, surface soil and sediment data, and tissue data for both terrestrial and aquatic species. Depending on the exposure pathway, risks are calculated on spatial scales related to an individual waste site or across the entire 100 and 300 Areas (approximately 20 square miles). Risk characterization and reporting for the assessment are still underway. However, it is evident that background levels of certain naturally-occurring radionuclides may present significant risks relative to risks related to the remediated waste sites.

705 Assessing Risk to Benthic Communities from Shallow Groundwater Fluctuations in a Large River System. B.L. Tiller, J. Nugent, Environmental Assessment Services, Richland, WA; R. Ryti, J. Markwiese, Neptune & Company, Los Alamos, NM; S. Weiss, J. Thomson, Washington Closure Hanford, Richland, WA. The Columbia River is the discharge area

for the unconfined aquifer underlying the Hanford Site in Washington State and is a key part of one of the largest human and ecological risk assessment projects conducted to date for the U.S. Department of Energy. Water level fluctuation is a key variable affecting the concentrations of Hanford's legacy materials entering the riverine environments and also affects the distribution and abundance of organisms. A standard approach was needed to measure contaminant exposure in the benthic communities along the Hanford Reach of the Columbia River. The shoreline areas may fluctuate daily and seasonally in response to both natural seasonal cycles and hydroelectric operations at upstream dams and can be up to 2-3 m vertically (river surface elevation relative to mean sea level) during any given day. In late 2005 and early 2006, 37 horizontal pore water tubes were deployed near the low-water mark in several areas known or suspected to contain elevated contaminant concentrations. The pore water tubes were buried at approximately 10 cm (4 in.) depth (biotic zone) into the matrix substrate. Pore water samples were subsequently collected during moderate and low river flow conditions. A simple analysis of water discharge patterns from the upriver hydroelectric facility was not enough alone to accurately describe the dynamic patterns of groundwater emergence into the river environments. A one-dimensional, unsteady river flow model was used to examine river conditions (river elevation fluctuation patterns) over the course of sampling. The model calculates river elevation using bathymetric data and time specified water discharge rates (cubic feet per second[CFS]) recorded from the tributaries and main-stem hydroelectric facilities. River water depth was inversely correlated ($p < 0.001$) with the amount of groundwater emerging into horizontal pore water devices. The initial sampling events were shown to reflect river conditions that occurred less than 50% of the year but more than 25% of the year. Some subsequent re-sampling efforts reflected low-flow river conditions that occurred less than 5% of the year. A multi-year analyses showed that river level conditions observed during the study period were similar to the long-term conditions evaluated between years 1997 and 2006.

706 Hanford Site River Corridor Baseline Risk Assessment – Ecological Risk. R. Ryti, J. Markwiese, J. Linville, Neptune & Co, Los Alamos, NM; S. Weiss, J. Thomson, Washington Closure Hanford, Richland, WA; B. Tillier, Environmental Assessment Services, Richland, WA. The project assessed ecological risks associated with affected media in the 100 Area and 300 Area component of the River Corridor Baseline Risk Assessment (RCBRA). The assessment evaluated the potential for ecological risks at post-remediation waste sites, riparian areas, and the near shore aquatic environment. The area considered in this assessment spans the entire Hanford Reach of the Columbia River. This project includes a set of workshops designed to incorporate regulator and natural resource trustee comments on the methodology into the assessment, which is intended to ensure greater acceptance of the approaches used in the report. The ecological risk assessment evaluated upland terrestrial (14 assessment endpoints evaluated using eight types of measures), riparian (15 assessment endpoints evaluated using eight types of measures), and near shore aquatic (12 assessment endpoints evaluated using eight types of measures) environments. Generally, the ecological measures indicated that post-remediation conditions at waste sites and the riparian areas were similar to reference site and local background concentrations. Evidence for exposure was noted in the near shore aquatic environment. There were differences in bioassay endpoints between sampling stations in the near shore and riparian areas, but these bioassay response measures were correlated to confounding factors like particle size and not contaminants. The project employed reference sites and a contaminant gradient approach and there were concerns expressed regarding the reference sites selected for the assessment.

707 Emerging Contaminants and the Great Lakes: Assessment of Risk to Human Health and the Environment-Introduction. E. Mastrocco, Pfizer Inc, New York, NY; D. Salvito, Research Institute for Fragrance Materials, Woodcliff Lake, NJ. Recent publications and regional scientific meetings (e.g., the 2006 State of the Lakes Ecosystem Conference) have highlighted an increased interest in chemicals that are not part of the traditional suite of environmental analytes (i.e., those being legacy chemicals such as PCBs and PAHs) within the Great Lakes region. These new analytes are often termed 'emerging pollutants' although their use may often go back decades. These chemicals include veterinary and human health pharmaceuticals, ingredients used in personal care products and other chemicals used in commercial applications (e.g., flame retardants). Data useful in human health and environmental risk assessments are available for many of these chemicals and are applicable to the Great Lakes ecosystem but may not be widely distributed. Often the available data do not indicate a present risk;

however, more may need to be done to ascertain possible potential impacts to humans and aquatic species within the Great Lakes ecosystem and make this information available within the Region. Historically, the binational efforts of the United States and Canadian governments to maintain and improve the quality of the Great Lakes have set the standard for water quality initiatives, worldwide. Therefore, it is vital that the best available science be brought to bear in assessing the potential risks to human health and environmental quality of the Lakes.

708 Aquatic Environmental Risk Assessment of Pharmaceutical and Personal Care Product Ingredients. D. Versteeg, D.C. McAvoy, R.D. Vashon, S.E. Belanger, T.W. Federle, S.D. Dyer, B.B. Price, Procter & Gamble, Cincinnati, OH. Overall, there is a lack of data on the fate, effects, and risk posed by pharmaceuticals and personal care product ingredients (PPCPs) in the environment, hence, compounds in this class are considered "emerging". Fortunately, much is known about the fate, effects, and environmental risk posed by consumer product ingredients (CPI). Since, both types of products are used in the home, washed off or excreted after use, and their primary disposal route is via municipal wastewater collection and treatment systems, the exposure and effect methods validated with CPIs can be applied to PPCPs to assess risk in the environment. This presentation provides an overview of procedures for collecting and assessing environmental fate and effects data. It includes a discussion of quantitative structure activity relationships (QSAR), ecotoxicity, environmental fate, exposure modeling, environmental monitoring, ecopidemiology, and the application of these tools to PPCPs. Predicted environmental concentrations and no effect concentrations are compared in risk assessments on multiple ingredients. The approaches used are applicable to the Great Lakes and other regions.

709 Assessing ecorelevance of emerging chemicals in sediments. V.E. Forbes, H. Selck, Department of Environmental, Social and Spatial Change, Roskilde University, Roskilde, Denmark; D. Salvito, Research Institute for Fragrance Materials, Woodcliff Lake, NJ. Environmental monitoring of the Great Lakes and elsewhere has detected the presence of a wide variety of chemicals which has raised concern that these chemicals pose risks to resident species. Sediments are of particular interest due to their tendency to accumulate hydrophobic and persistent chemicals and because less is known about toxic effects of chemicals to sediment-feeding organisms than to pelagic species. Data collected on the polycyclic musks provides available evidence relevant to assessing exposure and effects in Great Lakes' sediments. Studies at Roskilde University demonstrate how effects measured on individuals can be extrapolated to the population level. The consequences of these studies and their impact on the assessment of risk will be discussed. An important message is that not all organismal or sub-organismal responses that are currently measured are relevant for protecting populations.

710 Risks of Agricultural Pharmaceuticals in Surface Waters and Soil of the Great Lakes. K.R. Solomon, Centre for Toxicology, University of Guelph, Guelph, Ontario, Canada; K.R. Solomon, P.K. Sibley, D. Hillis, Environmental Biology, University of Guelph, Guelph, Ontario, Canada; L. Linda, Laboratory Services Division, University of Guelph, Guelph, Ontario, Canada. Although pharmaceuticals from human and animal use have been detected in the environment in a large number of locations few data are available that characterize the sources, exposure and effects of pharmaceuticals in the environment. We have studied the geographic and temporal distribution of pharmaceuticals detected within seven tributaries receiving primarily agricultural inputs in a model watershed in Southern Ontario, Canada. Of the twenty-nine pharmaceuticals surveyed, 14 were detected in surface waters. Although not used in agricultural situations, carbamazepine was detected in strictly agricultural watersheds without WWTP inputs. Temporal concentration trends for 5 pharmaceuticals showed pulses occurring between May and November at similar but varying times. Compared to acute toxicity values and distributions of potency, of pharmaceuticals detected in the surface waters present small risks to aquatic organisms from acute effects. Effects on population and community responses in microcosms support the observation of low risk to the environment. Bioassays of twelve pharmaceuticals on the arbuscular mycorrhizal fungi, *Glomus intraradices* grown on *Daucus carota* root organ cultures showed that sulfamethoxazole was the most toxic to both the fungi and roots, with EC50 values of 67 and 57 µg/L, respectively. Root organ cultures are useful method to evaluate chemical stressors on arbuscular mycorrhizal fungi and screen for root-based phytotoxicity. Risks to plants and mycorrhizal fungi from estimated environmental concentrations were small.

711 A first pass at evaluating potential human health risks from estrogens in surface water. D.J. Caldwell, Johnson & Johnson, New Brunswick, NJ; P.D. Anderson, AMEC Earth & Environmental, Westford, MA. Estrogens fall into three general classes: endogenous (e.g., estrone, estradiol); synthetic (e.g., ethinylestradiol (EE2)); and phytoestrogens (e.g., genistein). Improvements in analytical techniques have resulted in detection of low levels of estrogens that have raised concerns because of their potential to affect both aquatic and human health. A recent study found that estrogens derived from therapeutic use are predicted to be present in drinking water at less than 0.0001% of total estrogen exposure for all age groups studied. Phytoestrogens (present in surface water at 322 ng/L) dominate drinking water exposure, followed by naturally produced E1, E2 and E3 (present at a total of 6.4 ng/L), endogenous estrogens used in HRT (present at 0.3 ng/L), and the synthetic EE2 (0.02 ng/L). Estrogens from HRT in drinking water are predicted to account for <0.002%, while EE2 accounts for <0.0001% of total estrogen exposure in drinking water. However, the biological activities of these different estrogenic compounds on a mass basis are not equivalent and recent research demonstrates that the biological activities of estrogenic compounds are not determined solely by receptor binding affinity. The ability of a compound to elicit a response varies greatly from one organ, tissue, and endpoint to another. Evaluating the combination of these different biological responses requires an integrated measure of potential effects. One way to assess the overall impact of estrogens in surface water on human health is to compare measured or predicted concentrations to safe exposure levels that have been developed to protect workers occupationally exposed and evaluate the margin of safety (MOS). Preliminary calculations for the prescribed E2 and EE2 indicate MOS of 640 and 3300, respectively. These values can be put into perspective by comparing them to the phytoestrogen, genistein, with a MOS >5000, and total drinking water exposure (all sources combined) of naturally occurring hormones (E1, E2, and E3) with a MOS of no less than 30. 1. Anderson et al., An assessment of overall estrogen exposure for the general population and several subpopulations in the United States. Poster presented at Society of Toxicology Meeting, March 2007, Charlotte, NC and SETAC-Europe, May 2007, Porto, Portugal (as Mastrocco et al.)

712 Environmental fate and distribution of cyclic volatile methylsiloxane materials: A modeling assessment. K. Plotzke, G. Koserski, S. Xu, Health and Environmental Sciences, Dow Corning Corporation, Midland, MI; R. Gerhard, Degussa Goldschmidt GmbH, Essen, Germany; J. Bazinet, Clariant LSM Inc., Gainesville, FL. Low molecular weight cyclic volatile methylsiloxane (cVMS) materials are used in a wide variety of consumer products and may be released to various environmental compartments. Because of volatility and very low water solubility, cVMS materials occupy a chemical partitioning space that strongly influences the behavior of these materials in the environment. The fate and distribution of cVMS materials released to the environment will be discussed using modeling and the results from the most recent determination of partition coefficients. If released to air, cVMS materials appear to remain in air and degrade by reacting with hydroxyl radical. If released to water, cVMS materials appear to be removed from the water column by volatilization, deposition to sediment, and hydrolytic degradation. Because of the very low water solubility and high affinity for organic matter, cVMS materials that do not evaporate from the water column or hydrolyze, deposit to sediment and are predicted to be confined to the vicinity where released. (Sponsored in part by the Silicone Manufacturers)

713 Distribution of Pharmaceuticals from Tributaries into the Lake Michigan Ecosystem. R. Klaper, P. Anderson, Great Lakes WATER Institute, UW-Milwaukee, Milwaukee, WI; J. Piatt, Chemistry and Environmental Sciences, Carroll College, Waukesha, WI. The presence of human and agricultural pharmaceuticals in freshwater systems has been documented through several studies worldwide. Pharmaceuticals have the potential to cause greater problems than traditional pollutants such as pesticides and industrial pollutants as they collectively affect many different metabolic pathways in organisms. They are designed to have low acute toxicity, however they act on pathways that are thought to be conserved in vertebrates and therefore have the potential to have similar effects in other species including fish, with unknown consequences. The US Geological Survey has conducted studies in various watersheds, however their main focus in Lake Michigan has been on estrogenic substances. The levels of many pharmaceuticals in the tributaries of Lake Michigan are largely unknown and there have been no studies on the levels of pharmaceuticals found in the lake itself, its sediments and fauna.

Our preliminary studies have found measureable levels of hydrocodone (pain medication) and amoxicillin (antibiotic) in water and sediment samples in Milwaukee's inner harbor. In this presentation we will discuss our preliminary findings of surveys from the Milwaukee estuary out into Lake Michigan as well as samples from sediment and water in Green Bay. In addition we will discuss the potential for accumulation of these compounds in sediments, mussels, and fish. In order to determine the impact these chemicals may have in the ecosystem, we first need to understand their distribution. The data from this project will provide a basis for modeling the fate of these emerging contaminants into Lake Michigan and out into the food web of the Great Lakes. This information can be used to model the potential fate of other chemically related compounds and will be useful for municipalities and government regulatory purposes.

714 Fathead Minnow Lifecycle Exposure to the B-blocker, Propranolol. J.L. Parrott, B. Blunt, V. Palabricia, V. Balakrishnan, Environment Canada, Burlington, Ontario, Canada. Propranolol is a human pharmaceutical B-blocker used to control heart rate and blood pressure. It has been detected in municipal wastewater effluents in North America at concentrations of low ng/L to low ug/L. To assess the potential of this compound to affect fish, fathead minnows were exposed for a lifecycle in a flow thru system to propranolol concentrations of 0, 32, 100, 320, 1000 ng/L (nominal). Females exposed to 32, 100, 320 ng/L were shorter in length and weighed 20 % less than control females. The trend was similar for female fish exposed to 1,000 ng/L propranolol, but the changes were marginally significant. No significant changes weights or lengths were seen in male fathead minnows. There were no significant changes (from control fish) in condition factor (CF), gonad size (as gonadosomatic index, GSI), liver size (liver-somatic index, LSI) or sex characteristics in propranolol-exposed male or female fish. Despite their small size, female fathead minnows from propranolol exposures produced as many eggs (32 ng/L and 1,000 ng/L propranolol treatments) or more eggs (320 ng/L propranolol) than control fish. Fish exposed to 100 ng/L propranolol produced fewer eggs than control fish. Egg production was variable and showed no trends or dose-response with propranolol concentration. Currently we are repeating the lifecycle with a wider range of concentrations (1, 10, 100, 1,000 and 10,000 ng/L) to validate the fish exposure concentrations, to assess whether the growth reductions are repeatable, and to determine the LOEC and NOEC. The study is important as it assesses the potential for effects in fish exposed to environmentally-relevant concentrations of propranolol during all critical windows of exposure in their lifecycle.

715 Changes in Global Gene Expression in Larval Zebrafish Exposed to Microcystin. E. Rogers, T.B. Henry, Center for Environmental Biotechnology, University of Tennessee, Knoxville, TN; E. Rogers, T.B. Henry, Department of Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville, TN; M.J. Twiner, Center for Coastal Environmental Health and Biomolecular Research, NOAA, Charleston, SC; S.W. Wilhelm, Department of Microbiology, University of Tennessee, Knoxville, TN. The occurrence of blooms of toxic algae in freshwater environments is a global ecological and public health concern. Species of *Microcystis* are of particular importance because blooms occur in many freshwater environments throughout the world and microcystin toxins often exceed the World Health Organization advisory level of 1 µg/L. While microcystins have been associated with fish kills in aquatic environments, sublethal effects, including those on early life stages, are largely unknown. In the present study, we exposed zebrafish larvae to purified microcystin-LR (0-1,000 µg/L) or lyophilized cells of cultured *Microcystis aeruginosa* and determined effects on global gene expression. At 24-hour intervals, mortality and behavioral observations were recorded, and larvae were sacrificed at 96 hours for RNA extraction and global gene expression analysis (Affymetrix zebrafish array, ~15,000 genes). No significant mortality or behavioral changes were observed during the experiment; however, changes in gene expression were observed. Relative to control, 127 genes were differentially expressed (>two-fold change) in larvae exposed to purified microcystin-LR. In larvae exposed to lyophilized cells of *M. aeruginosa*, 59 genes differed in expression compared to control, 19 of which were also differentially expressed in purified microcystin-LR treatments. Results are being confirmed by quantitative real-time PCR, and ongoing analyses of microarray results will provide insight on molecular pathways activated during exposure. These analyses will contribute to our understanding of sublethal effects of microcystin in larval fish and provide potential biomarker genes for assessment of fish exposed to microcystin in aquatic ecosystems.

716 Tweakings TSCA - The Perfect Storm and the Future of Chemical Regulation in the United States. D.J. Kent, Keller and Heckman LLP, Washington, DC. For over 30 years, the Toxic Substances Chemical (TSCA) has been the governing chemical control law in the US. It has remained virtually unchanged since that time. While voices are raised periodically regarding the need to 'reform' the law, these voices have generally been a knee-jerk response to some event and have quickly died away. Recently, however, these voices have been louder and more sustained, so this begs the question as to whether this time is different. Is it possible that TSCA will be modified in the foreseeable future? Does it need to be or not? Despite the fact that more health and safety data have become publicly available in a shorter time than ever before (e.g., via the HPV and other voluntary programs), the voices of change appear to be gathering into a form of 'perfect storm' that could lead to a change to how we regulate chemicals in the United States...perhaps a major change. The three "storms" are Government pressure, Public/NGO pressure, and Industry precedent/stewardship. This paper will examine each of these contributing 'storms' and present some strategies for the future that consider the complementary goals of protecting human health and the environment and encouraging sustainable business practices and innovation.

717 REACH - Defending Embattled Products. D.J. Kent, Keller and Heckman LLP, Washington, DC; D. Graham, Keller and Heckman, San Francisco, CA. REACH – the Registration, Evaluation, and Authorization of Chemicals – is the new chemical control law in Europe. It requires that all chemicals, both existing and new, be registered in order to be manufactured or imported into Europe. However, the registration phase should not be the greatest concern for industry. The heart of REACH is actually in how it deals with what the new Agency considers very risk substances. SVHCs - Substances of Very High Concern – will be subject to intense pressure for removal from the European marketplace, with ramifications to their marketability well beyond the EU. SVHCs include the usual suspects, e.g., carcinogens, mutagens, and reproductive toxins (CMRs); persistent bioaccumulative toxins (PBTs), very persistent and very bioaccumulative materials (vPvBs); as well as anything that shows "equivalent effects" such as endocrine disruptors. This paper discusses how SVHCs will be identified, how they will be evaluated, and what kind of data will be required. Special emphasis will be given to the Authorization process and how to defend products in an atmosphere in which there is considerable pressure to find substitutes to existing chemicals. Finally, guidance and strategies for companies to pursue now are offered.

718 Multilateral Environmental Agreements for the International Management of Chemical Pollutants. S. Gardner, A.C. Rush, J.E. Thompson, OES/ENV, U.S. Department of State, Washington, DC. Numerous multilateral environmental agreements exist for the global management of chemicals. This presentation will provide a description of the current activities of four global treaties for the management of chemicals: the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal; the Rotterdam Convention on Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade; the Stockholm Convention on Persistent Organic Pollutants (POPs); and the Montreal Protocol on Substances that Deplete the Ozone Layer. With limited resources for implementing the conventions' mandates, prioritization of efforts is essential. Sound scientific information on the health and environmental effects of chemicals is the basis for international regulatory efforts.

719 Defining Data Quality in the Context of "Best Available Scientific and Commercial Information". A.T. Hall, Bayer CropScience, Research Triangle Park, NC; B.D. McGaughey, Compliance Services International, Lakewood, WA. The Endangered Species Act (ESA) at § 7(a)(2) requires that decisions in ESA § 7(a)(2) analyses be based on the "best scientific and commercial data available." 16 U.S.C. 1536(a)(2). All aspects of an assessment and any other processes or actions must comply with the standard set forth in the definition of "best scientific and commercial data available." In light of this, no endangered species can be considered to be affected unless that decision can be made on the basis of an assessment that complies with the criteria set forth to define "best scientific and commercial data available." However, the term is only generally defined in the Act itself and in resulting regulation, and there can be much controversy when it comes to which data an expert might rely upon to determine whether or not a species may be affected by a given action. For that reason, a definition and practical examples are discussed here. Application of "best available data" follows the logic of good science and provides a basis for putting the testimony of an expert witness in context with the reliability of the information presented.

720 Considering ecosystem resilience in watershed management: A case study on severe anthropogenic disturbance to aquatic ecosystems. C. Knight, Nautilus Environmental, Squamish, British Columbia, Canada; H. Bailey, Nautilus Environmental, San Diego, CA. The town of Squamish, British Columbia, population of 15,000, is located in the Squamish River watershed, in BC's coastal mountains. Urban development, logging and a hydro dam are the primary stressors on aquatic and riparian habitats in the watershed. However, two recent severe environmental disturbances have placed additional stress on the watershed. In August 2005, a train derailment spilled 40,000L of sodium hydroxide into the Cheakamus River, a major tributary of the Squamish. The resulting spike in pH caused the mortality of nearly all aquatic biota present in the water column at the time of the spill. Affected species were juvenile and adult salmon, char, and three brood years of steelhead trout (mortality > 90%), as well as benthic invertebrates, sculpins (Cottids), and lamprey. The estimated fish kill was 500,000; the largest documented fish kill in BC history. Then, one year after this spill, approximately 35,000L of Bunker C oil spilled from a container ship that was berthed at the mouth of the Squamish River estuary. Heavy oiling occurred in several kilometers of estuary shoreline and channel habitat, and channel/foreshore sediments continued to exhibit hazard quotients for several PAH compounds in excess of 600 – 800 many months after the spill. A number of Cheakamus River species rear in the estuary, including chinook, pink and chum salmon, and it is likely the most productive habitat in the watershed. Recovery efforts for the Cheakamus fish are on-going, and are based on species-specific recovery targets. Efforts include short-term hatchery programs for salmon species, as well as a two-year steelhead hatchery program. Considerable technical and political controversy surrounded the steelhead program decision; the potential for reduced genetic fitness was weighed against the real likelihood of extremely low adult returns (0-20 fish) for three consecutive years. In-river and off-channel habitat creation/enhancement works are also part of the recovery strategy to build more resiliency into the river and estuary ecosystems, in the hopes of increasing the watershed's capacity to withstand additional natural (e.g., flood events) and anthropogenic disturbances. The confounding effects of the oil spill on Cheakamus fish recovery efforts (e.g., reduced productivity in areas hit hardest by the spill) are also considered in the long-term decision making for river recovery.

721 Decision Evaluation for Complex Risk Networked Systems (DECERNS): Modeling Software and Applications. I. Linkov, Intertox Inc., Brookline, MA; T. Sullivan, Brookhaven National Laboratory, Upton, NY; A. Grebenkov, Joint Institute for Power and Nuclear Research, Sosny, BELARUS; B. Yatsalo, Obninsk State Technical University, Obninsk, RUSSIAN FEDERATION; L. Kapustka, Golder Associates, Calgary, Alberta, Canada; G. Kiker, University of Florida, Gainesville, FL. Environmental decision-making strategies have evolved with the development of computer capabilities and analytical tools. Strategies often involve incorporation of subjective judgment to incorporate public and stakeholder values, cost-benefit analysis, toxicological risk assessment, ecological risk assessment, and many methods. This evolution has led to an improved array of decision-making aides, including the development of Multi-Criteria Decision Analysis (MCDA) tools that offer a scientifically sound decision analytical framework. The existence of different MCDA methods and the availability of corresponding MCDA and Geographic Information Systems (GIS) tools both contribute to the possibility of practical implementation of these approaches/methods when investigating environmental problems. The objective of the DECERNS project is to develop the methodology, computer models and software tools that would facilitate the defensible, reproducible decision-making in the field of remediation and sustainable land use. The DECERNS software will have the following major elements of decision support system: (i) a multi-criteria decision analysis (MCDA) technique for defensible and sound decision-making, this will include tools to incorporate value judgments in the decision process (e.g., prefer to minimize health risks as opposed to total costs, etc.); (ii) a software with GIS applications for effective ranking and comparison of available options; (iii) environmental risk assessment models for ecological and human health and (iv) cost-benefit or least-cost analysis tools. This presentation will provide an overview of the DECERNS software product and applications to ecological risk assessment.

722 Ecological Soil Screening Levels (Eco-SSLs) for the USEPA Superfund Program 1999 to 2007. J. Burris, Syracuse Research Corporation, Denver, CO; D. Hoff, C. Russom, USEPA, Duluth, MN; S. Ells, USEPA, Washington, DC; D. Charters, M. Sprenger, USEPA, Edison, NJ. The US

Environmental Protection Agency (USEPA) has established ecological soil screening values for soil contaminants frequently of ecological concern for terrestrial plants and animals at hazardous waste sites. Initiated in 1998, the Eco-SSL effort represents the collaborative effort of a multi-stakeholder workgroup consisting of federal, state, consulting, industry and academic participants. The result of the effort was a series of guidance documents and contaminant specific documents issued in late 2003 and revised in early 2005 and again in 2007. Eco-SSLs are derived separately for four groups of ecological receptors: mammals, birds, plants, and soil invertebrates. These Eco-SSLs represent a set of screening ecotoxicity values that can be used routinely to identify those contaminants concern in soils requiring further evaluation in an ecological risk assessment (ERA). EPA developed the Eco-SSLs to conserve resources by eliminating the need for repetitious toxicity-data literature searches and evaluations; to increase consistency; and to allow resources to focus on key site studies needed for critical decision-making. This presentation provides an overview of the processes used to derive the Eco-SSLs as well the results for all twenty one contaminants of concern. The presentation also highlights the changes to processes made in 2005 and 2007 and the completed Eco-SSLs in 2007. Eco-SSL contaminants include seventeen metals (aluminum, antimony, arsenic, barium, beryllium, cadmium cobalt, chromium, iron, nickel, lead, selenium, vanadium, and zinc) and four organic contaminants including DDT, dieldrin, pentachlorophenol, and PAHs.

723 Characterization of Rapid Versus Deliberate Decision Analysis in Ecological Risk Assessment. I. Linkov, Intertox Inc., Brookline, MA; S. Cormier, NCEA, USEPA, Cincinnati, OH; L. Kapustka, Golder Associate, Calgary, Alberta, Canada. Ecological risk assessments always involve planning, analysis and synthesis phases that are used to inform the decision analysis process. However, implementation of that process is influenced in different ways by the temporal and spatial frames in which the decisions are made. Some decisions, such as those made within a rapidly evolving crisis, require extensive pre-planning and training so that decision-makers may react appropriately. Other decisions, in which the timing of the decision is less critical, can occur in a more deliberative or consensus-building manner. Although, both types of decision are based on risk assessments that inform decision-makers of their options and the potential outcomes of the choices before them, there are differences in the types of options and outcomes that would be considered acceptable. For example during problem formulation, the rapid-form of environmental assessment focuses on a "triage" level of assessment endpoints to prevent loss of human life, loss of property or irreplaceable environmental resources. The more deliberate-type also considers these critical objectives, but may also include longer term outcomes, aesthetics, and opportunities to achieve multiple goals. Furthermore, the more deliberate form of risk assessment can improve rapid decision analysis when they are done as a form or preparedness such as emergency response plans. Although we recognize that a continuum exists between these extreme situations, both rapid and deliberate risk assessments and decision analyses may be improved by recognizing similarities and differences encountered in these situations and optimizing strategies accordingly.

724 Streamlined Approach For Risk Evaluation Of Military Radar Installations On The North Slope Of Alaska. M. Roy, S. Smith, URS Corporation, Austin, TX; R. Porter, Noblis, San Antonio, TX; M. Sprenger, EPA Emergency Response Team, Edison, NJ; D. Cook, Headquarters Pacific AF, Hickam AFB, HI; M. Brewer, Alaska Dept. of Environmental Quality, Anchorage, AK. Long Range Radar Relay stations along the North Slope of Alaska present unique challenges for environmental investigations as well as clean up. Because of the limited field season and logistical challenges, traditional investigation and clean up timeframes are not necessarily practical. In 2006, the Air Force began a project to identify the unique circumstances associated with these sites and develop a framework using both human health and ecological risk assessment to assist remedial decision making. The process consists of six general steps: 1) prepare preliminary conceptual site model, 2) evaluate adequacy of existing data, 3) identify constituents of potential concern, 4) perform hazard evaluation, 5) conduct focused risk assessment if additional evaluation is warranted and 6) develop site-specific risk management plans. The scope of the project was developed using a stakeholder team including risk assessment experts from the AF, Alaska Department of Environmental Conservation, USEPA, and consultants. Four sites along the most northern portions of Alaska were chosen as test cases to apply the process. Site visits were conducted in July of 2006 to evaluate migration pathways and to identify potential human and ecological receptors.

Once the receptors were identified, back-calculated risk based screening levels were developed for comparison to the existing site data. The comparison to site data helped focus the risk evaluation using a weight of evidence technique. The goals of the project included: 1) develop a template screening/evaluation process that can be applied to other similar facilities in a cost-effective manner, 2) produce a document that will allow risk managers to make informed risk-based decisions and 3) provide risk managers with information needed to a) identify the scope of potential actions, b) derive cost-effective remediation goals for sites at the installations and c) communicate with the public.

725 Essential and non-essential elements in scalp hair of men exposed to volcanic emissions in the Azores. A. Amaral, S. Cabral, M. Arruda, A. Rodrigues, CIRN, DB, University of the Azores, Ponta Delgada, Portugal. Volcanoes are well known for their large production and release of toxic substances and compounds. Whether humans chronically exposed to volcanogenic gases and dusts demonstrate a higher level of trace metals was investigated. Washed scalp hair samples of men (between 3 and 89 years old) living in two rural areas of the Azores (Portugal), one exposed to volcanic emissions and the other not, were analyzed for six selected elements (Cd, Cu, Pb, Rb, Se, and Zn) by using High Resolution Inductively Coupled Plasma Mass Spectrometry (HR-ICP/MS). The concentrations of Cd, Cu, Pb, Rb, and Zn were significantly higher in the group of men exposed to volcanic emissions, while the levels of Se were significantly lower in this same group. The observed order of mean concentrations for both groups was $Zn > Cu > Pb > Se > Rb > Cd$. Strong element-to-element correlations were found for both groups of donors. The results of the present study are compared to those reported for subjects from other regions of the world, and discussed according to a couple of studies on the health outcomes present in these areas.

727 Use of Intake Fractions and blood half-lives in combination with Toxic Equivalency Factors (TEFs) to evaluate multi-compound emissions and blood concentrations. G. Soucy, M. Margni, R. Manneh, L. Deschênes, Chemical Engineering, Ecole Polytechnique de Montreal, Montreal, Quebec, Canada; O. Jolliet, Y. Wenger, School of Public Health, University of Michigan, Ann Arbor, MI; J. Dettling, Great Lakes Commission, Ann Arbor, MI; S. Humbert, Engineering and Project Management, University of California, Berkeley, CA. It is common to use Toxic Equivalency Factors (TEFs) to compare emissions of various congeners of dioxin-like compounds or PAHs. Based on dose-response experiments, these TEFs are adequate to compare intake, but are also often used inappropriately to produce TEF-weighted emissions or to compare serum concentrations of various congeners. The present paper develops a method to consistently compare both emissions and serum concentrations and applies it to the 29 WHO dioxin-like compounds and the 16 U.S. EPA PAHs. To relate emissions to intake, a multi-scale multimedia fate and exposure model is being developed with high resolution in the Laurentian Great Lakes region to determine Intake Fractions - the fraction of an emission that is taken in by the overall population. For PAHs, it shows that 3% of the emissions correspond to 53% of the intake, which account for 98-99% of the toxic impact. This demonstrates that it is essential to account for both toxic potential (i.e., TEFs) and environmental transport/exposure (i.e., intake fraction) to weight PAH emissions. For serum concentrations, it is important to relate intake to serum concentration, which is done by accounting for half-lives and pharmacokinetics in the body. This pharmacokinetic method is illustrated using the 29 dioxin-like compounds, resulting in a deviation of up to one order of magnitude from the TEF-only calculation. The result is a model and set of Emission Equivalency Factors combining iF and TEF that can be used to appropriately weigh emissions based on their potential fate, exposure and health impact. Similarly sets of Blood Equivalency Factors will be provided combining pharmacokinetics and TEF to appropriately weigh blood concentrations.

728 Dissolved Lithium Concentrations, Gender, Race, and the Geography of Texas Suicide Mortality Rates 1980-1998: A Correlation Study. W.M. Flanagan, Geography, University of North Texas, Denton, TX. This study examines the spatial distribution of suicide mortality rates in Texas counties, from 1980 to 1998. Using the conceptual framework of disease ecology, this study provides insight into selected risk factors associated with suicide mortality. In particular, the factor of dissolved lithium concentrations in the groundwater and the correlation to suicide mortality rates are tested. Spearman's rank correlations and the Wilcoxon test are used to examine race, gender, and dissolved lithium concentrations as risk predictors of suicide mortality. The results suggest that counties with lower dissolved lithium concentrations in their groundwater had significantly higher suicide mortality

rates. Counties with higher populations of Whites had significantly higher suicide mortality rates, but counties with higher populations of Hispanics had significantly lower suicide mortality rates. Males had higher suicide mortality rates than females. Further research into the relationship between lithium concentrations and suicide is warranted.

729 Naturally-Occurring Polonium-210 in Ground Water near Fallon, Nevada. R. Seiler, U.S. Geological Survey, Carson City, NV. Gross-alpha radioactivity was more than 10 times greater than could be explained by the presence of uranium isotopes in 33 of 100 wells sampled in 2001 in Fallon, Nev., the location of a childhood leukemia cluster. Analysis of the decline in gross-alpha radioactivity data over a 30 day period indicated that the unidentified radioactivity was due to unusually high concentrations of the radioisotope polonium-210 (^{210}Po). The U.S. Geological Survey is currently investigating the occurrence and geochemistry of ^{210}Po in Fallon ground water. ^{210}Po activities of 1-2 Bq/L have been measured in wells used as sources of drinking water near Fallon, and ^{210}Po activities greater than 2 Bq/L have been reported in only two other locations in the United States. Typically ^{210}Po activities in ground water are <0.04 Bq/L because it binds strongly to aquifer sediments. The source of the ^{210}Po is decay of naturally-occurring uranium-238 progeny in the sediments. ^{210}Po is a known human carcinogen and is probably the principal carcinogen in tobacco smoke. ^{210}Po is listed on the USEPA Unregulated Contaminant Monitoring Requirements for public supply, but a Maximum Contaminant Level has not been proposed.

730 Major and Trace elements chemistry of surface water around abandoned and active dumpsites in Lagos, Nigeria. A.M. Odukoya, Earth Science, Olabisi Onabanjo University, Ago-Iwoye, Ogun, Ogun State, NIGERIA; A.F. Abimbola, Geology, University of Ibadan, Ibadan, Oyo, NIGERIA. Abstract Dumpsites, over the years have become point source for pollution. Geochemical analyses of surface waters from streams flowing around abandoned and active dumpsites in Lagos, South Western Nigeria were carried out with respect to the influence of anthropogenic activities from the two dumpsites. This study highlighted the need to understand the interactions between the dumpsites and the surface water systems and in essence the environmental pollution management. Results show that the surface water samples have generally low TDS with average value of 193.62 and 193.38mg/l for abandoned and active dumpsites respectively, while average concentrations of the dominant ions for abandoned and active dumpsites are 71.8 and 39.86mg/l (Na) representing 40.7 and 46.3% of the total cations respectively and NO_3 (av. 136.89 and 111.51mg/l) representing 49.1% and 40% respectively of the total anions. Trace elements and major elements concentrations were extremely variable and consistently higher than world river average, WHO (2004) and EPA (2005) standards. Water samples collected upstream and downstream from the dumpsites indicated that anthropogenic activity of the dumpsites directly influenced its chemical composition. Samples collected did not invariably show similar patterns, with various elements having higher dissolved concentrations downstream. Although the impact of pollution is clearly recognizable in water samples collected in proximity to the two dumpsites. The impact of such anthropogenic activities from these two dumpsites is revealed by the very high degree of contamination as shown by the samples taken around the two dumpsites while the samples around the abandoned dumpsite showed higher level of contamination than those around active dumpsite. Keywords: Surface water; Trace elements; Dumpsites; Anthropogenic activities.

731 Ecological Community-Level Responses to Experimental EE-2 and Trenbolone Gradients in Stream Mesocosm Experiments. W.K. Taulbee, C. Nietch, D. Brown, USEPA-ORD/NRMRL, Cincinnati, OH; R. Flick, J. Lazorchak, USEPA-ORD/NERL, Cincinnati, OH; B. Ramakrishnan, M. Tompkins, Shaw Infrastructure and Environmental, Cincinnati, OH; M. Smith, Dynamac Corporation, Cincinnati, OH. Endocrine disrupting chemicals (EDCs) alter the normal functioning of the endocrine system, and are becoming increasingly concentrated in aquatic systems. Studies of the effects of EDCs on aquatic vertebrates are becoming more common; however, the effects of EDCs on algal and invertebrate communities, endpoints typically measured during aquatic bioassessments, are relatively poorly examined. To assess the effects of EDCs on ecological community-level responses, we examined the effects of an estrogenic (17α -ethynyl estradiol, EE-2) and androgenic (trenbolone) EDC in two stream channel experiments. In the first study, six channels were randomly assigned to one of five EE-2 concentrations (2.5, 5, 10, 50, and 100 ng/L) plus a sixth control channel. In the second study, three EE-2 concentrations (2.5, 12.5, 62.5 ng/L), three trenbolone

concentrations (5, 25, 50 ng/L), and one control, were randomly assigned to seven channels. Each experiment consisted of a two week colonization period, a three week dosing period, and a two week recovery period. Fine sediment levels, nutrient concentrations, periphyton chlorophyll-a, AFDM, and elemental composition, and invertebrate benthic densities and per capita emigration rates were measured at the end of the colonization period, weekly during the dosing period, and at the end of the recovery period. Abiotic and biotic responses were similar across EDC treatments in both studies. Significant temporal community-levels effects were common, and were largely explained by successional patterns as stream channels filled with fine sediments. Invertebrate communities differed markedly between the two experiments, most likely the result of the timing of the two studies. However, fathead minnow vitellogenin gene expression was positively correlated with EE-2 concentration in both studies. These results demonstrate that conventional bioassessment protocols are insufficient at measuring effects of EDCs at environmentally relevant concentrations.

732 Triclosan is a potent inhibitor of estradiol and estrone sulfonation in the sheep placenta. M.O. James, D.P. Summerlot, W. Li, Medicinal Chemistry, University of Florida, Gainesville, FL; M. Keller-Wood, Pharmacodynamics, University of Florida, Gainesville, FL; C.E. Wood, Physiology and Functional Genomics, University of Florida, Gainesville, FL. The personal care product, triclosan, is widely used in consumer products and is increasingly found as a contaminant of sewage sludge and wastewater. It is structurally related to known inhibitors of estrogen sulfotransferase, such as polychlorobiphenyls. Previous work demonstrated that sheep placenta expresses estrogen sulfotransferase, and that the sulfate conjugates of estradiol and estrone formed in the sheep placenta are transferred to the fetus, where they are hydrolyzed, and are important sources of estrogen for normal fetal development. In this study, we examined the effect of triclosan on placental cytosolic estrogen sulfotransferase activity with 17-beta-estradiol (E2) and estrone (E1) as substrates. The apparent K_m for placental cytosolic sulfotransferase activity with E2 was 3 ± 1 nM and exhibited substrate inhibition at concentrations higher than 20 nM, typical of other estrogen sulfotransferases. Studies of inhibition were conducted with 1 nM E2 or E1. Triclosan inhibited E2 sulfonation with an IC_{50} of 1.9 ± 0.8 nM and inhibited E1 sulfonation with IC_{50} of 0.6 ± 0.2 nM. The high potency of triclosan as an inhibitor of estrogen sulfotransferase activity raises concern about its possible effects on fetal growth and development.

733 Toxicity of the antimicrobial compound triclosan and formation of the metabolite methyl-triclosan in estuarine systems. M.E. DeLorenzo, NOAA, National Ocean Service, Charleston, SC; J.M. Keller, National Institute of Standards and Technology, Charleston, SC; C.D. Arthur, M.C. Finnegan, H.E. Harper, V.L. Winder, D.L. Zdankiewicz, College of Charleston, Grice Marine Biology Program, Charleston, SC. Triclosan is an antimicrobial compound used in a wide variety of personal care products. Triclosan and its primary degradation product, methyl-triclosan, have been measured in wastewater treatment plant effluent and surface waters. This study examined the effects of triclosan on marine species and the potential for biouptake and exposure in the estuarine environment. Acute toxicity was assessed using the bacterium *Vibrio fischeri*, the phytoplankton species *Dunaliella tertiolecta*, and three life stages of the grass shrimp, *Palaemonetes pugio*. Larval grass shrimp were more sensitive to triclosan than adult shrimp or embryos. Acute aqueous toxicity values (96h LC50s) were 305 $\mu\text{g/L}$ for adult shrimp, 154 $\mu\text{g/L}$ for larvae, and 651 $\mu\text{g/L}$ for embryos. Adult grass shrimp were found to accumulate methyl-triclosan in their tissues after a 14-d exposure to 100 $\mu\text{g/L}$ triclosan, indicating potential for trophic transfer of the metabolite. The presence of sediment decreased triclosan toxicity in adult shrimp (24h LC50s were 620 $\mu\text{g/L}$ with sediment, and 482 $\mu\text{g/L}$ without sediment). The bacterium was more sensitive to triclosan than the grass shrimp, with a 15min aqueous IC_{50} value of 53 $\mu\text{g/L}$, and a 15min spiked sediment IC_{50} value of 616 $\mu\text{g/kg}$. The phytoplankton species was the most sensitive species tested, with a 96h EC50 value of 3.55 $\mu\text{g/L}$. Triclosan was detected in limited surface water sampling of Charleston Harbor, SC at a maximum concentration of 0.001 $\mu\text{g/L}$; significantly lower than the determined toxicity thresholds. This preliminary assessment suggests triclosan poses low acute toxicity risk to estuarine organisms; however, the potential for chronic, sublethal, and metabolite effects should be investigated.

734 Immunotoxicology Perspective - past, present and future. E.T. Lavoie, Animal Sciences, University of Maryland, College Park, MD; M.J. Quinn, U.S. Army Center for Health Promotion and Preventive Medicine,

Aberdeen Proving Ground, Aberdeen, MD. A healthy immune system is critical to a quality life. Immune function is complicated and interplays with other organ systems. Researchers have demonstrated impacts of environmental contaminants on immune function in many cases and in a number of landmark studies. However, immune health is often difficult to measure in wildlife or non-traditional lab models. While human and rodent immunology advance at a rapid pace, implementing new knowledge and techniques to ecotoxicological studies is challenging – especially for field studies. Here we review the history, present work and future needs for ecological immunotoxicology. Landmark papers on immunotoxic impacts of environmental contaminants were published in the 1990s by several leading immunotoxicologists which strongly associated exposures to environmental contaminants with deficits in immune function and in turn potential causes of morbidity in wild birds and marine mammals. Further important work has been done in other vertebrate classes and with invertebrates. Immunological impacts of contaminants are continuing to be noted in on-going studies, for example, in fish eating birds and in amphibians. Currently investigators are also implementing genomic technologies to answer questions in immunotoxicological studies as demonstrated in papers presented at SETAC NA in the last few years. The benefit of these ‘omics’ data and relevance to responses to pathogens at the organismal level and not just the gene expression level needs discussion and study. Furthermore, how does work on immune function relate to population impacts during disease outbreaks? There is a continuing need for immunological data in ecotoxicological studies and careful evaluation of contaminant impacts at both laboratory and field levels.

735 Effects of Methoxychlor Exposure on the Development of CD4 T-Cells in C57BL/6 Mice. C. Broussard, A.J. Vasa, A. Parada, Biology, University of La Verne, La Verne, CA. T cells, one of many cell types comprising the immune system, protect the body from pathogens and diseases by initiating and orchestrating the adaptive immune response. T cells express one of two main types of co-receptors, CD4 and CD8. Before 1997, researchers were unable to study the development of T cells in the absence of the thymus, a lymphoid organ where T cells develop. However, Cibotti et al. (1997) found specific surface molecules (CD2 & TCR) that were able to signal immature T cells to become mature T cells in the absence of thymic epithelium. The goal of this project was to study the effects of methoxychlor (MXC) on the development of T cells using this in vitro model of T cell differentiation. MXC is an organochlorine pesticide adopted for use as a safer alternative to DDT, when DDT was banned. MXC is of particular concern because it mimics estrogens and acts as an endocrine disruptor. Previous studies have investigated the toxicological effects of MXC exposure and have found negative effects on the nervous and reproductive systems. Few studies, however, have been conducted investigating the effects of MXC on the development of the immune system, even though exposure to estrogens has been shown to reduce the number of T cells in the thymus (Barr et al., 1982). In agreement with studies of estrogen, we found that MXC did not appear to induce death of developing T cells (Zoller and Kersh, 2006), but rather to alter the T cell developmental program. *AJV & AP are ULV undergraduate researchers.

736 Immune Alterations in B6C3F1 Mice following Oral Exposure to PFOS. M.M. Peden-Adams, M. Mollenhauer, S. Bradshaw, Medical University of South Carolina, Charleston, SC; M.M. Peden-Adams, E. Driscoll, College of Charleston, Charleston, SC; J. Berger, D.E. Keil, University of Nevada - Las Vegas, Las Vegas, NV; P.A. Fair, NOAA/NOS/CCEHBR, Charleston, SC. Perfluorinated compounds (i.e., perfluorooctane sulfonate (PFOS)) have recently generated much interest, as they are persistent in the environment and detectable in blood samples of both wildlife and humans. Studies show that these perfluorinated compounds cause various toxicological effects; however, effects on immune function have not been fully characterized. The current study includes assessment of plaque forming cell response (PFC), splenic and thymic T-cell populations, plasma lysozyme activity, NK cell activity, cytokine production by splenocytes and peritoneal macrophages, and serum cytokine levels. Adult male and female B6C3F1 mice, depending on the experiment, were exposed to PFOS orally for 28 days (0, 0.00018, 0.0018, 0.0036, 0.018, 0.036, 0.107, 0.180, or 10.7 mg/kg/day). The PFC cell response, as we have shown previously, was suppressed in males beginning at 0.0018 mg/kg/day while female mice were affected beginning at 0.018 mg/kg/day. This seems to be related to B-cell function as challenge with the T-independent antigen TNP-LPS also resulted in suppressed IgM production. Numbers of splenic CD4+ and CD8+ cells were altered in male and female mice. Numbers of

B220+, CD40+, CD19+ CD21+ and MHCII+ cells were not altered by PFOS exposure. Additionally, numbers of T-helper cells (CD4+) expressing CD154 were not significantly altered. Plasma lysozyme activity was not altered compared to controls in male mice but was significantly increased in the females at 0.180 mg/kg/day. Macrophage secretion of IL-6 was increased following exposure to 10.7 but not 0.036 or 0.107 mg/kg/day. Intracellular levels of splenocyte TNF, IL-6, IL-10 and IL-1 were not altered by PFOS treatment. These data suggest that at environmentally relevant ranges PFOS can alter immunological function and that humoral immunity may be the target.

738 Immune Assessment and Relation to Contaminants in Healthy and Non-Healthy Bottlenose Dolphin. M.M. Peden-Adams, Medical University of South Carolina, Charleston, SC; C.D. Rice, Clemson University, Clemson, SC; D. Muir, M. Houde, Environment Canada, Burlington, Ontario, Canada; G. Bossart, Harbor Branch Oceanographic Institute, Ft. Pierce, FL; G. Mitchum, P.A. Fair, NOAA/NOS/CCEHBR, Charleston, SC; M.M. Peden-Adams, T. Romano, Mystic Aquarium and Institute for Exploration, Mystic, CT. Increases in the incidence of mass mortality events (MMEs) involving bottlenose dolphins (BND) has lead to concern over their health. Many of these mortality events are thought to be caused by infectious microbes such as morbillivirus. It is unclear if these agents were the primary cause of the MMEs or if compromised immunity, related to contaminant exposures, caused increased susceptibility to infectious agents. Studies with terrestrial and marine mammals have shown that various contaminant classes suppress immune function. A suite of assays for assessment of immune function in marine mammals, that can be performed from non-lethal blood collection was developed based on the NTP Immunotoxicity testing scheme. Samples from approximately 200 resident bottlenose dolphin in Indian River Lagoon, FL and Charleston, SC were collected during the summers of 2003-2005 and assessed for immune function using the developed suite. Each location has different primary contaminant classes of concern based on tissue residue analysis. Associations between contaminants and immunity were determined. Additionally, dolphins in Indian River Lagoon were noted to have higher rates of gastritis in 2003, which corresponded with associated immune data, and they were also found in general to have higher rates of skin disease than animals in Charleston. Immune function is currently being assessed in relation to various disease types such as Lobomycosis. Information from this study allows us to begin to assess the utility of dolphins as sentinel species for identifying estuarine areas of concern for human health and allows us to begin to determine associations between contaminants, immune, function, and diseases in populations and ecosystems.

739 The impact of different classes of PCBs on marine mammal and human health: a new assessment of immunotoxicity. S. De Guise, H. Leibrecht, M. Levin, C. Mori, M. Trailsmith, D. Joshi, Pathobiology and Veterinary Science, University of Connecticut, Storrs, CT; C. Mori, CBR Institute for Biomedical Research, Boston, MA. Environmental contaminants such as PCBs have been the source of increasing concern for their potential environmental and human health effects. We performed in vitro dose-response experiments to quantify the direct immunotoxicity of different PCB congeners in humans, mice and marine mammals, to quantify interspecies differences and determine if the conformation of PCB congeners can predict their immunotoxic potential (assessed on neutrophil and monocyte phagocytosis, as well as B and T lymphocyte proliferation). Results to date demonstrate structure (non-ortho (NO), mono-ortho (MO) and di-ortho (DO)-substituted congeners) sometimes helps predict toxicity, with DO PCBs generally reducing phagocytosis in most species, while NO did not. Nevertheless, species susceptibility sometimes appears to be more important, with most PCBs increasing lymphocyte proliferation in humans and marine mammals, but approximately half the congeners decreasing it in mice. Overall, our results highlight the differences between species, question the use of the conventional mouse model to predict toxicity in other species, and offers initial support to the hypothesis that the structure of PCBs may help predict their immunotoxicity, which is not solely associated with dioxin-like mechanisms. A better characterization of the immunotoxic effects of PCBs in different species will improve our ability to perform more focused, precise and relevant risk assessment for marine mammal and human health.

740 Effects of PCB 153 on the Fish Immune and Nervous Systems: Evidence for Underestimated Risk Estimates for the Noncoplanar Congeners. J. Duffy-Whittemour, J.T. Zelikoff, Department of Environmental Medicine, New York University School of Medicine, Tuxedo, NY; S. Kennedy,

Integrative Physiology, University of Colorado at Boulder, Boulder, CO. Polychlorinated biphenyls (PCBs) exist in the environment as a mixture of coplanar and noncoplanar congeners. Toxic equivalency factors (TEFs), calculated to determine the potential toxic risk for populations exposed to PCBs and other aryl hydrocarbon receptor (AhR) agonists, may be imperfect in that not all PCB congeners, specifically noncoplanar congeners, have a strong affinity for the AhR. Given that noncoplanar PCB congeners may produce toxicity by mechanisms independent of AhR activation, risk, predicted by TEFs alone, may be underestimated. To this end, the ability of an environmentally abundant noncoplanar PCB congener to induce toxicity in the immune and/or nervous systems of bluegill sunfish was evaluated. Fish, exposed via i.p. injection to noncoplanar PCB 153 (5.0 or 50.0 µg/g BW) and sacrificed after 1, 3 or 7 d, were examined for immune dysfunction and nervous system alterations. Results demonstrated that exposure of bluegill to PCB 153 caused significant elevations in oxyradical production and suppressed T- and B-lymphocyte proliferation at 3 d post-injection. At this same post-exposure time point, whole brain neurotransmitter levels were decreased, while levels of tryptophan hydroxylase (the enzyme involved in serotonin synthesis) were increased in the hypothalamus of PCB 153-exposed fish. By demonstrating that noncoplanar PCB 153 alters the homeostasis of critical physiological systems in the bluegill sunfish, strong evidence is provided which indicate that the use of TEFs alone may underestimate the actual threat to PCB-exposed populations. Moreover, this study highlights the necessity of examining non-AhR-mediated pathways of PCB-induced toxicity. Hudson River Foundation Graduate Fellowship and USACEHR No. DAMD 17-99-9011.

741 Utilization of Protein Expression Profiles as Indicators of Environmental Impairment of Smallmouth Bass from the Shenandoah River, VA. J.L. Ripley, C.M. Foran, Department of Biology, West Virginia University, Morgantown, WV; L.R. Iwanowicz, V.S. Blazer, National Fish Health Research Laboratory, United States Geological Survey, Kearneysville, WV. The Shenandoah River, VA, the largest tributary of the Potomac and an important source of drinking water, has been the site of extensive fish kills since 2004. Investigation suggests environmental stressors may be adversely modulating the immune system of smallmouth bass (*Micropterus dolomieu*) and other species. Comprehensive fish health assessments revealed a high frequency (>90%) of male smallmouth bass have oocytes within the testes. Environmental contaminants, including endocrine disrupting chemicals, are known to suppress immune function in fishes. Anterior kidney tissue, the major site of blood cell production in fishes, was collected from smallmouth bass at three sites along the Shenandoah River. Half of the tissue from each bass was used to measure immune function specifically bactericidal activity, respiratory burst activity, and capacity for cytotoxicity. The remaining anterior kidney tissue was flash frozen for proteomic analysis. Homogenized anterior kidney protein (400 µg) was separated using large format 2D gel electrophoresis (24cm, pH 3-10, 12.5% acrylamide SDS-PAGE) and compared with PDQuest software. Imaging detected eight dominant proteins within approximately 600 spots. Differences in protein expression are described and related to observed changes in immune function. The proteomic data suggest these fish differ in metabolic capacity of anterior kidney tissue and the ability to produce functional leukocytes. Our results allow us to hypothesize underlying physiological changes which may relate to fish kills and suggest relevant contaminants known to produce similar physiological disruption.

742 Multiple Stressors and Their Effects on the Early Life Stages of Striped Bass: Pushing the Limits of Survival. D.J. Ostrach, J. Groff, K.J. Eder, J.L. Spearow, D. Thompson, A.M. Funk, C.C. Chin, P.S. Fitzgerald, F.J. Loge, D.K. Nayden, L.C. Prak, John Muir Institute of the Environment, Center for Watershed Sciences and the Department of Civil & Environmental Engineering, University of California Davis, School of Veterinary Medicine, Davis, CA. The Interagency Ecological Program (IEP) reported a sharp decline in populations of pelagic fish in the San Francisco Estuary in 2001. In addition, IEP abundance indices calculated for these pelagic fish over the past five years suggest that significant declines in these populations are continuing. Here we report on current and past investigations of potential causes for the decline of this striped bass population. Current investigations focused on determining the health and condition of early life stage striped bass collected during spring-fall of 2005 and 2006. Earlier studies concentrated on larval striped bass over an extended eight year period of time (1988-1995). Findings indicate that the striped bass collected in July 2005 surveys were severely compromised as a result of infective disease processes. In August

2005 extremely low numbers were collected; all of these striped bass were experiencing two or more infective disease processes and were positive for cytochrome P4501A1 induction a biomarker of contaminant exposure and bioindicator of adverse sublethal effects. Preliminary results from 2006 found less severe disease than in 2005 but the presence of abnormal ecto-commensal organisms, positive EROD/P4501A1 and vitellogenin findings indicate sublethal contaminant exposure is continuing to affect early life stage striped bass. These results suggest that multiple stressors are adversely affecting this population of striped bass.

743 Life with Ligands: Views of the behavior of methyl and inorganic mercury from the analytical lab to the environment to the human body. C.W. Shade, Quicksilver Scientific, LLC, Lafayette, CO. Holistic understanding of any subject requires key elements of similarity in expression that can be applied across a gradient of parameters. As the softest of the transition metals, ionic Hg forms are always involved in a coordination complex, no matter what environmental or biochemical compartment they are in. Understanding of the nature of these complexes (i.e. charge, polarities, solubility) is central to a more holistic understanding of Hg behavior from its sources through to end points in biologic life...and back out. Knowledge of ligand exchange reactions can be used to understand bioavailability, mobility and transformation, or to design practical applications such as analytical systems for Hg speciation, systems for industrial Hg removal, or chelators for human detoxification. We will examine a ligand-exchange framework used to create a speciation system and analogies to environmental, industrial, and biochemical systems. Comparisons include elution from resin phases versus elution from the human body ('chelation therapy'), sediments versus the digestive system, and gas phase versus solution phase ligand exchange.

744 You are what you eat: Limitations and benefits to using Tree Swallows (*Tachycineta bicolor*) as biomonitors for mercury. D.A. Cristol, A.M. Condon, K.K. Hallinger, Biology, College of William & Mary, Williamsburg, VA; B.A. Hoskins, USEPA, N. Chelmsford, MA; J. Schmerfeld, USFWS, Gloucester, VA; D.C. Evers, O.P. Lane, Biodiversity Research Institute, Gorham, ME; R. Taylor, Trace Elements Research Lab, College Station, TX. Tree Swallows are rapidly becoming a model species in ecotoxicology. Because they recruit readily to nest boxes, Tree Swallows can be lured into even highly disturbed contaminated sites, where their tissues provide a rapid assessment of bioavailability of contaminants such as mercury. Dense artificial populations provide high statistical power and offer a practical alternative to traditional piscivorous biomonitors such as kingfishers. Over 200 nesting pairs of Tree Swallows in Virginia's Shenandoah Valley have, in just 2 years, provided spatially precise information on levels of legacy mercury in a contaminated river and two reference tributaries. Because of the large sample size, subtle reproductive and physiological effects were evident that could not have been detected in traditional avian biomonitors. Swallows had mercury levels comparable to those for piscivorous birds at the same sites, and proved to be a much more efficient biomonitors. However, just as an over-reliance on piscivorous birds has distorted the picture of mercury's impact on non-piscivorous birds, using Tree Swallows as the sole sentinel for mercury can obscure the nature of mercury's impact on other terrestrial birds. Interpretation of feather mercury from Tree Swallows is complicated by the fact that some feathers grow on the contaminated site before autumn migration, but most do not. Overall body burden will vary depending on whether the individual has spent the non-breeding season at a site with relatively high mercury levels. Most important, however, is that Tree Swallows eat a shifting mix of terrestrial and emergent aquatic insects. Therefore, blood mercury levels during the breeding season will vary widely depending on exact nest site location, and relative abundance of aquatic and terrestrial insects during the weeks prior to sampling. Tree Swallows offer promise as inexpensive biomonitors for mercury, but there are many untested assumptions that require further investigation. Most critically, it must be remembered that Tree Swallow's exposure to aquatic mercury will vary greatly depending on study site, and Tree Swallows may tell us very little about exposure among typical terrestrial songbirds that may be part of longer food chains.

745 Learning deficits and telencephalon abnormalities due to developmental exposure of methylmercury to zebrafish is not decreased by co-exposure to selenomethionine. L. Smith, Psychology, University of Wisconsin-Milwaukee, Milwaukee, WI; L. Smith, M. Carvan, D. Weber, UWM Marine and Freshwater Biomedical Sciences Center, Milwaukee, WI; D. White, F. Williams, University of Toledo, Toledo, OH. Methylmercury (MeHg) is a neurotoxicant that disrupts neural development. Studies of

humans and fishes exposed to MeHg have found a variety of symptoms including severe neuronal loss, subsequent offspring defects, neurobehavioral deficits, and impairments in language, attention, memory, and locomotion. Because selenomethionine (SeMet) is thought to lessen the effects of MeHg the present study assessed the effects of developmental exposure to varying concentrations of MeHg with or without SeMet using zebrafish as a vertebrate model. Fish were exposed to MeHg and/or SeMet (0.0, 0.01, 0.03, 0.06, 0.1, and 0.3 uM MeHg; 0.0, 0.06, and 0.3 uM SeMet; 0.01 uM MeHg with 0.0, 0.06, and 0.3 uM SeMet; and 0.3 uM MeHg with 0.0, 0.06, and 0.3 uM SeMet) from 2 to 24 hours post fertilization, encompassing the initial phase of neuronal development. Embryos were observed daily and each embryo/larva was given an early life stage (ELS) toxicity score of 0-4 based on the presence of specific endpoints of MeHg toxicity (cardiac edema, facial, trunk and tail malformations, air bladder inflation, fin abnormalities, lethargy). The ELS toxicity score increased in a dose-dependent manner to 0.1 uM MeHg (Kruskal-Wallis $P < 0.05$). SeMet was able to mitigate the toxic effects of 0.1 uM MeHg in a dose-dependent manner as evidenced by the reduction in the ELS toxicity score between 0.1 uM MeHg and 0.1 uM MeHg + SeMet (Kruskal-Wallis, $P < 0.07$). Individual adult zebrafish (4 months) were tested in a spatial alternation paradigm with food delivery on alternating sides of the aquarium. A correct response involved the fish predicting which side food was to be delivered. Zebrafish treated with MeHg displayed an inability to learn (0.1, 0.3 uM MeHg) or delayed learning of the task (0.01-0.06 uM MeHg) the spatial alternation task; SeMet co-exposure had little effect. Neuron cell body density in the adult telencephalon was analyzed using hematoxylin stain. Even at concentrations of 0.01 uM MeHg, there was a 25% decrease in cell body density (ANOVA, $P < 0.05$) in both the dorsal and lateral telencephalon, both important for spatial learning in teleosts. Histopathology of MeHg + SeMet paralleled behavioral responses.

746 An assessment of mercury sources and biogeochemical cycling in South Africa. R. Mason, G. Bernier, Marine Sciences, University of Connecticut, Groton, CT; J. Leaner, CSIR, Stellenbosch, South Africa. Global emission estimates suggest that mercury (Hg) emissions from South Africa (RSA) are currently some of the highest in the world, especially on a per capita basis, and if this is the case then the regional environment should be contaminated due to these anthropogenic emissions. Most of the energy in RSA is derived from coal burning, and RSA has an extensive mining and processing industry for ferrous and non-ferrous (Zn, Pb, Al) and precious metals (Au and platinum group metals); all activities that can result in substantial Hg emissions. In addition, there is extensive use of coal in home heating, and there is a growing artisanal gold mining industry. However, there is scant data to address or support the suggested environmental insult, and thus the South African Mercury Assessment (SAMA) Program was launched as a co-operation of scientists, government and industry in RSA, and involving the University of Connecticut. The objectives of the program are to obtain relevant information on the extent of emissions, and on the concentration of Hg and methylmercury (MeHg) in environmental media, and in fish, so that the impact of human activity, and the potential for environmental contamination can be assessed. Initial samples were collected in 2005 with a large follow-up effort in the summer of 2006, including the deployment of a Tekran air sampler, and collection of dated sediment cores for Hg historical profiling. In conjunction, an initial risk assessment has been performed to assess the potential risk for the RSA population from the consumption of both freshwater and coastal marine fish. This presentation will report on the results of these studies and provide a re-assessment of the emissions of Hg to the atmosphere from anthropogenic activities in RSA.

747 Biogeochemical controls on methylmercury production and cycling in the San Francisco Bay delta. G. Bernier, R. Mason, Marine Sciences, University of Connecticut, Groton, CT; A. Heyes, Chesapeake Biological Laboratory, University of Maryland, Solomons, MD; M. Marvin-DiPasquale, USGS, Menlo Park, CA; C. Miller, Chemistry, University of North Carolina - Wilmington, Wilmington, NC; E. Kim, Div Environ. Sci & Ecol Eng, Korea University, Seoul, South Korea. Environmental studies have shown that methylmercury (MeHg) concentrations in fish are influenced by both biogeochemical and food chain factors. We investigated their importance in a detailed study of two regions within the San Francisco Bay (SFB) delta and report here on the biogeochemical influences. A companion paper (Stewart et al.) focuses on the food chain. Total Hg (HgT), MeHg, ancillary parameters, methylation and demethylation rates, and sediment fluxes were measured seasonally in two different regions: Frank's Tract

(FT) in the moderately saline central delta and the freshwater inflowing Cosumnes River (CR). While HgT in sediments was similar in both regions, the relationship between Hg, MeHg and organic matter showed marked differences, reflecting differences in the cycling of Hg/MeHg. Porewater HgT was significantly greater, and Hg partitioning coefficients were significantly lower in CR, suggesting that inorganic Hg(II) was more readily available for methylation in the freshwater region. There was a negative relationship between sediment reduced sulfur and the pool of 'reactive' Hg(II) across regions, with FT having significantly lower concentrations of sediment Hg(II). Benthic methylation rates, from radiotracer $^{203}\text{Hg(II)}$ amendments, and the in-situ 'reactive' Hg(II) pool were highest in the CR region, confirming that methylation rate was strongly related to Hg(II) bioavailability. Methylation rates were highest in vegetated sub-habitats, and was strongly influenced by temperature. Demethylation rates did not differ significantly between regions. Porewater MeHg concentrations were also significantly higher in the CR, and this supported higher diffusive fluxes to the overlying water. Overall, the various lines of biogeochemical evidence suggest that there is more MeHg in available and cycling fractions in the CR sediments and porewaters, compared with the central delta (FT), and that this was the main driver of higher fish concentrations in CR, rather than food web considerations. It is therefore concluded that the freshwater CR region represents a biogeochemical setting that is both more conducive to net Hg(II)-methylation and to MeHg transfer to the food chain.

748 Methylmercury budget for a contaminated temperate reservoir. J. Kubitz, ENTRIX, Inc., Barrington, IL. The Deer Lake Area of Concern (AOC) is a freshwater reservoir in northern Michigan that received mercury from historic industrial and municipal sources, and continues to receive mercury from atmospheric deposition. Ten years after cessation of point source discharges, methylmercury concentrations in fish remained elevated above health guidelines, prompting contemplation of additional remedial actions. A methylmercury budget was developed using "clean-hands/dirty-hands" sampling techniques combined with ultra-trace laboratory analyses. Local reference lakes were also evaluated to establish regional conditions. The methylmercury budget was used to evaluate the relative methylmercury contributions from atmospheric deposition, local historic discharges, and in-lake generation during summer thermal stratification. The results of this study were used to evaluate mercury management remedies for the Deer Lake AOC.

749 Avian methylmercury exposure and sensitivity: Past assumptions, current findings. D. Evers, O. Lane, BioDiversity Research Institute, Gorham, ME; D.A. Cristol, S.L. Friedman, Department of Biology, College of William and Mary, Williamsburg, VA; J. Schmerfeld, U.S. Fish and Wildlife Service, Gloucester, VA; B. Hoskins, U.S. Environmental Protection Agency, N. Chelmsford, MA; R.J. Taylor, Texas A&M University, College Station, TX. Past assumptions of methylmercury exposure and sensitivity in birds are overly simplistic. Recent efforts dispelling assumptions stem from empirical laboratory and in situ findings. Risk of methylmercury exposure is generally considered to be greatest in piscivorous birds, particularly those that are long lived. While biomagnification and bioaccumulation of methylmercury is well documented in piscivores, it has not been well-established in invertivores. Our findings demonstrate that many avian invertivores can regularly equal or exceed methylmercury body burdens in associated piscivores from three riverine ecosystems. Forage guild also plays an important role in a bird's sensitivity to methylmercury. Species that have coexisted with elevated levels of methylmercury (e.g., marine piscivores) likely have a greater tolerance than those with historically minimal interactions (e.g., terrestrial invertivores). Recent anthropogenic changes in the rate and distribution of mercury emissions and deposition could place many species at greater risk than realized. Many invertivores, such as wetland songbirds, represent a group of species that may be both more at risk and more sensitive to methylmercury exposure than piscivores. Federal environmental programs assessing mercury risk and injury need to better incorporate bird species that reflect greatest potential risk.

750 Methylmercury (MeHg) accumulation at the base of aquatic food webs determines trophic enrichment and differences in bioaccumulation of MeHg in sport fish in contrasting regions of the San Francisco Bay Delta. A.R. Stewart, A.H. Lorenzi, M. Croteau, Water Resources Division, U.S. Geological Survey, Menlo Park, CA; P.C. Pickhardt, Biology, Lakeland College, Sheboygan, WI; A. Heyes, University of Maryland, Solomons, MD. Biomagnification of methylmercury in food webs can lead to extremely high concentrations of mercury in sport fish, which puts wildlife and humans at risk. Trophic enrichment of mercury in nature remains poorly understood,

although a number of processes have been identified that influence mercury accumulation in ecosystems. These processes include: 1) attributes of the organisms themselves (size, age-specific growth rates), 2) food web dynamics (food chain length, community structure), and 3) life history characteristics (herbivory versus carnivory, habitat utilization). While these processes modify mercury accumulation in food webs, we do not understand their importance relative to other (bio)geochemical processes (physical loading and transport, Hg-speciation, microbial Hg(II)-methylation, phase Hg partitioning) involved in the bioaccumulation of mercury. Here we show that in two distinct regions of the San Francisco Bay Delta ecosystem, a freshwater tributary (Cosumnes River) and the central delta (Frank's Tract), trophic enrichment of mercury in food webs is relatively insensitive to subtle differences in food web structure and species-specific attributes. The bioaccumulation relationship between MeHg concentrations in biota and trophic position in submerged aquatic vegetation (SAV) food webs were virtually identical for the two regions. Yet, the absolute concentration of MeHg in biota from the Cosumnes SAV food web was approximately twice that of the Frank's Tract food web. Consistent with the differences in consumer organisms, MeHg concentrations in epiphytic algae (dominant primary producer in SAV food webs) were also different by a factor of 2. These results suggest that the amount of methylmercury entering the base of the Cosumnes SAV food web was higher than that entering the Frank's Tract food web. Although small differences in water chemistry and particle characteristics could potentially influence uptake into the epiphytic algae, companion biogeochemical data indicate that local biogeochemical controls on microbial MeHg production result in 2-fold greater water column dissolved MeHg concentrations in the Cosumnes R., which parallels the 2-fold regional difference in MeHg concentrations at the epiphytic base of the food webs, and ultimately the 2-fold differences observed in sport fish.

751 Mercury sediment biogeochemistry in the northern Gulf of Mexico: seasonal, spatial, and disturbance-induced variability. B. Liu, L. Schaidler, M. Bank, J. Shine, D. Senn, Department of Environmental Health, Harvard School of Public Health, Boston, MA; R. Mason, Department of Marine Sciences, University of Connecticut, Groton, CT; N. Rabalais, Louisiana Universities Marine Consortium, Chauvin, LA. Methylmercury (MeHg) bioaccumulates in aquatic foodwebs, and understanding the controls on MeHg production in coastal systems is relevant for evaluating both ecosystem health and human health. The northern Gulf of Mexico (nGOM), along the Louisiana coast, is a highly productive and important fishery. This area of the nGOM is heavily influenced by the Mississippi River, which delivers 10 tons Hg y^{-1} , along with 1×10^6 tons N y^{-1} that leads to coastal eutrophication and bottom-water hypoxia over large areas. We explored controls on net MeHg production in sediments of nGOM along a ~400 km east-west transect during Summer 2006, and at a subset of those stations during Fall 2005 and March 2006 to evaluate seasonal variability. We measured total Hg (THg) and MeHg, along with ancillary chemical parameters (e.g., TOC), and incubated in-tact sediment cores spiked with enriched isotopes of $^{201}\text{Hg(II)}$ and Me^{199}Hg to measure methylation and demethylation "potential". Overall, the levels of THg ranged from 20 to 400 $\text{pmol}^{-1} \text{g}^{-1}$ dry weight, with approximately 0.4% of them existed as MeHg on average. The percent of total Hg present as MeHg, %MeHg, which is sometimes considered an indicator of net MeHg production, ranged from 0.08 to 1.3 across 15 stations and 3 seasons. Methylation potential varied from 0.0026 to 0.05 d^{-1} . Demethylation potential was relatively uniform (3.2 to 12 d^{-1}), both spatially and temporally. Factors controlling Hg speciation and conversion rates, including large-scale disturbances, such as the hurricanes, will also be discussed.

752 Effects of a Municipal Wastewater Effluent on Fathead Minnows and Northern Leopard Frogs. A. Sowers, K. Gaworecki, S. Klaine, Department of Biological Sciences, Institute of Environmental Toxicology, Clemson University, Pendleton, SC; A. Roberts, Department of Biological Sciences, Institute of Applied Sciences, University of North Texas, Denton, TX; B. Brooks, Department of Environmental Studies, Baylor University, Waco, TX; M. Mills, Office of Research and Development, National Risk Management Research Laboratory, United States Environmental Protection Agency, Cincinnati, OH. Endocrine disrupting chemicals (EDCs) have been found in municipal wastewater effluents worldwide. This study examined the developmental and behavioral effects of wastewater effluents on the fathead minnow, *Pimephales promelas*, and the northern leopard frog, *Rana pipiens*. Final wastewater effluent was collected biweekly from the Mauldin Road Wastewater Treatment Plant in Greenville, SC. A suite of pharmaceuticals,

personal care products, and estrogenic/androgenic compounds were measured weekly. Larval *P. promelas* were exposed to three treatments: 0, 50, and 100% wastewater diluted in moderately hard water. Survival was monitored, and fish were sampled at 7, 42, and 68 days for length/weight measurements and molecular biomarker analyses. At the conclusion of the exposure, secondary sex characteristics were assessed and gonads removed for histological analysis. *R. pipiens* were exposed as eggs to four treatments: 0, 10, 50, and 100% wastewater diluted in moderately hard water. Survival was monitored throughout the experiment. Upon hatching, tadpoles were divided into 4 replicates per treatment with 40 tadpoles per replicate. During the developmental period, startle response and swim speed experiments were conducted. At metamorphosis, weight, snout-vent length (SVL), and time to metamorphosis were measured. Gonads and thyroid glands were extracted for histological analysis. Brains and livers were taken for gene expression analyses. Organisms in the 100% wastewater treatment took significantly longer to reach metamorphosis than all other treatments and exhibited a significantly smaller weight and SVL. Interestingly, total survival was significantly higher in the 50 and 100% treatments than the control treatment. No differences in startle response were observed.

753 Quantifying the Effects of Physical Stressors in a Watershed Undergoing Urbanization for Use in Ecological Risk Assessment. K.L. Sciera, S.J. Klaine, Department of Biological Sciences, Clemson University, Pendleton, SC. Research has shown a correlation between land use change and decline in biotic integrity in aquatic systems. Land use changes in a watershed frequently result in physical stressors, such as changes in flow regime and habitat, as the risk drivers that affect the ecological integrity of the stream. The objective of this study was to quantify the mechanisms of aquatic ecosystem degradation in a stream as the watershed undergoes urbanization. By quantifying the development level and the changes in the physical parameters of the stream, the effects of land use change can be evaluated using a traditional ecological risk assessment framework. Knight Creek is a first-order stream near Greenville, SC that is currently undergoing development from forested land to suburban residential. Data from Knight Creek were compared to a highly developed watershed, Lost Creek, and a reference watershed, Baldwin Creek. Changes in habitat, stream morphology, flow, TSS, and benthic invertebrate indices were examined as development in the Knight Creek watershed increased. A quantitative negative relationship between the development level in the Knight Creek watershed and the stream habitat index from the EPA Rapid Bioassessment Protocol (RBP) was established. It was obvious from the data that stream deterioration occurs rapidly and early in the land development process even if currently recommended best management practices are implemented. The magnitude of physical stressors, such as flow and total suspended solids (TSS), also showed a significant increase with development. Ultimately, these stressors led to a significant decline in benthic invertebrate community indices. Through stepwise regression modeling, the most influential physical stressors on ecological integrity of streams were identified for development of regulatory criteria and incorporation into decisions regarding land use.

754 Implementation of Scientific Tools to Identify Aquatic Responses to Urban Gradients and Refine Aquatic Life Goals for use in Urban Stream Management Programs. M.T. Barbour, D. Bressler, M. Paul, Center for Ecological Sciences, Tetra Tech, Inc., Owings Mills, MD; A. Purcell, V. Resh, University of California, Berkeley, CA; E. Rankin, Midwest Biodiversity Institute, Columbus, OH. Impacts to aquatic life in urban and suburban watersheds present substantial challenges to managing such waters to meet aquatic life standards. Water quality standards, through definition of aquatic life uses and their associated water quality criteria are the primary instrument for setting protection and restoration goals for rivers and streams. Any enhancement of tools for addressing water quality standards in complex urban environments that recognizes the gradient of aquatic restoration potential will have great benefits for cost effective and environmentally sound administration of permits and setting realistic goals. We developed a process for developing alternative biological benchmarks for aquatic life use in urban catchments using data from three climatic regions: San Jose, Baltimore, and Cleveland. This scientific tool relies on a three-step process, which includes: developing a primary urbanization gradient, creating a sensitive urban biological index, and using these first two steps to define the highest biological potential currently achieved along the urban gradient using quantile regression. The selection of aquatic life goals for urban waters has substantial economic and administrative consequences for regulated entities. Major program areas in the United States

that would benefit from the refinement of aquatic life goals include NPDES programs, TMDL development efforts and Water Quality Standard programs although benefits of refined goals would extend to most applications of water quality management. Similarly, these tools could apply to the European Union Water Framework Directive and its ecological standard setting procedures.

755 Emerging Contaminants: Understanding Their Occurrence, Fate, and Effects. D. Kolpin, U.S. Geological Survey, Iowa City, IA; E.T. Furlong, M.R. Burkhardt, S.D. Zaugg, National Water Quality Laboratory, U.S. Geological Survey, Denver, CO; M.T. Meyer, U.S. Geological Survey, Lawrence, KS; L.B. Barber, U.S. Geological Survey, Boulder, CO; V.S. Blazer, National Fish Health Research Laboratory, U.S. Geological Survey, Kearneysville, WV. Research is documenting with increasing frequency that many chemicals (e.g. pharmaceuticals, hormones, fragrances, etc.) that have not historically been considered as contaminants are present in a variety of environments across the world. These emerging contaminants (ECs) are commonly detected in municipal, agricultural, and industrial wastewater sources. Since 1998, the United States Geological Survey (USGS) Emerging Contaminants Project (<http://toxics.usgs.gov/regional/emc/index.html>) has been conducting holistic "source to receptor" research on this rapidly advancing topic. The primary objectives of this project are to: 1) develop the analytical tools required for detecting ECs in the environment, 2) document the occurrence, concentration, and composition of ECs in the environment, 3) characterize contaminant sources and their potential pathways into the environment, 4) determine processes and factors that affect the transport and fate of ECs and 5) assess the potential deleterious effects of ECs and complex mixtures of ECs on aquatic and terrestrial organisms and ecosystems. To carry out these research objectives, an interdisciplinary team of scientists has been assembled. The overall mission of this USGS research is to provide reliable scientific data and information on ECs needed by regulators, resource managers, industry, and the public to make sound decisions about the use, disposal, and general management of these chemicals.

756 Verification of low surfactant risk via eco-epidemiological studies. S.D. Dyer, Central Product Safety - Environmental, Procter & Gamble Co., Cincinnati, OH. Environmental risk assessment is primarily a prospective activity where the relationships of potential environmental effects are compared to predicted environmental concentrations. Over several decades, the U.S. surfactant and detergent industries have assessed the risk of the major surfactants used in down the drain consumer products: alcohol sulfates, alcohol ethoxy sulfates, linear alkyl benzene sulfonates, and alcohol ethoxylates. These chemicals are used and discharged daily to waste water treatment plants with residual concentrations entering the receiving water environment. Prospective analyses have produced assessments that support the conclusion that surfactants do not pose a significant risk to waste water and the receiving environment. Via retrospective analyses (i.e., eco-epidemiology) these assessments were tested considering surfactants as mixtures in streams dominated by municipal effluents. The eco-epidemiological weights of evidence in rural and urban areas confirm that these chemicals pose minimal risk to aquatic communities.

757 Stressor Identification in Urbanized Watersheds. S.B. Norton, C.R. Ziegler, K.A. Schofield, US EPA, Washington, DC; J.T. Varricchio, Maine Department of Environmental Protection, Portland, ME. Determining probable causes of biological impairment can be a daunting task in urbanized watersheds. Multiple candidate causes of impairment, interacting causes, differing biological effects at different sites, irregularly collected data, lack of basic scientific information, and natural variability (e.g., seasonality, weather, and topography), for example, challenge scientists and managers. Spatial and temporal scale discrepancies among stressors, biological responses, and our methods for measuring both add additional complexity. As population continues to rise in many urban areas, leading to increased ecosystem stress, and as the importance of healthy ecosystems becomes more apparent in urban settings, we must fine tune methods of stressor identification thereby improving the basis of restoration efforts. EPA Stressor Identification protocol, which can be found at the Causal Analysis/Diagnosis Decision Information System (CADDIS) interactive Web site (www.epa.gov/caddis), provides a useful framework for organizing multiple lines of evidence available in complex urban case studies. We highlight an urban case study to demonstrate CADDIS' capabilities for helping to identify probable causes of biological impairment. We also explore development of situation-specific conceptual model diagrams for the CADDIS Web site, such as a diagram illustrating common urban causal pathways leading to biological impairment. The views

expressed in this abstract are those of the authors and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency.

758 Chemical occurrence in a linked waste-treatment/land-application/5-lake constructed wetland system. M.J. Hooper, K.J. Kuhns, T.J. McBride, Environmental Toxicology and Howard Hughes Medical Institute, Texas Tech Univ, Lubbock, TX; A. Ramirez, C. Chambliss, B. Fulton, J. Scott, T.W. Valenti, B.W. Brooks, Center for Reservoir and Aquatic Systems Research, Baylor Univ, Waco, TX; C.B. Fedler, Civil & Environmental Engineering, Texas Tech Univ, Lubbock, TX. At its headwaters on the southern High Plains of West Texas, the North Fork of the Double Mountain Fork of the Brazos River emerges from Lubbock, Texas, as an effluent and stormwater dominated river. The source and fate of Lubbock's effluent provides a unique case study of urban waste-water treatment, recycling and reuse. Lubbock waste water undergoes secondary treatment via an activated sludge process. Secondary-treated water (~12 million gal/day) is sprayed over 3000-acres of the Lubbock Land Application Site (LLAS). Groundwater wells pump water from the resulting perched underlying aquifer, to the head of Yellowhouse Canyon, where it is the source of, and flows through, the Jim Bertram Lake System (JBLS), a series of five recreational lakes covering 2000 acres along 6 miles of the canyon. After leaving the JBLS, the river feeds into two sequential residential/recreational lakes and exits to form the North Fork of the Double Mountain Fork of the Brazos. Depending on the season, from 90 to 99% of the nitrogen of the entering water (~16 mg/l) is removed through the JBLS lakes, which serve as a series of constructed wetlands. Pharmaceutical and personal care products were measured throughout the system, demonstrating varying degrees of efficiency of removal through the LLAS and JBLS. Hydrology, standard water quality endpoints, bioassay response and metal concentration data in the water and sediments will be presented as a function of collection location in the system and matrix sampled. The findings demonstrate that contaminant and nutrient inputs occur at differing locations throughout the system, creating characteristic spatial profiles of study components. Further, the high efficiency of nitrogen and PPCP removal suggests the system can play an important role in polishing potentially intransigent compounds from post-treatment wastewater.

759 Effluent-dominated Systems: Model Watersheds for Studying Impacts of Urbanization. B. Brooks, Baylor University, Waco, TX. As human populations expand, increased water usage may lead to a higher proportion of aquatic systems receiving effluent discharges. Instream flows in urbanizing systems can become dominated by or even dependent on reclaimed wastewater, particularly in arid and semi-arid regions. Although these effluent-dominated systems present numerous challenges to aquatic scientists, they provide excellent models for studying "emerging" areas of aquatic science. This presentation will examine several emerging water quality (WQ) issues in rivers and impoundments receiving effluent-dominated inflow in the Trinity River basin, Texas, USA. Specifically, it is now widely recognized that select pharmaceuticals and personal care products (PPCPs) are released from effluents to surface water, but the fate, transport and effects of these substances are less understood. Defining the relative risks posed by PPCPs in urbanizing landscapes requires coupling state-of-the science analytical chemistry and watershed models with an understanding of target-specific responses to PPCPs in aquatic biota residing in streams and the 29 major reservoirs in the upper Trinity River watershed. In recent years, a number of reservoirs in Texas have been placed on the 303(d) list due to non-attainment of dissolved oxygen water quality standards (WQS) and concern about nutrients. A large portion of the historical monitoring leading to 303(d) listings has occurred in the off-channel "arms" of the impoundments, which often do not meet WQSs. Effluent-dominated streams present challenges if the reservoir backwaters are effluent-dominated with WQ conditions dependent on effluent quantity and quality, or may not receive sufficient flushing to adequately mix with the main body of the reservoir during arid summer conditions. These locations are actually reservoir transition areas (RTA) from an inflowing stream to a reservoir system with underlying hydrological, biological and chemical attributes differing from river or lacustrine zones of an impoundment. In fact, these areas appear similar to tidal rivers and estuaries, which have been found to naturally contain lower oxygen levels and increased nutrients potentially due to physical changes occurring in RTAs. Here I present a methodology that defines the spatial extent of RTAs, which may support future assessment, permitting, and development or refinement of appropriate WQS for traditional or emerging contaminants in RTAs.

760 In-situ Fathead Minnow Spawning as an Indicator of Anthropogenic Influence on Stream Quality. S.R. Corsi, Water Resources Discipline, US Geological Survey, Middleton, WI; R. Klaper, D. Weber, Great Lakes WATER Institute, University of Wisconsin, Milwaukee, Milwaukee, WI; R. Bannerman, Wisconsin Department of Natural Resources, Madison, WI. Many streams in the U.S. are considered to be "impaired" due to anthropogenic influence. In order for watershed managers to achieve a practical understanding of causes of these impairments, a multitude of factors must be considered. Included in these factors are point and nonpoint influence on water chemistry as well as habitat and hydrologic changes due to agriculture and urban development. For this study, an in-stream fathead minnow spawning assay was developed to determine whether reproduction can be used to evaluate composite anthropogenic influence on streams. Six individual pairs of reproducing fathead minnows were contained in separate flow-through cartridges within one larger flow-through chamber at each of 27 streams in Eastern Wisconsin. Tested streams represented a wide range of urban and agricultural influence. Sediment quality was sampled for an array of chemistry parameters at most sites. In addition, all sites were sampled for an array of water chemistry, hydrology, biology, and habitat through a larger USGS study on urbanization effects. Egg production was monitored for each pair throughout 21 day test periods providing a composite assessment of reproductive success over an extended period of time. After the field exposures, liver and blood samples were collected from each male and female. Liver samples were extracted for RNA and analyzed for quantity of vitellogenin mRNA, a protein associated with egg production and a known indicator for endocrine disruption. A significant difference was found in the levels of vitellogenin in females across streams. Blood plasma was also extracted for quantification of estrogen and testosterone; levels of these hormones as well as vitellogenin were compared to egg production. Results from the egg production assay and reproductive biomarkers are compared with water and sediment chemistry as well as biological and land use indices for these watersheds. Low dissolved oxygen was a controlling factor for egg production in many streams with levels falling below 5 mg/L in more than one third of the sites monitored. Correlations of assay results were evident with some biotic indices and chemical markers, but not others.

D1 Making Decisions in the Face of Uncertainty. R. McCormick, Golder Associates, Ltd., Calgary, Alberta, Canada. Debate 4 – Uncertainty Plagues the Decision's Quality Charles Menzie, PhD, Principal Scientist, Exponent Corporation Peter Calow, PhD, Professor, Dept of Environmental, Spatial and Social Change, Roskilde University A. Uncertainty plagues most environmental decisions. The key challenge is how to represent or characterize the uncertainty and to communicate the implications of the uncertainty for the decision. The scientist must go beyond simply stating the degree of uncertainty and provide a bridge for decision makers to understand how to deal with the uncertainty as they make their decisions. B. Decisions should be evaluated on the basis of the quality of the decision at the time, and not on the basis of the outcome. If a decision is to reflect the best science available, care must be taken to not skew that information to fit preconceptions. This is a particular danger when there is much grey surrounding the underlying science that permits a range of alternative views that could be slanted based on individual bias. Debate 5 – Uncertainty and Systems Approaches: Ecology vs. Sociology, a Post-Normal Debate Joseph Tainter, PhD, Department Head, Environment and Society, Utah State University Timothy Allen, PhD, Professor, Botany & Env. Studies, U. of Wisconsin – Madison A. Social science can't contribute to reducing uncertainty because it is not possible to reflect the values of the constituencies or public who are affected by the decision in scientific analyses. B. Using a systems approach to decision making often takes too long for the timeframe of decision making because even when delay is determined to be the best option, decision makers usually can't afford to wait. Debate 6 – The Panel vs. The Audience

D1.1 Making Decisions in the Face of Uncertainty. R. McCormick, Golder Associates, Ltd., Calgary, Alberta, Canada. Debate 1 – The Fiddly Details of Uncertainty – Mathematics, Statistics, Hypotheses Katherine von Stackelberg, ScD, Center for Risk Analysis, Harvard School of Public Health vs. Wayne Landis, PhD, Huxley College of the Environment., Western Washington University Classical statistical analyses that compare a set of data to a null hypothesis have limited use for supporting decision-making, because they do not recognize that alternative states of nature are possible. Every hypothesis, not just the maximum likelihood hypothesis and the null hypothesis, should be considered. The key to good decision making is ensuring that techniques for reducing uncertainty (e.g., statistics) are understood and appropriately used. Once this is done, good decision making will follow. Debate 2 – The Scientist, The Uncertainty, Other Parties, and Their Communications Stella Swanson, PhD, Senior Env. Scientist, Golder Associates Ltd. vs. George Gray, PhD, Assistant Administrator, Office of R&D, U.S. EPA Scientists should limit their role in decision making to (a) characterizing uncertainty, (b) informing decision-makers of the relative influence of various sources of uncertainty, and (c) communicating options for reducing uncertainty and the expected value of reducing uncertainty. Scientists are not responsible for how decision makers use their information. Debate 3 – Decisions Happen When? Cynthia Stahl, PhD, Env. Scientist, U.S. EPA Region III vs. Alan Johnson, PhD, Assoc. Professor, Dept. of Bio. Sciences, Clemson University Real decision making does not have time for uncertainty analysis. If decision making requires the following: (a) uncertainty is characterized in ways that are easily understood, (b) all available decision alternatives are fully considered (including the status quo and decision delay), and (c) decision alternatives are evaluated taking into account the full range of costs/risks and benefits, then, we will more often have poor decision making than good decision making.

D3 Regional Citizens' Advisory Councils: Advocates for stakeholder driven science. J.S. French, J. Banta, PWSRCAC, Anchorage, AK. Prince William Sound Regional Citizens' Advisory Council (RCAC) is one of two self-governing citizens' councils enabled by the Oil Pollution Act of 1990 (OPA90). RCAC is responsible to the citizens and resources in the region impacted by the T/V Exxon Valdez oil spill. This includes Prince William Sound, lower Cook Inlet, and the northern Gulf of Alaska from the Copper River delta southwestward past Kodiak Island. The council has a paid staff, committees composed of volunteers, including a various subject matter specialists, and a Board of Directors representing 19 governmental and topical stakeholder entities. This council's duties include providing advice, recommendations on policies, and regulations, and to monitor the environmental impacts associated with the Valdez Marine Terminal at the terminus of the Trans-Alaska Pipeline, and associated crude oil tankers. RCAC is authorized to undertake an independent research and monitoring program in a manner which avoids unnecessary duplication with other programs. To assure the relevance and scientific quality of RCAC-funded projects, project

ideas may arise from within the staff, committees, or directly from stakeholder entities. Brief project descriptions implementing these ideas are built into the annual budget which is extensively reviewed before it is approved by the Board. Funded projects may include reviews of the current status of on-going external research, a synthesis of research findings, of support for new research or monitoring projects. The initial direction of a funded project is often proposed by an internal RCAC Project Team which solicits advice from the appropriate Committees which approve the final RFP. Responsive proposals are reviewed by a project team prior to negotiation of a contract. Contracts over \$30K require approval of the Board before going forward. This helps assure the relevance of the project to the stakeholder entities. Once completed project reports are subjected to both internal and external peer review. Final reports must also be approved by the Board as having fulfilled the contract objectives. Many project reports include lay summaries which aid the understanding of non-technically trained citizens. This process helps assure both the scientific integrity and independence of RCAC projects but also the relevance to stakeholder entities. Clearly RCAC believes in the importance of science being made understandable to interested citizens.

D4 Responsible Pest Management Practices in the Department of Interior. T. Parson, G. Masson, Division of Environmental Quality, U.S. Fish and Wildlife Service, Arlington, VA. To emphasize reduced risk pest management practices, the Department of Interior (DOI) recently adopted a policy on integrated pest management (IPM). The policy directs all eight DOI bureaus to incorporate IPM into their pest management activities. Although the DOI bureaus manage a broad spectrum of pests including Canada thistle (*Cirsium arvense*), German cockroaches (*Blattella germanica*), and zebra mussels (*Dreissena polymorpha*), all bureaus are directed to use IPM to manage pests using sound science and a risk reduction decision-making process. As part of an integrated approach, pesticide applications may be necessary to manage certain pest species. Most bureaus have a pesticide use proposal process which is a conservative, tiered approach to approving pesticide use, based on analysis of factors such as pesticide and adjuvant toxicity, application distance from water, application method, and probability of leaching. Additionally, the bureaus are developing guidelines for certifying contract pest control operators using a standardized approach in IPM to ensure IPM practices are implemented on DOI facilities.

IP1 Estimating metabolic biotransformation rates in fish from laboratory data. J. Arnot, D. Mackay, Canadian Environmental Modelling Centre, Trent University, Peterborough, Ontario, Canada; M. Bonnell, Science and Technology Division, Environment Canada, Gatineau, Quebec, Canada. Metabolic biotransformation rate data are needed to improve bioaccumulation estimates for assessing the potential hazards and risks of organic chemicals. A method is proposed for estimating *in vivo* metabolic biotransformation rates from measured laboratory bioconcentration and elimination rate data in fish. Data are selected based on a quality review to reduce uncertainty in the measured values. A kinetic mass balance model is used to estimate rates of chemical uptake and elimination. Biotransformation rates are calculated as the difference between two quantities: a modelled bioconcentration factor, or elimination rate constant assuming no biotransformation, and a measured bioconcentration factor, or elimination rate constant. Model parameterization exploits key empirical data when they are available, and default values are assumed or calculated when these data are not available. Uncertainty analyses provide screening level assessments for the reliability of the biotransformation rate estimates. The uncertainty analyses include the 95% range of the predicted values and 95% confidence intervals for the calculated biotransformation rates. Case studies are provided to illustrate the calculation and uncertainty methods. Biotransformation rates calculated by the proposed method are compared to estimates that have been published using other methods. The methods comparison shows general agreement for estimated values and includes 31 chemicals that range in log Kow from about 1 to 8 and represents over four orders of magnitude in biotransformation potential. Comparisons with rates estimated by *in vitro* methods and the development of a database and quantitative structure-property relationships are discussed.

IP2 Beyond lipophilicity: The influence of other physico-chemical parameters on water/gill uptake rates in fish. K.B. Woodburn, Toxicology, Environmental Research & Consulting, The Dow Chemical Company, Midland, MI; A.V. Weisbrod, Central Product Safety, The Procter & Gamble Company, Cincinnati, OH; B. Versonnen, EURAS, - member of ARCADIS, Gent, Belgium; N. Jeliakova, Ideacon Ltd., Sofia, Bulgaria. As part of the categorization review process applied to substances on the Canadian Domestic Substances List (DSL), generic bioaccumulation models are used to estimate the bioaccumulation and bioconcentration factors (BAF/BCF) for chemicals, with an emphasis on use of lipophilicity-based algorithms. The uptake rate constants for a majority of these models have been estimated from bioconcentration data on lower molecular weight (<400 amu) organic compounds that are recalcitrant to metabolism and may present elevated levels of uptake into fish via diffusion across the gills. Such models may not produce accurate uptake rate constants for chemicals with steric issues, higher molecular weights, or other deviations from chemicals used to develop the standard algorithms. Molecular size and shape (i.e., steric factors) have been previously noted as key parameters in controlling membrane permeation rates. In this work, we have examined the *in vivo* water/fish uptake rates (K_1 , mL·g⁻¹·day⁻¹) from OECD 305E bioconcentration studies for >15 chemicals of differing chemical classes and structural conformations. A variety of physico-chemical properties, such as octanol/water partition coefficient (K_{ow}), mammalian blood-brain barrier (BBB) ratio, and molecular size, were examined as potential predictors of K_1 . Our data indicate that neither K_{ow} nor BBB ratio serve as accurate predictors of K_1 values, while a molecular size of approximately 15 Å (modeled via OASIS software) appears effective at limiting chemical uptake via the fish gill. These results indicate that molecular steric factors should be considered when evaluating chemical uptake rates for chemicals, rather than relying strictly on lipophilicity-based algorithms, which may significantly overestimate uptake rates and therefore BAF/BCF values.

IP3 Assessment of alternative substrates for culturing *Lumbriculus variegatus*. P.J. Lasier, USGS Patuxent Wildlife Research Center, Athens, GA. The freshwater oligochaete, *Lumbriculus variegatus*, is tank-cultured to provide organisms for aquatic-habitat assessments, regeneration research and as a clean source of live food for aquarium fishes. Shredded paper is the typical substrate in cultures used to rear *L. variegatus* for these purposes. However, the effort needed to separate large numbers from decomposing paper can be prohibitive. Burlap and nylon mesh material were compared to paper as potential alternatives that could reduce this effort. Oligochaete production and the amount of time needed to separate animals from substrate were compared for eight weeks among experimental cultures containing burlap, nylon mesh and paper. Cultures with paper substrate increased in number and weight two to three times faster than those with burlap or nylon mesh

substrates. The time needed to separate animals from substrate was initially two to three times longer with paper substrate than with burlap or nylon mesh substrates, but this difference increased to between 10 and 40 times longer after six weeks as the paper substrate decomposed. Feeding rates varied by treatment and were based on average wet weight at the time of water replacement. Elevated ammonia and nitrite concentrations resulting from excess food may have reduced production in nylon mesh treatments and was lethal in paper treatments during the final phases of the study. The type of substrate recommended may depend on the desired production rate of oligochaetes, space available for cultures and the amount of effort available for substrate renewal and separating the animals from the cultures.

IP4 96-Hour Metabolism Study in Rainbow Trout with ¹⁴C-Decamethylcycllopentasiloxane (D₅). J. Domoradzki, D. McNett, J. Sushynski, L. Thackery, K. Plotzke, Health and Environmental Sciences, Dow Corning Corporation, Midland, MI; T. Springer, Wildlife International, Ltd., Easton, MD. To investigate the metabolism of D₅ in fish, three rainbow trout were administered 15 mg ¹⁴C-D₅/kg body weight via oral gavage. The trout were fitted with an in-dwelling cannula for blood collection and a urinary catheter for the collection of urine over 96 h. At sacrifice the concentrations of parent and radioactivity were determined in liver, bile, digestive tract, egg sacs, blood and fat. An average of 78% of the administered dose was recovered. Based on the percentage found in the tissues, bile, blood, remaining carcass and urine, the absorption of D₅ was estimated to be 25% of the recovered dose. The highest concentration of radioactivity was found in the bile with less than 1% of the dose attributed to parent material. Liver and digestive tract samples contained 60 and 76%, respectively, of the total recovered radioactivity in those samples as parent material and in the fat all radioactivity represented parent material. The concentration of parent in the blood was not detectable until 8 h post-administration (~0.8 ug D₅/g blood) and the highest concentration was observed at 24 h, 1.4 ug D₅/g blood. Radioactivity was detected in urine at all collections post-administration. The highest concentration in the urine was found during the 72 - 96 h collection interval, 0.35 ug equivalents of D₅/g urine, and parent was not found in urine. The majority of the recovered dose, 75%, was eliminated in the feces. Urinary excretion of radioactivity represented a minor elimination pathway. The calculated percentage of parent metabolism in rainbow trout under conditions of this assay is estimated to be 14% based on the total metabolite in µg divided by the total µg equivalents recovered in carcass, tissues (including bile) and urine. This study supports that radioactivity detected in liver was due to the presence of metabolic products (~40%) as a component of the total radioactivity measured and that clearance occurs via hepatic enterohepatic circulation of metabolic products (~99%) in bile with excretion via the digestive tract and urinary clearance of polar metabolites. (Supported by Centre Européen des Silicoes).

IP5 The Comparison of Fish Liver *In Vitro* Systems to Estimate Bioconcentration. M. Bernhard, S.D. Dyer, C. Cowan-Ellsberry, A.V. Weisbrod, Central Product Safety - Environmental, Procter and Gamble Company, Cincinnati, OH. Cellular and sub-cellular fish liver *in vitro* systems have been used to estimate metabolism and bioconcentration in fish. *In vitro* methods could result in 1) refined BCFs (bioconcentration factors) compared to approaches only considering lipid partitioning (Kow); 2) rapid and less expensive screening capabilities; and 3) reduced animal use. We evaluated various *in vitro* systems including primary carp and cryopreserved trout hepatocytes, and carp and trout S9 fractions. A variety of compounds were tested with varying Kows and metabolic profiles. Included are the selected compounds, 4-nonylphenol, pyrene, fluropyr 1-methylheptylester, dibenzylether, chlorpyrifos, and methoxychlor, which are part of an ongoing ILSI-HESI validation for use of trout S9 as a model system to predict *in vivo* metabolism of chemicals. *In vitro* biotransformation rates were incorporated into a mass-balanced BCF model to predict bioaccumulation estimates which were compared to *in vivo* data. The data, along with the advantages and disadvantages, of each will be assessed.

IP6 Co-administration of benzo(a)pyrene and methoxychlor reduces the tissue residues of methoxychlor and metabolites in channel catfish following oral administration. M.O. James, B.A. Nyagode, Medicinal Chemistry, University of Florida, Gainesville, FL; K.M. Kleinow, Comparative Biomedical Sciences, Louisiana State University, Baton Rouge, LA. Methoxychlor (MXC) is an organochlorine pesticide whose mono- and bis-demethylated metabolites, OH-MXC and HPTE, are estrogenic and antiandrogenic. Studies *in vitro* showed that catfish pretreated with a

polycyclic aromatic hydrocarbon (PAH) metabolized MXC (phase I and phase II) more rapidly than untreated catfish. To determine the in vivo effects of co-exposure to MXC and PAH, groups of four channel catfish were treated by gavage for six days with 2 mg/kg ^{14}C -MXC alone or 2mg/kg ^{14}C -MXC and 2 mg/kg benzo(a)pyrene. On day seven, blood samples were taken and catfish were dissected. Portions of each liver were taken for preparation of microsomes, to assess induction of CYP1A. Samples of all tissues were taken for determination of total radioactivity and metabolite analysis. EROD activity was 10-fold higher in the benzo(a)pyrene-treated catfish, indicating CYP1A induction. More MXC-derived radioactivity remained in control ($45.4 \pm 8.9\%$) than benzo(a)pyrene-induced catfish ($30.2 \pm 6.8\%$), mean percent total dose $\pm$ S.D. Bile, muscle and fat contained approximately 90% of the remaining radioactivity in controls and induced catfish. Analysis showed that OH-MXC, HPTE and their glucuronide conjugates were formed, but no sulfate conjugates were detected. Liver contained MXC, OH-MXC and HPTE and the two glucuronides, while bile contained primarily glucuronides of OH-MXC and HPTE. Muscle contained OH-MXC and HPTE with small amounts of MXC, but no conjugates. Fat, brain and gonads contained mainly MXC with small amounts of OH-MXC and HPTE. This study showed that co-exposure of catfish to benzo(a)pyrene and MXC resulted in enhanced elimination of MXC and that potentially toxic metabolites of MXC were present in the edible muscle tissue. Supported in part by NIEHS ES-07375

IP7 Factoring Initial Body Burden into Steady State Concentration Estimates for Standard 28-Day Bioaccumulation Tests. J. Steevens, G. Lotufo, USACE, Vicksburg, MS; K. Drouillard, University of Windsor, Windsor, Ontario, Canada; E. Bennett, Intertox, Salem, MA. Evaluation of dredged material typically requires an assessment of long-term bioaccumulation potential for benthic organisms using standard 28-day laboratory bioaccumulation tests in which the body burdens of chemicals of concern are determined in model test organisms. Since 28-d exposures may underestimate steady-state body residues because of insufficient exposure time, the initial body burden of field-collected test invertebrates may overestimate body residues resulting from exposure to test sediment due to insufficient time for the elimination of the initial burden. The goal of this study was to evaluate to investigate the elimination of PCBs in *Nereis virens* using kinetic modeling to assess the impact of initial body residue of PCB congeners on 28-day bioaccumulation results and derive an adjustment factor, if needed, to compensate for the initial *Nereis virens* body residue on 28-day bioaccumulation results for total PCBs. *N. virens* were preloaded with 7 different ^{13}C PCB congeners for a period of 7 days via the dietary route to establish an elevated initial concentration. Preloaded organisms were exposed to relatively contaminant-free sediments to evaluate elimination of ^{13}C PCB in presence of 3 substrates (water, low OC sediment, high OC sediment) and NY Harbor sediments to evaluate uptake of NY PCB and 28-day concentration of total and congener PCB. Results of the study were analyzed using nonlinear kinetic models to calculate adjustment factors used to adjust 28-day bioaccumulation test results based on initial tissue concentrations.

IP8 Generation of Proposed Chemical List for use in the Protocol Standardization Phase of a Rainbow Trout Liver S9 Metabolism Assay. S. Erhardt, Toxicology and Environmental Consulting and Research, The Dow Chemical Company, Midland, MI; S. Dyer, A. Weisbrod, Procter & Gamble, Cincinnati, OH; J. Sahi, CellDirect, Inc, Pittsboro, NC; B. Escher, Ewag, Dübendorf, Switzerland; C. Eickhoff, CANTEST Ltd, Burnaby, British Columbia, Canada; J. Domoradzki, Dow Corning Corp., Midland, MI; G. Panter, AstraZeneca Global SHE, Brixham, United Kingdom; K. Thomas, ILSI/HESI, Washington D.C., DC; X. Han, Dupont, Wilmington, DE. Bioconcentration data are increasingly needed for regulatory programs that require assessment of the bioaccumulation potential of substances for PBT categorization. To improve bioaccumulation estimates in fish, methods to estimate metabolism are critical. An in vitro trout liver S9 test has been developed to provide this estimate. Two sets of chemicals have been selected for use in the prevalidation phase of this in vitro S9 metabolism assay. The intent is for these chemicals to be used for development of all new in vitro and in vivo assays supporting the recent advances in bioaccumulation across academic, government, and industry labs in North America and Europe. The chemicals proposed were chosen by an interdisciplinary team representing many of these entities. The chemical selection was based on criteria originally developed at the March 2006 ILSI-HESI SETAC workshop examining in vitro techniques and their application in a tiered approach for

bioaccumulation assessment in fish. The critical properties included quality in vivo BCF, a range of biotransformation pathways (Phase I and Phase II), varied clearance/metabolic stability, range of K_{ow} values between 3.5 and 6.5, availability of analytical methods and ease of analytical determinations, and availability of test materials. The presentation will provide details on the creation of the test chemical database, which required finding scarce data and evaluating the quality of measured bioaccumulation and fish metabolism data this set of chemicals. The 21 chemicals chosen are among a short list of chemicals that meet all the criteria and represent a diversity of chemical classes (e.g. hydrocarbons, esters, phthalates, PAHs). Six compounds are proposed for use in the initial phase prevalidation at four laboratories and a second set of 15 chemicals which will be used to examine the chemical range of application and full validation of the proposed in vitro technique at an expanded number of laboratories. The two sets of chemicals will be presented as well as steps taken to assess the reliability of available data during the selection process.

IP9 Overview of the Pellston Workshop on the Tissue Residue Approach for Toxicity Assessment. J. Meador, NOAA Fisheries, Seattle, WA; W. Adams, Rio Tinto, Magna, UT; B. Escher, EAWAG/ETH, Dübendorf, Switzerland; L. McCarty, L.S. McCarty Scientific Research & Consulting, Markham, Ontario, Canada; A. McElroy, Stony Brook University, Stony Brook, NY; K. Sappington, EPA, Washington, DC. A Pellston Workshop was convened in Leavenworth, Washington in June, 2007 to explore the scientific basis for using tissue residues as the dose metric for toxicity assessment. Currently, the tissue residue approach (TRA) for toxicity assessment is becoming more widely explored and applied in various evaluations; however, a detailed review has not been conducted. Forty scientists from ten countries were divided among five workgroups to examine various aspects of the TRA. The major themes for this workshop were 1. Scientific underpinnings, 2. Mixtures and mechanisms, 3. Metal toxicants, 4. Organic toxicants, and 5. Application of the TRA. This workshop was focused on theory, processes, feasibility, scientific soundness, and application of the TRA. While the workshop was dominated by examples for fish and invertebrates (aquatic and terrestrial), data and examples for all taxa, including mammals, were included; however, human health was not considered. The overarching goal of the TRA workshop was to characterize the current state of the science for using tissue residues as the dose metric and to examine the advantages and disadvantages of such an approach for all toxicant classes. A synopsis of the major findings will be presented, which will be explained in detail in posters from each of the workgroups.

IP10 Tissue Residues in Environmental Toxicology and Risk Assessment: An Overview. L. McCarty, LS McCarty SR&C, Markham, Ontario, Canada; P. Landrum, Great Lakes Environmental Research Lab, Ann Arbor, MI; S. Luoma, USGS, Menlo Park, CA; A. Merten, NOAA Coastal Response Research Center, Seattle, WA; B. Shephard, US EPA, Seattle, WA; A. van Wezel, Kiwa Water Research, Nieuwegein, Netherlands. The use of body/tissue residues in environmental risk assessment of chemical substances was examined at a recent SETAC Pellston Workshop. The key question was: how can tissue residues improve toxicity assessment? The group charged with an overview and examination of the scientific underpinnings reviewed the history of body/tissue-based dose metrics and the factors that led to the current situation dominated by dose surrogates based on exposure-media concentrations. Introductory examination of a number of issues were carried out including: body/tissue residues in the toxicity of organics versus inorganics/metals, the role of time in dose metrics, acute versus chronic response endpoints, modes/mechanisms of toxic action, the influence of toxicity modifying factors, and the current challenges in risk assessment for regulatory activities. Additional issues considered were the theoretical and practical aspects of using body/tissue residues in toxicity test design and interpretation, approaches to improve the utility and understanding of the large 'legacy' toxicity datasets based on exposure-based dose metrics, possible revision to standard toxicity test protocols to facilitate the use of body/tissue residues and enhance understanding of toxicokinetics and toxicodynamics, and thoughts on development and validation of tissue residue relationships for field monitoring data.

IP11 Applying mechanisms of toxic action in tissue-residue based mixture toxicity modeling and assessment. B.I. Escher, R. Ashauer, Eawag, Dübendorf, Switzerland; R. Ashauer, CSL, York, United Kingdom; J. Hermens, IRAS, Utrecht, Netherlands; S. Dyer, Procter and Gamble, Cincinnati, OH; J. Lee, NeoEnBiz Co., Seoul, South Korea; M. Warne, Centre for Environmental Contaminant Research, CSIRO, Adelaide, South

Australia, Australia; H.A. Leslie, IVM, Amsterdam, Netherlands. At a recent Pellston Workshop on Tissue Residues, we explored the idea that mechanistic considerations would permit an improved categorization of tissue residues and toxicokinetic/toxicodynamic modeling of internal effect concentrations. In general, a measured tissue residue is a better descriptor for exposure (or dose) and shows less variability with respect to species sensitivity and time dependence of toxicity compared to a concentration measured in ambient environmental media, i.e. outside the organism. However, this statement only holds true if the tissue residue can be regarded as being closer to a direct measure of the target dose (or concentration at the target site) and if the effect is directly proportional to the target dose/concentration. Whether this condition applies or if more sophisticated temporally-based toxicokinetic/toxicodynamic models need to be used depends on the underlying mechanistic processes. For the baseline toxicity mechanism, the tissue residue approach is fairly well established. Effective target site concentrations of baseline toxicants, i.e. concentrations in the cell membrane, are relatively constant for all aquatic organisms. In contrast, for specifically acting compounds, additional toxicodynamic factors play a role. Instead of target concentrations, other measures of the interaction between toxicant and target site must be defined, e.g., the critical target occupation or the target depletion rate. In such cases it is not possible to rely on constant tissue residues but more temporally-based toxicokinetic/toxicodynamic models need to be developed and applied. These models have the advantage that they can be calibrated with measured internal concentrations. We show the common basis of the different published models and propose a generalized model. The elegance of the tissue residue approach is best recognized when it comes to mixture toxicity. Here mixture components with the same mode of toxic action clearly act additively in terms of internal-concentration, which can be mechanistically justified and exploited to predict mixture toxicity and conduct site-specific risk assessments.

IP12 Metal Tissue Residue Dose Metrics For Assessing Effects in Aquatic Organisms. W.J. Adams, Rio Tinto, Magna, UT; R. Blust, University of Antwerp, Antwerp, Belgium; U. Borgmann, Environment Canada, Burlington, Ontario, Canada; D. DeForest, Parametrix, Bellevue, WA; A. Green, IZA, Research Triangle Park, NC; J. McGeer, Wilfrid Laurier University, Waterloo, Ontario, Canada; J. Meyer, Arcadis US Inc., Golden, CO; P. Paquin, HydroQual, Manhaw, NJ; P. Rainbow, The Natural History Museum, London, United Kingdom; C. Wood, McMaster University, Hamilton, Ontario, Canada. A Pellston Workshop convened in Leavenworth, Washington in June, 2007 explored the scientific basis for using tissue residues as the dose metric for toxicity assessment. The metals workgroup focused its review on the fundamental principles associated with metal accumulation, storage and regulation as well as pharmacokinetic approaches to assessing metal accumulation and effects. Case examples where tissue residue approaches have been developed for metals were reviewed and summarized. These include, the Biotic Ligand Model approach to assess respiratory ligand accumulation of metals, use of metal residues in Hyallella to assess effects, use of a bivalve accumulation model to assess effects, and the USEPA selenium tissue residue data set. Additionally, a new and promising data set was developed to explore the ability to use cadmium tissue residues in aquatic organisms to predict effects. A summary of the case studies, models and workshop conclusions are presented.

IP13 Application of the tissue residue approach to evaluate toxicity of organic contaminants. A. McElroy, Marine Sciences, Stony Brook University, Stony Brook, NY; M. Barron, Gulf Ecology Division, U.S. EPA, Gulf Breeze, FL; N. Beckvar, Coastal Protection & Restoration, NOAA, Seattle, WA; S. Driscoll, Exponent Inc., Maynard, MA; T. Parkerton, Toxicology and Environmental Sciences, Exxon Mobil Biomedical Sciences, Annandale, NJ; T. Preuss, Bio 5 Worringerweg 1, Aachen University, Aachen, Germany; J. Steevens, CEERD-EP-R, U.S. Army Engineer Research & Development Center, Vicksburg, MS. A recent Pellston Workshop was convened to evaluate the use of tissue residue analysis in the assessment of chemical toxicity. The application of this approach to organic contaminants, including organometallics was reviewed, with special consideration given to factors limiting its application, such as metabolism, and the influence of multiple mechanisms of toxic action, and factors that need to be considered, such as data quality, and biotic and abiotic factors that influence the relationship between accumulated dose and toxicity. It was concluded that: 1) tissue residue/toxicity relationships can provide useful insights with respect to mode of action of organic chemicals 2) the target lipid model can provide a useful framework for integrating both aqueous and residue based toxicity data for

many organic chemicals; and 3) that since biotransformation complicates interpretation of tissue residues among chemicals and across species, there is a need to explicitly address this issue. Other data and research needs include further evaluation of sublethal and chronic endpoints, the influence of life stage and exposure route, and evaluation of phototoxic compounds, pesticides and emerging contaminants that biomagnify in aquatic biota. Despite the data and research needs, tissue residue analysis provides a robust framework from which better understanding of dose/effect relationships can be ascertained

IP14 Development of a Framework for Integrating Tissue Residue-based Toxicity Data into Ecological Risk Assessment. K. Sappington, S. Bradbury, Office of Prevention, Pesticides and Toxic Substances, U.S. Environmental Protection Agency, Washington, DC; T. Bridges, Engineer Research and Development Center, U.S. Army Corps of Engineers, Vicksburg, MS; R. Erickson, D. Mount, Office of Research and Development, U.S. Environmental Protection Agency, Duluth, MN; J. Hendriks, Department of Environmental Science, Radboud University, Nijmegen, Netherlands; R. Lanno, Department of Entomology, Ohio State University, Columbus, OH; M. Salazar, Applied Biomonitoring, Kirkland, WA; D. Spry, Science and Risk Assessment Directorate, Environment Canada, Gatineau, Ontario, Canada. The Society of Environmental Toxicology and Chemistry (SETAC) recently convened a workshop for reviewing the scientific basis of the tissue residue approach (TRA) in toxicity assessment. Workgroup 5 was charged with developing a framework for incorporating TRA into ecological risk assessment (ERA). Although widely recognized for its toxicological appeal, the utility of TRA in specific applications will depend on numerous factors such as the availability of tissue residue-response data, chemical properties, exposure characteristics, assessment type, and the ability to quantify chemical exposure. Therefore, the decision to use TRA should include an evaluation of the relative strengths, limitations, and uncertainties among external exposure- and tissue residue-based methods for characterizing toxicological effects. Furthermore, rather than supplanting exposure concentration-based toxicity assessments, TRA can be highly effective for evaluating and reducing uncertainty when used in a complementary manner (e.g., when evaluating multiple lines of evidence in field studies). To address limitations with the available tissue residue-response data, approaches for extrapolating residue-based toxicity data across species, tissues, and exposure durations are discussed. Some of these approaches rely on predicted residue-response relationships or toxicological models that contain an implicit residue-response basis (e.g., biotic ligand model). Because risk to an organism is a function of both its exposure potential and inherent sensitivity (i.e., on a residue-basis), bioaccumulation models will be required not only for translating tissue residue criteria into corresponding water and sediment criteria, but also for defining the most vulnerable species in an assemblage (i.e., highly exposed and highly sensitive species). 'Lessons learned' from incorporating TRA into selected criteria derivation and ERA applications are summarized.

IP15 Assessment of Critical Body Residues for Cadmium in Aquatic Biota. D.K. DeForest, Parametrix, Bellevue, WA; W.J. Adams, Rio Tinto, Magna, UT; K.V. Brix, EcoTox, Jacksonville, FL. We conducted an assessment of the critical body residue (CBR) concept for cadmium (Cd) in aquatic biota. Based on a scientific literature review, a database of chronic toxicity studies was developed in which Cd concentrations were measured in whole body or individual tissues. Only laboratory toxicity studies in which Cd was the only toxicant tested were included in the database. Overall, studies in which chronic Cd toxicity and whole body Cd residues could be linked were identified for more than 30 species of aquatic biota, and concentration-response relationships between whole body Cd and toxicity were consistently observed. The majority of the data compiled were for fish and arthropods and the following trend in sensitivities, as a function of whole body Cd, was observed: fish > arthropods ≈ amphibians > molluscs > annelids. Given that Cd is a non-essential metal and is not well regulated via mechanisms of active uptake and excretion it appears that whole body Cd concentrations in aquatic biota are generally reflective of concentrations in abiotic media, which perhaps increases the feasibility of linking whole body tissue residues to adverse effects in the field. However, use of the term "critical" in the CBR concept contains certain implications that are not applicable to Cd because species-specific differences in detoxification strategies result in highly variable Cd levels that are tolerated on a whole body basis and even within a species varying Cd exposure conditions in the laboratory impart uncertainty when attempting to extrapolate the results into a field-based assessment. It is clear that more studies, at environmentally relevant concentrations, are needed

to better understand (1) the influence of combined waterborne and dietary exposures on Cd bioaccumulation and toxicity; (2) the relationship between Cd bioaccumulation rate (uptake, detoxification, and excretion rates) and Cd toxicity; and (3) the influence of water quality characteristics on the relationship between internal Cd concentrations and toxicity. In addition, reviews of existing field studies published in the scientific literature would help to “ground truth” whether possible tissue residue-based Cd toxicity levels are relevant to natural situations.

IP16 Using the Target Lipid Model as an Approach to Assess Tissue Residues and the Response of Baseline Toxicants in Fish and Aquatic Invertebrates.

A. McElroy, Marine Sciences, Stony Brook University, Stony Brook, NY; **M. Barron**, Gulf Ecology Division, U.S. EPA, Gulf Breeze, FL; **N. Beckvar**, Coastal Protection & Restoration, NOAA, Seattle, WA; **S. Driscoll**, Exponent, Maynard, MA; **T. Parkerton**, Toxicology & Environmental Sciences, Exxon Mobil Biomedical Sciences, Annandale, NJ; **T. Preuss**, Bio5 Worringerweg 1, Aachen University, Aachen, Germany; **J. Stevens**, CEERD-ER-R, U.S. Army Engineer Research & Development Center, Vicksburg, MS. As part of a Pellston Workshop evaluating the use of tissue residue analysis in assessment of chemical toxicity, the workgroup on organic contaminants considered the use of the target lipid model (TLM) approach developed by DiToro and co-workers to help interpret residue toxicity relationships. The TLM approach utilizes a linear free energy relationship between chemical properties (Kow) and aquatic toxicity (LC50) data to estimate critical target lipid body burdens. A theoretically derived species sensitivity distribution using TLM model output on acute lethal responses for 43 aquatic species was constructed. This was compared against CBR data for two model compounds exhibiting baseline toxicity at high exposure concentrations, one that can be metabolized by some organisms, fluoranthene, and another which is not, pentachlorobenzene. While CBR data for penachlorobenzene matched the TLM predictions quite well, observed CBR values for some organisms deviated from model predictions for parent fluoranthene while values based on body residues for parent compound and metabolites provided a better fit. This approach can be expanded to evaluate relationships between lethal and sublethal responses and used to evaluate compounds with either specific modes of action or cases where metabolism influences tissue residue response relationships.

IP17 Implicit Versus Explicit Applications of the Tissue Residue Approach.

R.J. Erickson, Mid-Continent Ecology Division, U.S. Environmental Protection Agency, Duluth, MN. Toxic effect models based on the relationship of toxic effects to chemical concentrations within receptor organism tissues can often be reformulated to describe the relationship of toxic effects to exposure concentrations without actual specification of the tissue concentrations. Such ‘implicit’ versus ‘explicit’ versions of models were compared using results from a study on the lethality of pentachloroethane to juvenile fathead minnows that examined effects under continuous and time-varying exposures, assessed chemical uptake and elimination rates, and monitored chemical residues in dead and surviving organisms. Comparisons were also made between toxic effects models with different assumptions regarding toxicokinetic and toxicodynamic processes. Implicit and explicit versions of each model were parameterized based on continuous exposure tests, and evaluated regarding their fit to these tests and their predictions for time-varying exposure tests. Advantages and disadvantages regarding model parameterization, assumptions, and performance were identified for the various models and versions. This abstract does not necessarily reflect USEPA policy.

IP18 Environmental Health: From Lab Bench to Community and Classroom Poster Session.

D. Weber, J.B. Hewitt, E.I. Bromberg, L. Petering, D.H. Petering, Marine & Freshwater Biomedical Sciences Center, University of Wisconsin-Milwaukee, Milwaukee, WI. Environmental toxicology and human health can help students and the general public to understand and value science, and for public health professionals to form evidence-based policy and risk communication messages. These messages can be created in several formats. For students, educational modules and curricula provide the basic framework within which they are able to explore the basic science behind environmental health issues and begin to understand how the environment impacts their own health. For the public health workforce, targeted elements of these modules and other scientific information can be used to integrate environmental health evidence into public policy decisions and health messages conveyed to the general public. To accomplish this dual-targeted objective, universities have partnered with school systems, as well as public

health and community organizations. For the school system, particularly those in urban settings, this poster session focuses on demonstrating how to create, test, and implement science modules that focus on integrating basic science with environmental health concepts at a grade-appropriate level. Key to the success of such programs is the training of teachers in the proper use of these programs, especially those that involve live animals as models of human health. For the public health and community organizations, this poster session highlights examples of how community outreach programs have been developed across the country to assist local, at-risk populations understand and act upon fundamental scientific concepts that pertain to the environmental health of their neighborhoods. Among the many methods used to accomplish outreach are videos, posters, and health fairs. These projects are often coordinated with local public health professionals who routinely work with these more vulnerable populations. The public and private sectors are also critical partners in this effort to translate environmental health science into usable information for the general public, as well as vulnerable populations. All posters in this symposium will be presented in an interactive forum to facilitate dialogue among all the various stakeholders in translating environmental health science for the benefit of the public’s health and to foster collaboration among the participants in future efforts.

IP19 Urban Environment and Human Environmental Health: Public Participation in Environmental Health Research.

K. Olden, NIEHS, NIH, Research Triangle Park, NC. The objective of biomedical research is to improve the health and well-being of mankind. Realizing that this will require improved translation and dissemination of new knowledge and technologies. Researchers will need to more fully engage the public in both the priority-setting and research process and give appropriate consideration to the concerns expressed by the American people. Improving human health will require investments in research that goes beyond basic and clinical research. It will require development of innovative strategies to promote healthy lifestyles. About half of the Nation’s healthcare costs result from unhealthy behaviors and environments. Yet, approximately 88% of the Nation’s investment in biomedical research targets basic laboratory and clinical research. Nevertheless, many public and private funding agencies have begun to support community-based prevention/intervention research and community outreach and education. These programs seek to expand knowledge and understanding of potential causes and remedies of behavioral and environmental related disorders, while at the same time enhancing the capacity of communities to participate in the processes that shape research approaches and intervention strategies. Given the complexity and magnitude of environmental health problems, research endeavors aimed at improving knowledge and ability to resolve these issues can benefit from establishing collaborative relationships with the communities experiencing these problems. Such community-research partnerships have benefits for both the researchers and the community. These partnerships can, for example, facilitate the definition of important environmental health issues and concerns, the development of measurement instruments that are culturally appropriate, and the establishment of trust that enriches the value of data collected. In conclusion, continuing the current emphasis in biomedical research on individualized, therapeutic solutions to solve the problem of complex diseases is problematic. Such a clinical medicine approach will impede the discovery of important mechanisms that could be exploited to prevent the major causes of human illness. A more fruitful strategy would involve interdisciplinary research that integrates the social and behavioral sciences with the traditional disciplines of genetics and environmental health research to develop population-based public health prevention.

IP20 Urban Environment and Public Health: Need for a Convergence of Science and Outreach.

T. Sinks, National Center for Environmental Health at the Centers for Disease Control and Prevention, National Center for Environmental Health at the Centers for Disease Control and Prevention, Atlanta, GA. Public health provides the broad underpinnings for the health and wellness that any society experiences. At the Federal level, responsibility for environmental science, environmental health science, and public health tend to be segregated into different agencies. Similarly, within the scientific community at large, research interests also congregate into these areas and do not necessarily make connections that are needed to address real-world problems. As the world continues its move toward globalization in step with economic growth, it is increasingly important to foster interdisciplinary cooperation on major current and projected disease issues. For cities, those issues include the built environment and its future configuration,

the availability of clean water, and how to operate in a sustainable way for the surrounding environment. An overarching concern is the prospect of global climate change and how that will affect not only the environment but also human health. This talk will address these cross-cutting issues from the perspective of the Centers for Disease Control with an emphasis on opportunities for scientific collaboration across the environment-public health continuum.

IP21 Science literacy and the responsibility of the science educator: doing what is best for science and society. B. Shakhshiri, Department of Chemistry, University of Wisconsin, Madison, WI. Chemistry is a discipline practiced by highly competent and responsible professionals who are engaged in enterprises that are self-rewarding and can benefit society. Chemistry is both the central science and the science of the familiar. The familiarity of chemistry has yet to be fully exploited in reaching all segments of society, especially the non-specialists. We must increase awareness of chemicals, their transformations, hazards, and how they benefit our health, safety, and environment. Chemistry brings a wide range of goods and functions to everyone and thus is vital to our democracy. Science literacy is necessary for the democratic process to work. I make a distinction between scientific literacy, expertise in a particular field, and science literacy, a broad appreciation and understanding of science and its practitioners, and of what science is capable of achieving and what it cannot accomplish. Science literacy enlightens and enables people to make informed choices, to be skeptical, and to reject shams, quackery, unproven conjecture, and to avoid being bamboozled into making foolish decisions where matters of science and technology are concerned. Science literacy is for everyone --chemists, artists, humanists, all professionals, the general public, youth and adults alike. I will address specific approaches aimed at promoting environmental awareness and responsibility in the classroom and in other settings. Examples will be drawn from successful programs such as "Chemical of the Week"; Science in the City; Science, the Arts, and the Humanities; Women in Science; ONCE UPON A CHRISTMAS CHEERY IN THE LAB OF SHAKHASHIRI; Science on the Radio; Conversations in Science Series; and Experiments You Can Do at Home.

IP22 Environment and Environmental Health at a Milwaukee Inner City Health Clinic. P. McAvoy, Environmental Health, Sixteenth Street Community Health Clinic, Milwaukee, WI. The Sixteenth Street Community Health Center serves the near south side residents of Milwaukee. It provides a broad array of medical and public health services for a largely Latino population. A special component of its offering directed at preventing disease is its program in environmental health that has reached out into the community to address environmental deterioration in order to reduce disease incidence. At the foundation of the program are two general assumptions, first, that the quality of the built environment contributes broadly to the health of area residents and second, that dialog and communication are critical to developing effective programs within the community that address environmental issues. The presentation will sketch the urban environmental landscape including the housing stock, brownfields, waterways that may affect Latino and other families in the area. Following this overview, a discussion of remedial actions and effective means to implement them will be presented, with attention given to the Sixteenth Street Center's successful child lead reduction program and its broad effort in the Menomonee Valley to reestablish a sustainable, healthy environment.

IP23 Integrating Water Quality Stewardship into the Milwaukee Region. K. Shafer, Milwaukee Metropolitan Sewerage District, Milwaukee, WI. In 2002, the Southeastern Wisconsin Regional Planning Commission (SEWRPC) and the Milwaukee Metropolitan Sewerage District (MMSD) initiated an integrated study of the sources of water pollution in the Greater Milwaukee watersheds. Referred to as, the Water Quality Initiative uses the U.S. Environmental Protection Agency's recommended watershed approach. By using the watershed approach, nature's boundaries drive decisions based on science and engineering instead of jurisdictional limits. This approach requires strong partnerships and public involvement with people, interest groups, and agencies. When completed later this year, the plan provide recommendations for the control of both point sources and polluted stormwater runoff private, and will provide the basis for decisions on community, industrial, and private waste disposal systems. Implementation of these recommendations will require integration of education and water quality stewardship into Milwaukee's urban fabric. The challenge for the region will be to put these actions into place to improve the environmental health of the region and protect human wellbeing.

This presentation will discuss what the next steps are and how will they ultimately impact every resident in the region.

IP24 Science and Culture Meet: Key to Environment-Environmental Health Improvement. D. Petering, Marine & Freshwater Biomedical Sciences Center, University of Wisconsin-Milwaukee, Milwaukee, WI. Alan Leshner, the chief executive officer of the AAAS and the executive publisher of Science magazine has been deeply concerned about the status of science vis a vis the public. "It was the best of times, it was the worst of times," meaning that as scientific understanding continues to unfold, public lack of understanding, disregard, and disinterest in science continues apace. Leshner is campaigning to get scientists to see communication with the public as part of their portfolio and to learn how to do it effectively. This presentation centers on examples of community outreach and education in the environmental health area that have been stimulated by the National Institute of Environmental Health Sciences through its past requirement that NIEHS extramural centers include an integral robust community outreach and education program (COEP). Two types of projects will be highlighted: (a) communication with ethnic communities about the risks and benefits of consuming fish laced with mercury and/or PCBs and (b) professional development with middle school life science teachers to bring authentic environmental health experiments with aquatic organisms into the class room, including ones involving lead and mercury. Emphasis will be placed on effective strategies to communicate program content. The first example focuses on small group communication coupled with polished video dissemination; in the second, full experiment development, documentation, and support for teachers in the classroom. Supported by NIH grant ES-04184

IP25 Summary of Recommendations for Wildlife TRV Development and Use. R.N. Hull, Intrinsic Environmental Inc., Mississauga, Ontario, Canada; P. Allard, Azimuth Consulting Group, Vancouver, British Columbia, Canada; A. Fairbrother, U.S. EPA, Corvallis, OR; B. Hope, Oregon DEQ, Portland, OR; M.S. Johnson, US Army CHPPM, Aberdeen Proving Ground, MD; L.A. Kapustka, Golder Associates, Calgary, Alberta, Canada; B. McDonald, Golder Associates, North Vancouver, British Columbia, Canada; B.E. Sample, CH2MHill, Sacramento, CA. There is little guidance on the scientific aspects of development and use of wildlife Toxicity Reference Values (TRVs) in ERA. A group of individuals experienced in ecology, toxicology, and ERA met to discuss the scientific (not policy) issues associated with avian and mammalian TRV development and use. The outcome of this meeting resulted in a series of recommendations and conclusions intended as guidance to those who derive TRVs. Examples include: do not extrapolate toxicity data between classes when deriving chronic TRVs; do not use allometric dose-scaling using body mass when assessing chronic toxicity; do not extrapolate chronic TRVs from acute data; do not assume all TRVs will be protective for all species within a class; do not limit toxic endpoints to mortality, reproduction and growth; do not apply uncertainty factors for inter-species extrapolation without scientific justification; in most cases it is more predictive to use complete dose-response information instead of N/LOAELs unless no data are available; Hazard Indices should not be calculated; be transparent on the corroboration of the data set and the uncertainty. Other recommendations include: allometric scaling is proper in estimating exposure (e.g. food ingestion rates) when empirical data do not exist; provide all supporting information used in TRV derivation; consider relative sensitivity of species, when conducting inter-species extrapolation; use "confidence qualifiers" for data sets and subsequent TRVs; use dose-response relationships when possible; use EDx values or distributions; link the TRVs to the assessment endpoints (and Problem Formulation); use HQs only to screen out chemical/receptor combinations, rather than imply magnitude of effect; consider dosing method, dose vehicle and chemical form when extrapolating data; understand differences/similarities in test organisms and receptor of concern; explicitly represent uncertainty and confidence; be transparent with all data, calculations and assumptions. The group is now seeking critical review of our recommendations in the hopes of developing a broad consensus of practitioners, industry and regulators on these recommendations.

IP26 Criteria for Selection of Toxicity Reference Values for Ecological Risk Assessment. B.E. Sample, CH2M HILL, Sacramento, CA; M.S. Johnson, Center for Health Promotion and Preventive Medicine, US Army, Aberdeen, MD; B. McDonald, Golder Associates, Vancouver, British Columbia, Canada. Few published toxicity studies provide optimal data or were designed for the development of toxicity reference values (TRVs) for ecological risk assessment applications. Data can vary widely in quality,

depending upon the purposes for which they were conducted. Additionally, the controlled design component essential for the elucidation of compound-related adverse effects restricts the use of wildlife models and integration of ecological important endpoints. To minimize the probability of integrating erroneous or extraneous data into class-specific toxicity benchmarks, identification and selection of high quality toxicity studies is essential. Key attributes to guide selection of toxicity studies have been identified and include: Restriction to primary data sources; Correspondence between exposure pathway and chemical form in toxicity study and expected exposure pathway and form in field; Analytical confirmation of dose; Clear presentation of animal mass throughout exposure duration; Clearly identified exposure duration, with those encompassing multiple generations and critical life stages ranked higher; Toxicity endpoints that reflect the primary targets of toxicity; Multiple treatments to allow delineation of dose-response relationships; Variability in dose response (i.e., power of the statistical comparisons) assessed to be relevant and comparable to other studies on the specific substance or class of test species; Dose (administered) quantified appropriately with minimal variability; Sufficient information presented to allow study and its results to be repeated; and, Corroboration with other similar data. When satisfied, these attributes have been found to provide the optimal data set from which to derive TRVs. These recommendations provide the first step in the establishment of criteria necessary for TRV derivation and provide a basis for recommendation of toxicity study design intended for ecological risk assessment applications. However, we recognize that study design for TRV derivation requires a consideration of specific intended purpose (contaminated sites or pesticide registration) and further integration of ecological endpoints (e.g. behavioral) in controlled laboratory situations to be useful.

IP27 Linking assessment endpoints and wildlife TRVs. L. Kapustka, Golder Associates Ltd, Calgary, Alberta, Canada; A. Fairbrother, US EPA, Corvallis, OR; B. Sample, CH2M Hill, Sacramento, CA. The challenge with all ecological risk assessments is to get the questions right. The steps taken in the Problem Formulation stage of a risk assessment are intended to hone the focus of the assessment through the careful delineation of the assessment endpoints. Problem Formulation is intended to be an iterative process that involves "thought experiments" that consider what is of value and to be protected, what can be assessed and what can be measured. This should include consideration of the type of toxicity data that should be applied to the entity (species of interest) and attributes. Are data available and of adequate quality? Which indicator or surrogate species can be used? Are there sufficient data to evaluate population endpoints using toxicity data? How much uncertainty can be tolerated in the assessment? What are the implications (in terms of risk management or additional data collection) of this uncertainty? What alternative measures (other than TRVs) can be used in assessing risk to the valued ecological components? This poster will present a range of scenarios to illustrate degrees of linkage between assessment endpoints and wildlife TRVs.

IP28 Using Dose-response Relationships for Wildlife TRVs. P. Allard, R. Hill, G. Mann, C. Mackintosh, Azimuth Consulting Group Inc., Vancouver, British Columbia, Canada; R. Hull, Intrinsic Environmental Inc., Mississauga, Ontario, Canada; L. Kapustka, B. McDonald, Golder Associates Ltd., North Vancouver, British Columbia, Canada; B. Hope, Oregon Department of Environmental Quality, Portland, OR; B. Sample, CH2M Hill, Sacramento, CA; A. Fairbrother, USEPA/NHEERL/WED, Corvallis, OR; M. Johnson, USACHPPM, Aberdeen, MD. Evaluation of ecological risks for wildlife often is based on the use of toxicity reference values (TRVs) to understand the significance of predicted exposures to environmental contaminants. There are several challenges and limitations to existing approaches for developing TRVs, particularly since they often are generated from single point estimates such as NOAELs and/or LOAELs. Such estimates are determined based on statistical significance within individual laboratory studies or, more rarely, among toxicity data sets. However, NOAEL- and LOAEL-based TRVs are not innately related to biologically relevant thresholds, nor do they provide information on the magnitude of effects in the reported studies. Rather, they tend to reflect a study's ability to detect statistical differences (e.g., study design, replication, and within-treatment variability). These characteristics make NOAEL/LOAELs undesirable in ERA. While not always possible due to data limitations, TRVs for deterministic ERAs are best derived from underlying dose-response relationships (i.e., point estimate EDX values). This approach is flexible in that different protection goals (i.e., allowable magnitude of effects) can be tailored for different land uses and/or different receptor groups (e.g., rare

versus common species). It is important to note that hazard quotients (HQs) derived from any point estimate TRV (i.e., NOAEL/LOAEL or EDX) represent a measure of "hazard", not risk (e.g., an HQ of 10 does not indicate that risks are five times greater than an HQ of 2). For this reason, comparing predicted exposure directly to underlying dose-response information is necessary for understanding the likelihood and magnitude of potential effects as well as response to incremental increases in exposure. This poster presents a data-dependent hierarchical approach for developing TRVs, including species sensitivity distributions, single species/endpoint dose-response relationships, multiple species/endpoints meta-analyses, NOAELs/LOAELs, and QSARs. An example is provided for methyl mercury.

IP29 Representation and Consequences of Uncertainty in the Toxicity Reference Value. B. Hope, Air Quality, Oregon DEQ, Portland, OR; P. Allard, Azimuth Group, Vancouver, British Columbia, Canada; A. Fairbrother, USEPA/NHEERL/WED, Corvallis, OR; R. Hull, Intrinsic Environmental, Mississauga, Ontario, Canada; M. Johnson, U.S. ARMY, Aberdeen Proving Ground, MD; L. Kapustka, Golder Associates, Calgary, Alberta, Canada; B. McDonald, Golder Associates, Vancouver, British Columbia, Canada; B. Sample, CH2M Hill, Sacramento, CA. Both the exposure and effects components of an ecological risk assessment manifest uncertainty, a combination of stochastic variability (natural heterogeneity) and incertitude (lack of knowledge). Clear elucidation of uncertainty in any risk estimate is critical if decision makers are to judge their degree of confidence in the estimate. While it is becoming common to apply quantitative uncertainty analysis (typically Monte Carlo) techniques to the exposure component, this is still not the case for the effects component. With notable exceptions, a toxicity reference value (TRV) is typically represented as a point estimate, without adequate expression of its inherent variability or incertitude. Uncertainty in the TRV must then be discussed qualitatively because probabilistic measures of uncertainty are not appropriate for a TRV when complete data on all species, life stages, and endpoints are not available. But any TRV is subject to variability (e.g., inter- and intraspecific differences in response to a stressor) and incertitude (e.g., lack of knowledge due to limited or inadequate testing). Whenever practicable, a TRV should be expressed either as a quantitative stressor-response relationship (for an individual species or group of species (species sensitivity distribution (SSD)) or, to meet regulatory mandates, as a point estimate drawn from such a relationship (EDp or ECp, where the value of "p" may be both a technical and policy choice). This approach allows more straightforward representation of variability in the estimate of the biologically effective threshold dose and has the added advantage of avoiding use of arbitrary uncertainty factors. Use of TRVs whose certainty cannot be addressed is discouraged. We will illustrate derivation of TRV relationships, and how selection of a derivation data set reflects trade-offs between toxicological relevance and statistical validity. We will also show how uncertainty in the TRV influences remediation or response goals generated through back-calculation of the risk assessment.

MP1 Comparison of Michigan and Canadian Wildlife Service Great Lakes Herring Gull Biomonitoring Program Results 2002 to 2006. K.G. Drouillard, GLIER, University of Windsor, Windsor, Ontario, Canada; W.W. Bowerman, Forestry and Natural Resources, Clemson University, Clemson, SC; D. Weseloh, Canadian Wildlife Service - Ontario Region, Environment Canada, Burlington, Ontario, Canada; J.G. Sikarskie, College of Veterinary Medicine, Michigan State University, E. Lansing, MI; D. Bush, Water Division, Michigan Department of Environmental Quality, Lansing, MI. The Canadian Wildlife Service's Great Lakes Herring Gull Biomonitoring program has been in operation since the early 1970's. This program collects between 10-13 eggs from 15 colonies distributed across the five Great Lakes and St. Lawrence Seaway and has generated one of the premiere contaminant data bases for documenting spatial and temporal patterns of bioaccumulative contaminants in the Great Lakes and North America. In 2002 the Michigan Department of Environmental Quality implemented a complementary program which began collecting herring gull eggs for an additional 10 herring gull colonies distributed between Lake Superior, St. Mary's River, Lake Michigan, Lake Huron and Lake Erie. This study compares data generated from both egg monitoring programs over collection period of 2002-2006. Spatial patterns and lake rankings with respect to contamination were similar between the two data sets. Both programs indicate higher PCB contamination of western Lake Erie that were from 2 to 3 fold higher than other lake sites, although variable results in contaminant ranking among certain colonies from Lake Huron and Lake Michigan were noted.

MP2 Developing New Approaches for Assessing the Bioaccumulation of Organic Chemicals. R. Stevenson, J. Pasternak, Environmental Stewardship Branch, Environment Canada, Vancouver, British Columbia, Canada; P. Doyle, R. Chenier, Science and Technology Branch, Environment Canada, Gatineau, Quebec, Canada. Canadian regulatory criteria for determining whether a substance is considered bioaccumulative were originally developed during the 1990s and incorporated into Canada's Persistence and Bioaccumulation Regulations in 2000 under the Canadian Environmental Protection Act (CEPA, 1999). Substances having a bioaccumulation or bioconcentration factor of ≥ 5000 , or a log octanol-water partition coefficient (Kow) of ≥ 5 may be considered to have a significant potential for bioaccumulation. These criteria were based on historical experience with aquatic bioconcentration of neutral, non-metabolized organic substances. Their use represents a simple regulatory method for determining whether a substance should be considered bioaccumulative. Environment Canada's recent experiences gained from the Categorization of the Domestic Substances List and screening assessments of substances such as perfluorooctanesulfonate and polybromodiphenyl ethers have provided an opportunity to consider new scientific understanding on bioaccumulation. For some substances there may be a need to evaluate measures of food web biomagnification. Relatively new endpoints which address this need and are gaining acceptance in the scientific community include biomagnification and trophic magnification factors. Until recently, a significant gap in knowledge existed regarding the influence of chemical biotransformation on overall bioaccumulation. New research on the development of models and predictive QSARs makes it possible to consider biotransformation potential as an integral component of a bioaccumulation assessment. Relatively recent research indicates that bioaccumulation in air-breathers depends primarily on the partitioning behaviour between air and tissues rather than water and tissues. The octanol-air partition coefficient rather than Kow, thus may be a better parameter for predicting partitioning and the resulting bioaccumulation potential in air-breathing organisms. For substances which are currently known to be "model-difficult" (e.g., ionizing chemicals, perfluorinated substances) bioaccumulation is unlikely to be driven by partitioning to organic phases such as lipid. Further research in this area is needed. Environment Canada is following such research and is considering its implications for future assessments on existing substances in Canada.

MP3 Effect of a novel mercury chelator on mercury excretion and distribution in rats exposed to inorganic mercury. P. Williamson, R.A. Buchanan, Arkansas BioSciences, Arkansas State University, Jonesboro, AR; N. Gupta, Department of Chemistry, University of Kentucky, Lexington, KY; D. Clarke, R. Hannigan, Environmental Sciences, Arkansas State University, Jonesboro, AR; L. Beale, Forensics, Arkansas State University, Jonesboro, AR. A novel mercury chelator has been developed with binding characteristics such that it is suitable for use in ameliorating environmental mercury contamination and mercury poisoning. An animal study was conducted to test the efficacy of this chelation agent in ameliorating the deleterious effects of

inorganic mercury in rats exposed to HgCl_2 . The two aims of the project were to determine whether treatment with this chelator altered the excretion rate of Hg; and the effect of treatment with the chelator on the distribution of Hg *in vivo*. Four treatment groups (n=10 animals per group) were used. Group 1 (control) was not exposed to Hg and was not treated with chelator. Group 2 was injected with 3mg/kg body weight HgCl_2 . Group 3 was given the same dose of HgCl_2 , but was injected with the chelator in 10 fold mol/mol excess ($\sim 100\mu\text{M}$). Group 4 was given the same dose of chelator, but was not exposed to Hg. Animals were injected on day one, urine and feces samples were taken twice daily for 5 days. On day six animals were euthanized and liver, brain, kidney, peritoneal and epididymal fat pad were removed and immediately frozen (in liq N_2). Frozen samples were stored and -80°C before being digested (in ultrapure HNO_3 and H_2O_2) and analyzed for total Hg using a DRC II ICP-MS. Comparison of Hg content of urine and feces allowed effect of chelator on Hg excretion to be characterized. Measurement of the Hg content of organs from exposed and unexposed animals allowed total mercury distribution to be characterized. Comparison of Hg content of organs from treated and untreated animals allowed the effect of treatment with the chelator to be determined.

MP4 Cardiovascular Parameterization in Fish: Essential Information For Bioconcentration/Bioaccumulation Modeling. D. Huggett, E. Dzialowski, University of North Texas, Denton, TX. Current techniques for bioconcentration/bioaccumulation (BCF/BAF) modeling of contaminants in fish rely heavily, if not solely, on a compound's octanol-water partitioning coefficient (Kow). Extensive efforts are underway to incorporate and scale *in vitro* metabolism data into the current BCF/BAF models. A sensitivity analysis revealed that scaling of *in vitro* data is greatly influenced by cardiac output (CO) and net hepatic blood flow. These data are somewhat available for rainbow trout, but not readily available for other species such as common carp, channel catfish, fathead minnow, zebrafish and Japanese medaka. In addition, data are not available illustrating how these variables may change across age groups or temperature profiles. Cardiac output and hepatic flow (i.e. arterial and portal flow) will be presented for the species of interest.

MP5 Analysis of Polybrominated diphenyl ethers (PBDEs) in Human Placenta. P.S. Dassanayake, C. Chen, H. Wei, A. Li, Environmental and Occupational Health Sciences, University of Illinois at Chicago, Chicago, IL. Polybrominated diphenyl ethers (PBDEs), a widely used flame retardant in consumer products are significant indoor air pollutants. Pre- and neo-natal exposure of human to PBDEs occurs through contaminated maternal blood. Determination of placental concentration is important in investigations on cross placental transport of PBDEs. Elevated levels of PBDEs in human blood, breast milk and adipose tissue have been documented for the US populations but placental levels of PBDEs have not been reported to date. Present study aimed at optimizing the laboratory procedures of extraction, cleanup and analysis for the determination of PBDEs in human placental tissue. Liquid extraction and Soxhlet extraction was tested using swine placenta samples spiked with PBDE standard solution. Similar recovery was found for both extraction methods. In using the Soxhlet method, a combinations of acetone + hexane + dichloromethane (45:45:10) proved a better solvent mixture for the extraction. Appropriate duration of the extraction was tested for 24h, 48h and 72h. The lipid content of placenta was determined gravimetrically before the cleanup. Gel permeation columns (GPC) and multi-layered silica gel columns were used to remove lipid and other interferences. The lipid removal efficiency of GPC alone was 93%. Analyses of BDEs 28, 47, 66, 85, 99, 100, 153, 154 and 183 were performed on GC/MS using selected ion monitoring (SIM). BDE 47 showed the highest concentration in human placenta followed by BDEs 99, 28 and 153. Key words: human placenta, polybrominated diphenyl ethers, analytical method, gas chromatography/mass spectrometry

MP6 Analysis of perfluoroalkyl anion fragmentation pathways during LCMS: Evidence for fluorine migration prior to secondary and tertiary fragmentation. G. Arsenault, B. Chittim, A. McAlees, N. Riddell, Wellington Laboratories, Guelph, Ontario, Canada; R. McCrindle, Chemsitry Department, University of Guelph, Guelph, Ontario, Canada. It is known that under LC/ESI-MS/MS conditions, the $[\text{R}_\text{F}\text{CO}_2]^-$ anion first loses CO_2 to give a perfluoroalkyl anion R_F^- , $[(\text{M}-\text{H})-\text{CO}_2]^-$, which can subsequently fragment to give (inter alia) lower mass carbanions. It has been suggested in a previous study that such secondary fragmentation involves cleavage of CnF_{2n} segments. The objective of our study was to complete a more in-depth study on the fragmentation mechanism of perfluoroalkyl anions. Our analysis of the LC/ESI-MS/MS of a series of ^{13}C -labeled perfluoroalkyl carboxylic acids

(PFCAs) indicates that fragmentation of the R_F^- anion does not involve simple “unzipping” of a primary perfluoroalkyl anion of the type $F_3C(CF_2)_nCF_2^-$. For example, we have discovered that the secondary transition for the mass-labeled PFOA, perfluoro-1,2,3,4- $^{13}C_4$ -octanoic acid (MPFOA), gives two signals of equal intensity at m/z 169 and m/z 172. We propose a mechanism of fragmentation that involves rapid fluorine shifts, after the initial decarboxylation, which generate a series of new anions prior to secondary and tertiary fragmentation. The production of two product ions from a ‘single’ secondary transition of mass-labeled PFCAs may impact some work done in analytical labs since the response factors will be about half of those observed for the corresponding native PFCAs.

MP7 Possible matrix effect when using oxygen-18 labeled perfluorohexanesulfonate as a reference standard. N. Riddell, G. Arsenault, B. Chittim, A. McAlees, Research Division, Wellington Laboratories, Guelph, Ontario, Canada; R. McCrindle, Chemistry Department, University of Guelph, Guelph, Ontario, Canada. Perfluorohexanesulfonate (PFHxS) is a known residual by-product found in PFOS-related products. It has also been reported that PFHxS is produced and used as a building block for compounds incorporated into fire-fighting foams and specific post-market carpet treatment applications. Many laboratories are now seeking to identify and quantitate PFHxS in a variety of samples. The availability and use of mass-labeled perfluoroalkylsulfonate standards should prove to be of great benefit in enhancing the reliability of the resulting data. $^{13}C_4$ -PFOS, $^{18}O_2$ -PFOS and $^{18}O_2$ -PFHxS have recently been introduced as potential mass-labeled reference standards. When the mass-labeled atoms are “hidden inside” the molecule, as is the case of carbon-13 in ^{13}C -labeled compounds, such compounds exhibit essentially identical physical characteristics as those of the native homologues. However, when the mass-labeled atoms in a compound are “exposed” to the physical environment, such as in deuterated compounds, it is known that the physical behavior of these compounds is affected. For example, shorter retention times are observed during GC analysis. In the case of ^{18}O -labeled sulfonates, the oxygen-18 atoms are exposed to their environment and this led us to question the impact this might have on their physical properties and the possible consequences, if any, during LCMS analyses. The objective of this work was to evaluate potential problems when sodium $^{18}O_2$ -perfluoro-1-hexanesulfonate ($^{18}O_2$ -PFHxSNa) is used as a standard during LCMS analysis. When $^{18}O_2$ -PFHxSNa is used as an internal standard for LC-electrospray ionization-MS (LC/ESI-MS) analysis, the actual and theoretical concentration ratios closely match those for related native sulfonates as long as they do not co-elute. However, when they do co-elute, the peak intensities of the native species are enhanced by about 5%, while those of the labeled compound are suppressed by a similar amount. If this effect were not taken into account, the apparent concentration of the native compound would be inflated by 10%. This observation is possibly due to differences in the ability of ^{18}O versus $sup>16O$ to ion-pair and solvate in the droplets formed during the electrospray process.

MP8 Determination of Relative Response Factors and Matrix Effects on Quantification of Perfluorinated Compounds. J. Naile, J. Khim, P.D. Jones, Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; J.P. Giesy, Department of Biomedical Veterinary Sciences and Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; J.P. Giesy, Zoology Department, Center for Integrative Toxicology, National Food Safety and Toxicology Center, Michigan State University, East Lansing, MI. Perfluorinated compounds (PFCs) are widely distributed in the environment. Accurate and precise measurement is essential for effective decisions regarding the production and usage of PFCs. The methods for identifying and quantifying PFC are relatively new and changing rapidly. Many issues such as un-pure standards, synergistic effects between isotopically labeled and unlabeled analytes, and the presence of multiple isomers make accurate and precise measurement of PFCs exceedingly difficult. It has been reported that the relative response factors of isotopically labeled standards and unlabelled standards of the same PFC could be different. Individual 10 ppb (ng/mL) solutions of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) were supplied to the University of Saskatchewan by the 3M corporation and were analyzed using LC/MS/MS under negative ion electrospray to detect any impurities present down to 0.05 to 0.1% relative to the major component. Standard solutions of unlabeled and isotopically labeled materials were analyzed to compare response factors of isotopically labeled analytes versus its non-labeled counterpart in three different matrices at equivalent concentrations: organic solvent (methanol),

serum extract, and water. Standards were reanalyzed this time with an isotopically labeled analyte concurrently present in the solvent, serum extract, and water with its non-labeled counterpart at the same concentration. This allowed for determination of possible interactions. Standard solutions of PFOS and PFOA were quantified using calibration curves prepared from standards consisting primarily of linear standards only. This verified that the response factors of isomer peaks are equivalent to the linear peaks and that 3M-produced materials can be accurately quantified using the linear only standards when using the appropriate mass transitions.

MP10 Differential Effects of Environmental Chemicals and Selected Pharmaceuticals on Aromatase Activity. E.B. Higley, M. Hecker, J.L. Newsted, J.P. Giesy, Michigan State University, East Lansing, MI; M. Hecker, J.L. Newsted, Entrix, Inc, Okemos, MI; J.P. Giesy, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Due to concerns about potential disruption of endocrine processes by chemicals, the role of aromatase in the growth and reproduction has been investigated. In the current study, seven chemicals (atrazine, prometon, ketoconazole, aminoglutethimide, fadrozole, prochloraz and forskolin) with different primary modes of action on steroidogenic systems were tested to determine their differential effects on aromatase activity (AA) as measured by the tritium release assay in H295R adrenal carcinoma cells. Three studies were conducted: (A) Cells were exposed to each chemical for 48h and aromatase was evaluated without addition of chemicals to the assay; (B) Cells were exposed as in A but the chemical was also added to the aromatase reaction; and (C) the chemicals were added to unexposed cells during the assay only. Atrazine and forskolin increased aromatase activity when cells were exposed prior to the initiation of the assay but there was no change in aromatase activity when these compounds were added directly to the enzymatic assay. Prometon and aminoglutethimide increased aromatase activity after exposure for 48 h but decreased aromatase activity when cells were exposed directly in the assay. Exposure to fadrozole and prochloraz of up to 0.1 μ M resulted in an increase of aromatase activity but at greater concentrations enzyme activities gradually decreased. Direct addition of fadrozole and prochloraz to the assay resulted in decreased aromatase activity for all doses tested. Aromatase enzyme activity was increased by over 12-fold in cells exposed to ketoconazole. However, when ketoconazole was added directly to the assay there was a slight increase in aromatase but at greater concentrations aromatase enzyme activities started to decrease again. The chemicals tested could be grouped into three categories based on their specific interaction with aromatase activity in H295R cells.

MP11 Automated Solid Phase Extraction of Sulfonyl Ureas and Related Herbicides in Fortified and Natural Water Samples from Ontario and Quebec Region using LC-ESI/MS/MS. S.J. Cagampan, J.M. Grabuski, J. Struger, Environment Canada, Burlington, Ontario, Canada; B. Rondeau, Environment Canada, Montreal, Quebec, Canada. The identification and determination of sulfonyl ureas and related herbicides have presented a challenge when using conventional analytical techniques. Recent advances in solid phase extraction (SPE) technology combined with liquid chromatography tandem mass spectrometry (LC/MS/MS) have greatly improved this process. Hence, analytical techniques and supporting instrument and method detection limits have been determined on fortified water samples and the applicability of the analytical method on approximately 100 natural water samples from urban, rural and Great Lakes regions were investigated. Nine sulfonylureas and six related herbicides in water were simultaneously extracted by an automated Autotrace SPE Workstation. The 800mL fortified and natural water samples were loaded onto a Oasis HLB cartridge at a flow rate of 5mL/min, dried with nitrogen for 10 minutes, eluted with 8 mL of methanol and concentrated to 1 mL for analysis by LC-ESI/MS/MS. Recoveries of spiked method blanks were 96% or higher for all compounds except rimsulfuron that recovered at 60% for a sample set of $n=12$. Instrument detection limits ranged from 0.33 to 9.88 pg/ μ L and method detection limits ranged from 0.7 to 22.0 ng/L.

MP12 Development of Sulfonamide and Fluoroquinolone ELISAs For the Monitoring of Ground and Surface Waters. F.M. Rubio, J. Church, L. Kamp, R. Slawewski, Abraxis LLC, Warminster, PA; W. Shelper, USDA-ARS, Fargo, ND. Sulfonamide and fluoroquinolone compounds are common chemotherapeutic agents used in veterinary and human medicine to treat bacterial and protozoa infections. Because of their widespread usage, these antibiotics are released into the aquatic environment via wastewater effluent and agricultural runoff as a result of incomplete metabolism, ineffective removal or improper disposal. Sulfonamide and Fluoroquinolone ELISAs for

the monitoring of waters have been developed. The sulfonamide ELISA has a limit of detection below 20 parts per trillion, the fluoroquinolone ELISA has a limit of detection below 50 parts per trillion. No sample pre-concentration or clean up is needed. The within and between day variation were below 15%. The ELISA results were confirmed with results obtained from q-TOF-LC-MS/MS.

MP13 Antibacterial Compounds in Environmental Reference Materials. A.M. Peck, Skidaway Institute of Oceanography, Savannah, GA. Triclocarban and triclosan are antibacterial compounds used in a variety of personal use and household products. The occurrence of triclosan in water and sediments in the aquatic environment has been well established. Methyl triclosan, the primary metabolite of triclosan, has also been documented in biota and sediment. While the use of triclocarban is similar to that of triclosan, there has been relatively little work on its environmental fate and occurrence. Methods for the analysis of these compounds in sediment and sludge have been developed. These methods and their application to several National Institute of Standards and Technology (NIST) Standard Reference Materials (SRMs) will be described.

MP14 Effects of estrogenic compounds on *Melosira varians*, a common component of the aquatic primary production community. J. Stepanek, M.L. Julius, Biological Sciences, St. Cloud State University, St. Cloud, MN. Estrogenic compounds have been discovered in many surface water samples in many anthropogenically altered surface waters. Wastewater effluent is identified as a major pathway of contamination and found to revert much of the metabolic products of these biologically active compounds back to their original form. This presentation explains methodology for determining exposure effects through a newly developed bioassay, examining the physiological response of a diatom to these compounds. Diatoms represent an important aspect of the primary production community. They are a desirable food source over other members of the primary production community through storage of photosynthetically produced sugars in the form of lipids rather than starch. Therefore, members of higher trophic levels selectively feed on diatoms when present with other members of the primary production community. This study examines the effects of 17β -estradiol, ethylene estradiol, and estrone on the physiological development of the diatom species *Melosira varians*. Clearly, unicellular protists such as diatoms are not susceptible to these contaminants in a manner directly analogous to that expressed in vertebrates. However, these estrogenic are lipophilic making them particularly effective in entering the diatom cell membrane. This diatom was selected because it commonly occurs in most freshwater environments and has been the subject of other toxicological studies. An adequate literature base also exists for evaluating results of this experiment. The species grows rapidly and is easy to maintain in culture. Comparing cell density, chlorophyll A, and lipid content in control and exposed cultures allowed the development of a dose response to compound concentrations. The use of a phytoplankton species as a test organism complements other investigations involving vertebrate models at or near the apex of the trophic hierarchy by considering effects at the base of the food web.

MP15 A Phylo-chip for Analysis of Eukaryotic Microbes in Complex Communities. J. Magnuson, S. Baker, J. McDermott, J. Collett, Pacific Northwest National Laboratory, Richland, WA. A high density microarray for the analysis of eukaryotic microbes has been constructed using ribosomal RNA genes as probes. The taxa included on the microarray include the fungal kingdom, phylum chlorophyta (green algae) and phylum bacillariophyta (diatoms). The microarray is intended to be broadly useful for the assessment of the complex eukaryotic microbial communities present in terrestrial ecosystems from soils to aquatic sediments. Periphyton communities collected from the Columbia River in southern Washington State have been grown in the laboratory using a flow-through fresh water system. The phylo-chip has been used to assess the eukaryotic community present in this periphyton. The power and limitations of the microarray approach in general and the current generation phylo-chip specifically will be discussed.

MP16 Assessment of spatial recovery of toxic industrial effluent using algal bioassay, changes in algal communities, and chemical characteristics. M.I. Abdel-Hamid, E.I. Abdelaal, Y.A. Azab, Botany Department, Faculty of Science, Mansoura University, Mansoura, Dakahlia, Egypt. The spatial toxicity recovery of an alkaline ammonia rich industrial effluent was assessed along a wastewater receiving drain. Wastewater samples were collected at different sampling stations located downstream the effluents outlets.

Assessment tools include qualitative and quantitative analyses of periphyton and phytoplankton, photosynthetic pigments, ash-free dry weight, some quality-relevant chemical parameters (e.g. N, P, BOD, Cd, Co, Cu, Ni, Pb, Zn, Pb) in addition to standard algal toxicity tests using the ISO standard test alga *Pseudokirchneriella subcapitata*. Diatomic index, trophic diatom index, compound eutrophication index, Shannon-Wiener diversity index, and saprobic index were calculated for both periphytic and planktonic algal communities and were employed for the biological assessment of spatial improvement in wastewater quality. Data of chemical analyses were used to calculate the water quality index (WQI). Toxicity figures were calculated from dose-response curves of algal biotests and were reported as EC_{50} . Spatial changes in diversity index and WQI indicated progressive improvement of wastewater quality. Values of EC_{50} revealed obvious spatial downstream reduction in effluent toxicity. Biological indices and the biomass development of the indicator algal species gave quality consequence congruent with that revealed by the chemical characteristics

MP17 Rapid detection of aquatic toxins using chlorophyll fluorescence in microalgae. C. Choi, J.A. Berges, E.B. Young, Department of Biological Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI. Unicellular algae are important model organisms for testing of aquatic toxins, but standard growth bioassays require cultures to be monitored over a several days. In contrast, use of *in vivo* chlorophyll fluorescence parameters could provide rapid detection of dissolved chemicals toxic to algal photosynthesis. We compared the relative sensitivity of freshwater microalgae to aquatic toxins using a pulse-amplitude modulated (PAM) fluorometer. Several species representing five major freshwater phytoplankton groups (diatoms, chlorophytes, cryptophytes, chrysophytes and cyanobacteria) were tested for the effects of short-term exposures to a range of toxins important for water quality and ecosystem health. Using chlorophyll fluorescence, we monitored declines in quantum yield of photosynthesis (F_v/F_m) over 80 min after exposure to a range of toxin concentrations. Toxins tested included triazine herbicides (atrazine, metribuzin, terbuthylazine), organophosphate insecticides (carbamate, carbofuran, malathion, methyl parathion, phosdrin (mevinphos)), potassium cyanide (KCN), diuron (DCMU), glyphosate and paraquat. Photosynthetic quantum yield was sensitive to most toxins except organophosphate insecticides. Diatoms were 5 times more sensitive to the herbicide glyphosate than the commonly used test green alga, *Pseudokirchneriella subcapitata*. Chrysophytes and cryptophytes were more sensitive to KCN than other groups. All groups showed significant sensitivity to triazine herbicides and DCMU, however did not show general sensitivity to organophosphate insecticides. For example, phosdrin has a 24 h LC50 in fish of $0.04 \mu\text{g ml}^{-1}$ but no effects were detected using algal fluorescence at $500 \mu\text{g ml}^{-1}$. Algal and cyanobacterial fluorescence-based photosynthetic quantum yield could provide rapid detection of herbicides in aquatic systems. However, there is no single taxon which is the most sensitive to all classes of toxins, and sensitivity of natural phytoplankton assemblages to toxic contamination will likely depend on species composition.

MP18 Atrazine Increased Citric Acid Cycle Activity in the Freshwater Mussel, *Elliptio complanata*. E.M. Ciummo, K. Flynn, Biology, Adelphi University, Garden City, NY; K. Flynn, Environmental Studies Program, Adelphi University, Garden City, NY. Atrazine is the most commonly used herbicide in the United States, with 80 million pounds applied to food crops and lawns each year. It's a suspected endocrine disrupter which may have estrogen-like activity and ultimately include effects on metabolism. Laboratory-acclimated adult freshwater mussels (*Elliptio complanata*) were exposed to atrazine at 1.5, 15, or 150 micrograms per liter for one 7 day trial. These concentrations are 0.1, 1, and 10 times the U.S. Environmental Protection Agency's allowable concentration. Eight animals were in each atrazine tested group, 8 in EtOH (negative control), and 8 in estradiol (positive control). During exposure, behavioral data was collected, and the animals were sacrificed and frozen at -80 C for a month. Assays of citric acid cycle activity were performed in one day; the mussels were defrosted, homogenized separately and centrifuged for 1 minute at 1000rpm, and then 10 minutes at 3000rpm. 150 microliters of mitochondrial suspension was pipetted into a 2.5 milliliter solution containing 150 microliters of DCPIP, 1.9 milliliters sucrose-phosphate buffer, and 300 microliters of succinate. DCPIP accepts electrons released by succinate in step 6 of citric acid cycle and changes color from dark to light blue. A spectrophotometer is used to record percent transmission through the DCPIP mixture at 5 min intervals for 30 minutes, % difference was taken from time zero for each animal. Results were

analyzed by 2way ANOVA with time and treatment as factors, followed by a Games-Howell post hoc test. The effect of atrazine treatment of citric acid cycle activity was ($p < .0001$) with estradiol and high and low concentrations of atrazine-exposed mussels all showing more activity compared with the negative control ($p < .02$). High atrazine exposed was 100% higher, estradiol 112% higher and the low atrazine exposed 158% higher than control. Results suggest ecologically relevant atrazine increases metabolic activity of the bivalve organism and also increases citric acid cycle oxidation of succinate. We may speculate the behavioral pattern of inability for mussel to burrow may be linked with unnecessary high output of energy due to high and low concentrations of atrazine.

MP19 Bioaccumulation and distribution of brominated flame retardants and current use pesticides in an Arctic marine food-web. A.D. Morris, S.K. Sturman, K.R. Solomon, Environmental Biology, University of Guelph, Guelph, Ontario, Canada; A.D. Morris, D.C. Muir, S.K. Sturman, C. Teixeira, Aquatic Ecosystem Protection Research Directorate, Environment Canada, Burlington, Ontario, Canada. Persistent organic pollutants (POPs) and pesticides can be distributed globally by several vectors including atmospheric and oceanic currents and by particle-mediated transport. Recently, brominated flame retardants (BFRs) such as polybrominated diphenyl ethers (PBDEs), and hexabromocyclododecane (HBCD) have been detected in polar bears (*Ursus maritimus*) and ringed seals (*Phoca hispida*), while current use pesticides (CUPs) endosulfan, dacthal, and chlorothalonil have been reported in seawater, snow, and in Arctic air. We investigated the potential pathways for bioaccumulation of several BFRs and CUPs in the Canadian Arctic by sampling key components of the arctic marine food-web; ocean water (dissolved and particulate), under ice-algae, crustaceans, arctic cod (*Boreogadus saida*), and ringed seals. Sampling was conducted in Lancaster Sound (Nunavut, Canada) during June, a period of ice-melting and high primary productivity in the upper ocean waters. Additional sub-sampling was performed on ringed seals in order to investigate the tissue-specific accumulation of pollutants in this animal. Several BFRs including PBDEs, HBCD, and pentabromoethylbenzene were detectable in seals and fish but near or at detection limits in sea water, and algae. Several CUPs, including endosulfan, and dacthal, were present in seawater and in invertebrates but near detection limits in fish and seals. The relevance of these results will be discussed.

MP20 Stereoisomer quantification of polychlorinated biphenyl methylsulfone metabolites by chiral high performance liquid chromatography-tandem mass spectrometry. V.I. Cooper, C.S. Wong, Department of Chemistry, University of Alberta, Edmonton, Alberta, Canada. A high performance liquid chromatography tandem mass spectrometry method (HPLC-MS-MS) was developed for the separation and detection of chiral *meta*- and *para*-substituted methylsulfonyl polychlorinated biphenyl (MSCB) metabolites. These compounds possess a bioaccumulative potential similar to their parent polychlorinated biphenyls (PCBs) and have been detected widely in several animal species, including humans. However, relatively little is known about their toxicology and effects, particularly for individual stereoisomers. Gas chromatography (GC) has generally been used to separate MSCBs, but the run times are prohibitively long, and some MSCB enantiomers are extremely difficult to separate on many chiral GC columns. HPLC has recently been investigated as an alternative method for the separation of PCB metabolites, including chiral MSCBs on a semi-preparative scale. We have developed an HPLC method employing tandem MS detection in multiple reaction monitoring mode for the quantification of MSCB enantiomers. Atmospheric pressure photoionization (APPI) and atmospheric pressure chemical ionization (APCI) were examined as ion sources due to their demonstrated efficacy for the ionization of non-polar compounds. For the APPI source, photoionization was accomplished using a Kr lamp, and several dopants were explored, including toluene and acetone. The MSCBs all formed $[M-Cl+O]^+$ as the dominant ion in the first quadrupole and $[M-MeSO_2Cl+O]^+$ as one of the daughter ions in the third quadrupole with toluene as the dopant. However, the pattern and efficiency of daughter ion formation appears to depend on the positions of the methylsulfonyl and chloro substituents. A published, semi-preparative, reversed-phase method using methanol-water as the mobile phase was used as the starting point in HPLC method development. The mobile phase composition, pH, flow rate and column temperature were optimized in order to achieve maximum enantioselectivity and separation efficiency. Several chiral columns, including Nucleodex β -PM⁺, were also examined. GC-MS analysis by existing protocols

was applied for validation purposes. Preliminary results suggest that our HPLC-based method may be a viable alternative to current GC-based techniques for MSCB stereoisomer quantification.

MP21 Toxicogenomic cDNA library construction for sheepshead minnow, *Cyprinodon variegatus*. J.A. Roling, A.E. Pozhitkov, R.A. Ryan, L.A. Hendon, A.J. Dangre, N.J. Brown-Peterson, M. Brouwer, Gulf Coast Research Lab, University of Southern Mississippi, Ocean Springs, MS; Y. Deng, Biological Sciences, University of Southern Mississippi, Hattiesburg, MS; B.J. Carter, EcoArray Inc., Alachua, FL. We have sequenced over 10,000 *Cyprinodon variegatus* cDNAs to produce an extensive collection of genes that will potentially aid in developing a molecular monitoring device for pollutant and anthropogenic stressors. Genes were isolated from adults, larvae, or embryos after suppression subtractive hybridizations (SSH) following a toxicant exposure to cadmium, chromium, copper, or pyrene. SSH also identified genes in response to chronic hypoxia (DO less than 1.5 mg O₂/L) or cyclic hypoxia (8 to 1.5 mg O₂/L). Thus far, we have identified 1000 contigs consisting of 2 or more overlapping sequences making a total of 4000 unique sequences. Analysis of overlapping contigs reveal only a few (3 ribosomal proteins, apolipoprotein, and a predicted protein) that overlap all three oxidative metals in this study. This small group of overlap indicates a unique toxicogenomic fingerprint of gene expression may be possible for contaminants of a similar mechanistic class. There was also a low proportion (less than 20%) of the contigs that overlap between cyclic hypoxia and chronic hypoxia, indicating a potentially different mode of action. Those genes that were isolated in both hypoxia exposures include 15 different ribosomal protein subunits, aldolase A and B, and cytochrome c oxidase. Further, many contigs appear to be age specific with little overlap between life stages. For example, of the 857 genes that were identified in pyrene exposures, only 10% overlapped two life stages. Finally, when the genes that were differentially expressed in females relative to males are compared to the toxicant response libraries, there was a significant overlap with the copper exposure. This overlap of vitellogenin, zona radiata-2, and choriogenin H may indicate a female-specific response to toxicant exposure. The next step is to manufacture an oligo microarray to measure differential gene expression to stressors produced in the laboratory or in the field. Supported by NOAA NA05NOS4261163.

MP22 Comparison of in vivo and in vitro chemical screening assays for estrogen-responsive protein biomarker expression in the Sheepshead Minnow (*Cyprinodon variegatus*). S.S. Vickery, P.S. Harris, K. Salinas, C. Walker, M. Hemmer, US EPA, Gulf Breeze, FL; J. Ng, Student Services Contractor, Gulf Ecology Division, Gulf Breeze, FL. Animal welfare concerns and the high cost associated with in vivo chemical screening methods have prompted efforts to develop highly specific and sensitive in vitro techniques to evaluate chemicals for endocrine activity. Diagnostic biomarkers developed using in vitro methods should be associated with expression of identical biomarkers, specific toxicity pathways, or adverse effects in whole animal studies. In this study, a comparison of the presence and relative abundance of four estrogen-responsive protein biomarkers discovered in sheepshead minnows (SHM) plasma was made with protein expression in a SHM hepatocyte in vitro assay. Plasma from male SHM treated for 7 days to aqueous concentrations of 0.05, 0.1, 0.2, 0.5 and 1.0 μ g/L of 17 β -estradiol (E₂), and growth media from cultures of female SHM hepatocytes treated with media concentrations of 13.5 – 1,350 μ g E₂ /L for 4 days were examined using matrix assisted laser desorption and ionizations-time of flight (MALDI-TOF) mass spectrometry. Four estrogen-responsive protein biomarkers at 2950, 2978, 3003 and 3025 m/z were significantly elevated in both the in vivo and in vitro E₂ treatments although the hepatocyte media assay demonstrated a lower relative abundance of the four biomarkers. A clear dose associated increase in biomarker expression was evident with increasing E₂ concentration in both assay systems.

MP23 Metabolomics as a Tool for Discriminating Among Adaptive, Compensatory, and Toxic Responses Upon Exposure of Small Fish to EDCs. D.R. Ekman, T.W. Collette, Q. Teng, Ecosystems Research Division, U.S. Environmental Protection Agency, Athens, GA; G.T. Ankley, D. Martinovic, K.M. Jensen, D.L. Villeneuve, M.D. Kahl, Mid-Continent Ecology Division, U.S. Environmental Protection Agency, Duluth, MN. Determining the impact(s) of exposure on aquatic organisms by endocrine disrupting compounds (EDCs) is essential for determining the risks that these chemicals pose. However, to accurately evaluate these risks, beyond simply measuring a "before and after exposure" snapshot, researchers must assess the ability of the exposed organisms to adapt or compensate for the presence of

these compounds. The extent of true harm from sub-lethal exposure is often a complex relationship of both time and chemical concentration. Due to the large number of samples required to map this complex response profile, a robust molecular technique with low per-sample cost of analysis is desirable. Therefore, we have employed a metabolomics approach for studying these responses in small fish toxicity models (e.g., fathead minnow) using nuclear magnetic resonance (NMR) spectroscopy. This approach provides the ability to measure molecular responses in different tissue and biofluid types, both rapidly and inexpensively, making it ideal for this application. Using this approach, we have been able to observe apparent compensatory responses to the presence of EDCs over the duration of an exposure. Furthermore, it appears that after the chemical has been removed from the water (i.e. during a depuration phase) that fish are able in some cases to return to a near "pre-exposure" state, providing evidence of partial recovery once the chemical has been removed. These results demonstrate the potential of this approach for improving the assessment of risk(s) that various EDCs pose to sentinel small fish species. Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

MP24 Use of *Daphnia* genomics for aquatic ecotoxicology. H. Watanabe, T. Iguchi, National Institutes of Natural Sciences, Okazaki, Japan; N. Tatarazako, S. Oda, National Institute for Environmental Studies, Tsukuba, Japan. Toxic chemical contaminants have a variety of detrimental effects on various species, and the impact of pollutants on ecosystems has become an urgent issue. However, the majority of studies of chemical contaminants effects have focused on vertebrates. Among aquatic organisms, *Daphnia magna* has been used extensively to evaluate organism and population-based responses of invertebrates to pollutants, using acute toxicity or reproductive toxicity tests. Although these types of tests can provide information on hazardous concentrations of chemicals, they provide no information about their mode of action. Recent advances in molecular genetic techniques have provided tools to better understand the responses of aquatic organisms to pollutants. In this study, we adapted some of the techniques of molecular genetics to develop new tools, which form the basis for an ecotoxicogenomic assessment of *Daphnia magna*. Based on a *Daphnia* expressed sequence tag (EST) database, we developed an oligonucleotide-based DNA microarray having 10,000 genes. The DNA microarray was used to examine gene expression profiles of neonate daphnids exposed to several different chemicals: copper sulphate, hydrogen peroxide, pentachlorophenol or beta-naphthoflavone. Exposure to these chemicals resulted in characteristic gene expression patterns that were chemical-specific, suggesting that the *Daphnia* genomics is useful for aquatic ecotoxicology.

MP25 Developmental Gene Expression Within and Among Natural *Fundulus* Populations. G. Bozinovic, Environmental and Molecular Toxicology, North Carolina State University, Raleigh, NC; M. Oleksiak, Rosenstiel School of Marine & Atmospheric Sciences, University of Miami, Miami, FL. Populations of the teleost *Fundulus heteroclitus* inhabit heavily contaminated sites and have adapted to the pollutants present in their environment. We are analyzing patterns of gene expression in developing *Fundulus* embryos adapted to these sites to better understand the effect of pollution during sensitive developmental stages. Changes in gene expression can be used as a sensitive and measurable endpoint of toxicity and are thought to be an important factor in adaptation to environmental changes that may underlie phenotypes necessary for developing resistance. Preliminary analysis of metabolic genes expression during late organogenesis revealed significant differences among reference, polluted, and hybrid embryo populations. In addition, significant differences in heart rate and developmental delays were observed in Superfund embryo populations. Analyses of gene expression in these *Fundulus* embryos clarify the roles of polygenic responses and gene-gene interactions important for adaptation to polluted environments during critical life stages of a developing organism.

MP26 Effects of Fluoxetine Exposure on Genes that Influence the Developing Vertebrate Neural Circuitry. A. Schmoldt, R.D. Klaper, A.J. Udvadia, Biological Sciences & Great Lakes WATER Institute, University of Wisconsin - Milwaukee, Milwaukee, WI; A. Schmoldt, R.D. Klaper, A.J. Udvadia, Great Lakes WATER Institute, University of Wisconsin - Milwaukee, Milwaukee, WI. Antidepressant pharmaceuticals released into the environment from sewage treatment facilities can result in inadvertent, chronic low-level exposure of freshwater vertebrates, as well as in the exposure

of children and nursing mothers through the detectable levels of these drugs found in municipal water supplies. The short and long-term consequences of such unintended psychopharmaceutical exposures on the developing vertebrate nervous system are largely unknown. We are particularly interested in the effects of SSRIs (selective serotonin reuptake inhibitors) on processes such as axon growth and synaptogenesis in developing vertebrates. While these drugs are designed to target neurotransmitter systems that regulate mood, new research suggests that many of these drugs can enhance neurogenesis and/or neurite outgrowth in cultured neurons. In order to investigate the effects of early SSRI exposures on vertebrate nervous system wiring, we are using zebrafish as a model organism to determine how developmental exposure to fluoxetine, a commonly used SSRI, affects genes expressed in neurons undergoing axon growth. Using quantitative PCR, we have observed a significant effect of a 2-day developmental exposure of fluoxetine on a known axon growth regulatory gene, *gap43* (growth associated protein 43). We have also recently generated a library of cDNA sequences that are enriched in neurons undergoing axon growth and synaptogenesis in the developing zebrafish, on which we are also studying the effects of early fluoxetine exposure. Our preliminary analysis indicates, that in addition to *gap43*, several genes encoding different components of intracellular signaling cascades in neurons are affected by early exposure to fluoxetine. Even subtle misregulation of genes involved in axon growth and guidance during development could have a significant impact on the proper formation of neural circuits, and hence on learning, memory, behavior and emotion. Our future studies will test this hypothesis by functionally characterizing genes that are perturbed by fluoxetine exposure using cell biological and behavioral assays.

MP27 Non-reproductive effects of 17 α -ethinylestradiol in zebrafish. E. Notch, G. Mayer, Biochemistry, Microbiology & Molecular Biology, University of Maine, Orono, ME. Significant attention has focused on pharmaceutically derived compounds and their metabolites in the aquatic environment. One class of pharmaceutically derived compounds that have emerged as salient aquatic toxicants are hormones, such as 17 α -ethinylestradiol (EE₂) the major component of oral contraceptives and hormone replacement therapies. Ethinylestradiol and other estrogen mimics have been implicated in reduced reproductive fitness of aquatic organisms. In contrast to well-delineated reproductive effects of estrogens on aquatic organisms, less is understood about non-reproductive effects. Despite known carcinogenic effects of estrogens including attenuation of nucleotide excision repair (NER) in human cells, no previous research has examined effects of estrogens on DNA repair in aquatic organisms. We exposed adult zebrafish (*Danio rerio*) to EE₂ for seven days to examine disruption of non-reproductive cellular processes, particularly nucleotide excision repair. Using fluorescence based quantitative RT-PCR we examined effects of EE₂ on hepatic mRNA abundance of multiple NER genes. NER is the primary DNA repair pathway responsible for removing bulky DNA adducts formed by ubiquitous environmental mutagens. EE₂ exposure decreased hepatic transcript of nucleotide excision repair genes in adult male and female zebrafish at environmentally relevant concentrations. Further studies showed that EE₂ exposure does significantly reduce bulky adduct repair capacity in zebrafish liver cells. Failure to remove DNA adducts leads to higher incidence of somatic mutations, potentially resulting in genomic instability or neoplasia. This novel finding indicates synthetic estrogens may play a role in environmental carcinogenesis by potentiating the effects of environmental mutagens.

MP28 Comparison of Genetic Diversity in Mouse Populations Historically Exposed to Polycyclic Aromatic Hydrocarbons. J.K. Leet, M. Kovach, J. Shaw, S.M. Richards, Biological and Environmental Sciences, University of Tennessee at Chattanooga, Chattanooga, TN. Chattanooga Creek flows from northern Georgia through southern Chattanooga, TN to the Tennessee River. This creek has been the site of industrial dumping for over 100 years, particularly the dumping of coal tar. Polycyclic aromatic hydrocarbons (PAHs) and other contaminants from this coal tar have been found in South Chattanooga, and are bioavailable to mammals in the area. Theoretically, mice living in the contaminated area have been exposed for hundreds of generations. Exposure could result in three types of effects on this mammalian population: (1) an increase in advantageous mutations, (2) an increase in deleterious mutations, or (3) death of individuals in each generation from the toxicity of the contaminants. An increase in heterozygosity in the contaminated population would demonstrate that advantageous mutations might be occurring due to contaminant exposure, causing an increase in genetic diversity. Conversely, reduced heterozygosity

may suggest a bottleneck effect due to either deleterious mutations or death of individuals from contaminant exposure. An increase or decrease in genetic diversity would be a definitive indicator of population-level effect. The purpose of this study is to evaluate genetic diversity as measured by microsatellite heterozygosity among white-footed mouse (*Peromyscus leucopus*) populations in the South Chattanooga area. Mice were collected from four contaminated sites in South Chattanooga (20 samples from each site) and an uncontaminated reference site in northern Georgia (40 samples). The observed allelic diversity for microsatellite marker PLGT66 ranged from 0.716 to 0.898 among the contaminated sites as compared to the 0.886 of the reference site. We are currently working on a combined analysis of genetic diversity with additional microsatellite markers that will contribute to an understanding of the mechanism by which PAH exposure influences the genetic diversity of mammalian populations.

MP29 Modeling the influence of climate change on the global distribution of persistent organic pollutants. M. MacLeod, H. von Waldow, M. Scheringer, K. Hungerbühler, Swiss Federal Institute of Technology, Zürich, Switzerland. We have applied the BETR Global contaminant fate and transport model to analyze the effects of a climate change scenario on the global distribution pattern and overall residence time of persistent organic pollutants released from three locations in the Northern Hemisphere. The BETR Global model describes the global environment as a set of connected regions on a 15 degree grid. Within each region the fate of pollutants is modeled using a seven-compartment fugacity-based multimedia contaminant fate model. The regions are connected by flows of air in two atmospheric layers, freshwater and ocean water. Two environmental scenarios have been defined by loosely-coupling the BETR Global model to results from the atmosphere-ocean general circulation model ECHAM5/MPI-OM, which is one of the models used in the consensus reports prepared by the Intergovernmental Panel on Climate Change. Key environmental inputs examined in this work are temperature, rainfall rate, atmospheric wind fields and ocean circulation currents. The first scenario represents current climatic conditions and was constructed by averaging ECHAM5 output from the 20th century control experiment (20C3M) for the period 1980 – 2000. The second scenario uses an average of predicted conditions for the years 2080 – 2100 under a moderately extreme climate change scenario (SRESA2). Results indicate that the extent of inter-continental transport of persistent organic pollutants increases under the climate change scenario, with more efficient transport from Asia to North America, from North America to Europe, and from Europe to Asia and Africa. However, the overall residence time of persistent organic pollutants in the global environment decreases under the climate change scenario because of assumed enhanced degradation at higher average temperatures. Model results for hypothetical combinations of partitioning properties illustrated in partitioning maps indicate that chemicals with Log octanol-air partition coefficient of about 7 are most strongly affected under the climate change scenario because their bulk partitioning between the surface and the atmosphere is sensitive to the anticipated temperature changes. Results of the current model analysis are broadly consistent with earlier modeling that used years with positive North Atlantic Oscillation (NAO) index as a surrogate to represent future conditions under a climate change scenario.

MP30 Chemical speciation of trace metals in fly ash from coal combustion as a tool for the environmental impact assessment of its applications and disposal. I. Twardowska, K. Janta-Koszuta, S. Stefaniak, Institute of Environmental Engineering, Polish Academy of Sciences, Zabrze, POLAND. Most of Potentially Toxic Elements (PTE) content in fly ash (FA) is about an order of magnitude higher than in the lithosphere. Its possible applications for different purposes or disposal may thus pose a risk to the environment, although total concentrations of PTE in waste do not necessarily reflect its potential for release to the environment. Metal mobility depends on the chemical form (phase) in which it occurs. The aim of this study was easy and reliable assessment of mobile/mobilizable PTE distribution, the mode of occurrence and mobility of trace elements in representative samples of freshly generated fly ash, 'pure' (FA) and with flue gas desulfurization solids after semi-dry desulfurization (FA+FGDS), with use of chemical speciation of metals by a 7-step sequential extraction. Total PTE concentrations extracted by the sequential extraction method were significantly lower than actual total concentrations of these elements in FA. Both FA and FA+FGDS appeared to display similar distribution of binding mechanisms and binding strength for metal ions in labile/mobilizable fractions, and showed

high enrichment of PTE in a residual fraction ($Pb > Zn > Cd > Ni > Cu$ and $Pb > Ni > Cd > Zn > Cu > Cr$, respectively). Most of Fe load in FA and FA+FGDS occurred as amorphous Fe-Oxam, (F4 fraction) that bound major part of Zn, Ni, Cu, Cr and Pb ions in labile/mobilizable fractions F0-F5; Ca and most of Mg ions in FA occurred in ion-exchangeable form, while in FA+FGDS they were represented by carbonate (F2) fraction that also readily bound Ni, Zn, Cu and Cr ions; Cd enriched easily reducible F3 (Mg-Ox), the most labile F0 (water-soluble) and F1 (ion-exchangeable) fractions. FA+FGDS appeared to contain somewhat higher concentrations of mobile/mobilizable PTE than 'pure' FA. Distinctly higher concentrations showed Zn, Pb and Ni; much higher was also content of Ca (9-fold) that was justified by the desulfurization process. To summarize, in freshly generated FA trace metals are highly enriched and strongly bound in residual fraction of FA that may lead to its wrong environmental impact assessment. Time-dependent transformations of FA (and FA+FGDS) should be strongly considered at FA use that has been proved by the results of monitoring studies.

MP31 Lack of complete exposure pathways for metals in natural and FGD gypsum. L.J. Yost, Health Sciences, Exponent, Saint Paul, MN; J.J. Noggle, Environmental Affairs, Georgia-Pacific LLC, Atlanta, GA; S.S. Shock, Environmental, Exponent, Bellevue, WA. Use of wallboard made from synthetic gypsum generated via flue gas desulfurization (FGD) by coal-fired power plants (FGD gypsum) has raised questions regarding metals concentrations in the gypsum, and the potential for exposure to these metals. A suite of 23 metals were analyzed in 74 samples of uncalcined gypsum, including samples from 15 facilities that use natural (mined) gypsum, and three that use FGD gypsum. A conceptual model was developed to evaluate potential human health exposure pathways within a wide range of possible uses of natural and synthetic gypsum wallboard. Maximum metals concentrations in gypsum were compared with background concentrations in soil and with conservative, health protective risk-based concentrations (e.g., EPA PRGs) in soil. Metals concentrations in natural and FGD gypsum products were largely consistent with background concentrations occurring naturally in soils, except antimony and selenium. These metals were both present in FGD gypsum at concentrations higher than background soil, but much lower than PRGs for residential soil. Further comparisons showed natural and FGD gypsum metals data were below screening values for leaching to groundwater and for protection of agricultural soils. Only arsenic was present in synthetic gypsum at concentrations greater than PRGs, but concentrations were not greater than those in background soil. Based on this screening, the potential pathways related to incidental ingestion, dermal contact and inhalation of particulates are considered to be incomplete and insignificant. Thus, trace metals in evaluated sources of natural and FGD gypsum do not appear to pose health concerns. While pathways associated with exposure to particulate dusts were ruled out in screening, no data were available to assess whether mercury in wallboard could volatilize into indoor air. Therefore, analyses of mercury volatilization were conducted and this pathway was also found to be incomplete (see companion abstract, Noggle et al.).

MP32 Preliminary Assessment of Coal Combustion Flue Gas Desulfurization Waste on Element Uptake by Maize (*Zea mays* L.). K.S. Sajwan, S. Ebanks, P. Sivapatham, S.K. Kurunthachalam, Department of Natural Sciences and Mathematics, Savannah State University, Savannah, GA; A.K. Alva, USDA-ARS, Prosser, WA. A greenhouse study was conducted to assess the feasibility of using flue gas desulfurization waste (FGD) as a soil amendment to grow maize. The FGD was collected from a coal fired power plant, located in Cope, South Carolina. The FGD was weathered by flushing it through water periodically for over a month. The Ogeechee loamy sand soil an initial pH of 5.5 used in this study was collected from Garden City, Georgia. The FGD was added at 0, 1, 2, 4, 6, 8, and 10% by weight to 6 Kg soil in polyethylene pots and mixed thoroughly. The experiment was arranged in complete randomized block design with three replications. Pots were incubated for two weeks at field capacity moisture content. At the end of two weeks incubation period pioneer corn seeds were planted in each pot. All the pots were watered daily throughout the growth period to maintain the field capacity moisture content. Leachate from each pot was collected once a week during a growth period of six weeks. At the end of the six weeks above ground plant parts were harvested, oven dried, and plant biomass recorded. Harvested plant samples as well as leachate samples from each treatment were analyzed for elemental composition. The results of this study indicated that biomass production significantly increased up to 1% of FGD application there after reduced significantly at higher levels of FGD application rates.

However, elements such as Cd and Pb in plant tissues increased up to 2% FGD application. Elements such as P and Cr decreased with increasing rates of FGD application. Based on the preliminary assessment, FGD could be used for the amendment of soil not exceeding 1%. However, further analysis for elements such as Se, As and B needs to be assessed prior to use as an agricultural amendment.

MP33 Uranium and cesium in bituminous coal and coal fly ash and their effects in the environment for twelve coal producing countries. A.B. Mukherjee, Biological and Environmental Sciences, University of Helsinki, Helsinki, FINLAND; R. Zevenhoven, Faculty of Technology, Abo Akademi University, Turku/Abo, FINLAND; K.S. Sajwan, Department of Natural Sciences and Mathematics, Savannah State University, Savannah, GA. Coal was brought to the forefront of global energy by the industrial revolution of the 19th century. Today coal is a major source of energy in developed and developing countries and it will continue to be so at least until the mid-21st century. Coal combustion releases trace elements and radio-nuclides, part of which is emitted to the environment. After the Chernobyl accident many countries are cautious with respect to radioactive pollution. Therefore, it is necessary to understand the behaviour of uranium (U), cesium (Cs) and other radionuclides during coal burning, the pollutant emissions and the utilization of coal fly ash. Radioactive decay for U-235 and U-238 is 7.1×10^8 yr and 4.5×10^9 yr, respectively. These species have been selected by the U.S. EPA as indicators of radionuclide risk for the environment. The U.S. Geological Survey (USGS) have also studied the mode of occurrence of trace elements and radionuclides in coal, suggesting that U is bound in both mineral and organic fractions. In this presentation, we will address the radionuclides uranium (238U, 235U) and cesium (137Cs) in coal and coal combustion by-products for major coal producing countries, and mechanism by which radionuclides enter a coal bed from groundwater. In addition, their discharge mechanism, accumulation in the environment, and their effect on human and animal health will also be discussed.

MP35 Comparison of Predicted vs Actual Partition Coefficient Results. D.M. Mullee, Analytical Services, Safepharm Laboratories, Derby, United Kingdom. With the forthcoming implementation of REACH the use of QSARs to predict various physico-chemical properties of new chemicals will become more prevalent. The partition coefficient (Kow) is considered to be a significant parameter for the prediction of the environmental fate of materials. Therefore, this parameter has been selected for the purpose of this study. The suitability of the KOWWIN program was assessed by comparing predicted Kow values against experimental results obtained from regulatory testing of new novel compounds.

MP36 An Overview of U.S. EPA's High Production Volume Challenge Program. J.G. Suski, R. Northrop, M. Sonawane, T. Henry, O. Hernandez, M. Townsend, Office of Pollution Prevention and Toxics/ Risk Assessment Division, U.S. Environmental Protection Agency, Washington, DC. U.S. Environmental Protection Agency (EPA) High Production Volume Challenge Program was officially launched in 1998. The objective of the program is to provide the public with knowledge of the potential hazards associated with High Production Volume (HPV) chemicals. With this information the public may make informed decisions related to human and environmental hazards of chemicals that they may encounter on a daily basis. HPV chemicals are defined as chemicals that are manufactured or imported in amounts equal to or greater than one million pounds per year. The program initially identified HPV chemicals through data reported under the Toxics Substances Control Act, Inventory Update Rule in 1990 and challenged U.S. manufacturers and importers to voluntarily sponsor listed chemicals. Once a chemical is sponsored, a suite of data or planned testing is submitted and the case is subsequently posted to the HPV Information System (HPVIS) on EPA's website. Each complete submission contains data on 18 internationally agreed to Screening Information Data Set endpoints that are used as screening-level indicators of potential adverse effects for humans or the environment. Briefly, endpoints are mammalian toxicity (i.e. acute and repeated exposures) aquatic ecotoxicity (fish, invertebrates and algae) physical-chemical parameters and environmental fate. Upon data submission, the HPV Challenge Program reviews the data for completeness and quality; EPA's comments are then sent to the sponsor and made publicly available through HPVIS. Frequently, EPA requests the Sponsor respond with a revised test plan and/or clarification of data submitted. Submitted data are used to characterize hazards in a tiered approach. Tier 1 is an automated process which prioritizes chemicals for review based on toxicity and environmental fate criteria.

Following prioritization, chemical specific data are reviewed in-depth and a screening level hazard assessment (Tier 2). EPA anticipates completing hazard characterizations for several chemicals in 2007 by designing a strategy to implement a systematic approach for completing the remaining HPV chemicals. Ultimately the hazard characterizations will be used along with exposure information to inform risk-based chemical management decisions.

MP37 Estimating No-Observed-Effect Concentrations and EC10s in Closed-System Algal Toxicity Tests. C. Chen, C. Yang, K. Tsai, Y. Wang, Institute of Environmental Engineering, Chiao Tung University, Hsinchu, Taiwan. No-observed-effect concentrations (NOEC), lowest-observed-effect concentration (LOEC) and EC10 values for 108 organic compounds including phenols, aldehydes, nitriles, alkanes, benzenes, anilines, alcohols, PAHs, and pesticides, were estimated from previous data obtained by a closed-system algal toxicity test (test alga: *Pseudokirchneriella subcapitata*). NOEC and LOEC values were derived using the Dunnett's test. EC10 values were calculated using the best-fit model (probit, logit, or Weibull) which was determined by the G-test. Good correlation relationships were established for NOEC and EC10 in relation to the median effective concentration (EC50), with R^2 equal to 0.90 and 0.88, respectively. Attempt was also made to establish quantitative structure-activity relationships (QSARs) to enhance the predictive capability for estimating NOEC, LOEC, and EC10 values. For nonpolar narcotic compounds, hydrophobicity (1-octanol:water partition coefficient, KOW) was found to be a satisfactory descriptor with R^2 varied from 0.84 to 0.9. On the other hand, log KOW and the lowest unoccupied molecular orbital energy (Elumo) also provide good correlations (R^2 varied from 0.76 to 0.84) with NOEC, LOEC, and EC10. The predictive power for the above QSAR relationships varies from 0.74 to 0.9, based on the leave-one-out analyses. Compare to literature NOEC values for *Pseudokirchneriella subcapitata*, conventional algal batch tests consistently yielded much larger NOECs than that produced by our closed-system technique, except for 4-chlorophenol. For 36% of the cases in the above comparisons, the differences between the conventional batch test and the closed-system technique are greater than one order of magnitude. Therefore, literature NOEC values were over-estimated and did not provide satisfactory protection to the test alga. *Pseudokirchneriella subcapitata* is the most commonly used algal indicator and is extensively applied for assessing the risk of various chemicals and wastewater effluents. Our analyses indicate that NOEC and EC10 can be estimated with good precision, using either correlation equations with the median effective concentration or the QSARs. The low-toxic effect concentrations (NOEC and EC10) and their QSARs derived by the present study are valuable information to risk assessment of chemicals.

MP38 Contrasting Carbaryl Exposure Stress on Different Development Stages of Medaka (*Oryzias latipes*) and Corresponding Problem on Ecological Risk Assessment. S. Kashiwada, Environmental Health Sciences, Public Health Research Center, Columbia, SC; S. Kashiwada, H. Tatsuta, M. Kameshiro, Y. Sugaya, K. Goka, Environmental Risk Research Center, National Institute for Environmental Studies, Tsukuba, Japan; M. Kameshiro, The Institute of Environmental Toxicology, Johso, Japan. Fish embryo toxicology is of concern because embryos are believed more susceptible than adult fish to chemicals and may develop irreversible morphological alterations. Recently, fish embryo bioassay was proposed to replace conventional fish toxicity testing in the OECD guidelines for testing chemicals. Acceleration of the establishment of a chemical toxicity database is a pressing issue for environmental and human health, but the underlying issue is whether fish embryo toxicity data can be used to replace conventional fish toxicity data. There is no certain evidence for the ecotoxicological advantages of using embryos for environmental risk assessment. We tested the effects of exposure to carbaryl (a neurotoxic insecticide, 0, 5, or 10 mg/L) on embryos and post-hatch larvae of medaka (*Oryzias latipes*, a freshwater fish). Embryos exposed to carbaryl until hatching showed multiple embryo developmental malformations and reduction in subsequent survival rates over 3 months, but intrinsic growth rates (r) were unchanged. In contrast, exposure of larvae for 96 h resulted in a heavy reduction in tolerance to starvation for 7 days and degraded the 3-month survival rate and r . These results may underpin the view that cross-sectional life table test is insufficient and longitudinal data is necessary for the global evaluation of ecological risk against potentially hazardous chemicals.

MP39 Development and Use of Site-Specific Bioaccumulation Factors in a Baseline Ecological Risk Assessment at Longhorn Army Ammunition Plant, Karnack, Texas. J. Lindberg, Shaw Environmental and Infrastructure, Knoxville, TN; M. Weisberg, Shaw Environmental and Infrastructure,

Monroeville, PA. A food chain model using literature-based uptake values was used to estimate intake doses for aquatic and terrestrial wildlife receptors at Longhorn Army Ammunition Plant (LHAAP) in Karnack, Texas. Several chemicals in soil and sediment resulted in hazard quotients (HQ) greater than 1 for several receptors using this initial desktop model. To refine the assumptions used in the food chain model, site-specific soil-to-plant, soil-to-earthworm, and sediment-to-benthic invertebrate bioaccumulation factors (BAF) were developed using abiotic and biotic samples collected from areas of known contamination at the installation. Soil-to-plant BAFs were obtained by collecting co-located soil and plant (both leaves and grass) tissue samples. Soil-to-earthworm BAFs were developed by introducing earthworms (*Eisenia fetida*) to site soil for a 28-day bioaccumulation test. Sediment-to-benthic invertebrate BAFs were developed by introducing oligochaetes (*Lumbricus variegatus*) to site sediment for a 28-day bioaccumulation test. If the data were sufficiently robust, regression equations were developed to describe the relationship between abiotic and tissue concentrations. Otherwise, BAFs were calculated using the ratio of chemical concentrations in tissue divided by concentrations in soil or sediment. The site-specific BAFs were then used to calculate new HQs using a revised food chain model. This poster describes the methodology used to develop the BAFs, and depicts their use in the food chain model at LHAAP.

MP40 Performance and Repeatability of the OECD Marine Biodegradation Test for Insoluble Substances (BODIS) using Texas Coastal Seawater. R. MacGregor, K.S. Wolfe, Bioassay Lab, Halliburton, Houston, TX. The objective of this study was to evaluate the performance and repeatability of the OECD marine aerobic biodegradation test for insoluble substances (Marine BODIS test) using natural seawater from the Gulf of Mexico, offshore Galveston, Texas. This marine biodegradation test using natural seawater was developed by the OSPAR nations ISO work group from a freshwater ready biodegradability test (OECD 301D, 1981) using added sewage inoculants. The current Marine BODIS test uses natural seawater fortified with selected minerals and nutrients but without any inoculants. The method incorporates a two phase (air/water) closed-bottle incubation with continuous shaking to maintain the air/water equilibrium; re-aeration after each weekly BOD measurement; and an inert silica support media for greater dispersal and surface area exposure of insoluble test materials. Total percent (%) biodegradation is calculated as measured BOD divided by sample COD or ThOD, after corrections for oxygen saturation levels and BOD of a blank seawater medium. Changes in selected test parameters were evaluated for effects on test performance and repeatability. Parameters evaluated were: 1-batch date of seawater collection; 2-seawater storage conditions; 3-dose levels of selected mineral and nutrient additives to seawater media; and 4-doses of reference materials, both soluble and insoluble. A change in any one of the selected parameters affected the measured % biodegradation of the reference materials. Repeatability was most affected by the seawater batch (date of collection) and by the batch storage conditions. Changes in the dose levels of selected mineral/ nutrients affected the % biodegradation of the soluble reference material differently from the insoluble reference material suggesting that the nutrients were rate limiting. These data from the Marine BODIS tests may offer some insights for global biodegradation studies using different local natural seawaters within a standardized test procedure.

MP41 Human Health Assessment Approach Bridges Environmentally Relevant Contaminant Mixtures and Early Life-Stage Developmental Toxicity. W.E. Hillwalker, L.E. Shorey, R. Tanguay, K.A. Anderson, Oregon State University, Corvallis, OR. The unique bio-analytical approaches of passive sampling devices (PSD) and the zebrafish (*danio rerio*) developmental model have been combined to bridge measurements of environmental contaminants with their potential biological responses. For these preliminary experiments, a range of dilutions from extracts of PSD deployed within, and upriver of, the Portland Harbor Superfund site, Willamette River during Spring 2006 were used to expose early life stage zebrafish embryos to determine if these environmentally relevant mixtures were developmentally toxic. Dilutions of the extracts were nominally equivalent to a contaminant concentration range from 1 to 1/100 times that of the river water. Initial experiments for repeated exposures ($n > 3$) demonstrate concentration-response increases in the appearance of a diverse collection of toxic endpoints including: notochord malformations, growth retardation, pericardial edema, delayed hatching, and gene induction. These initial experiments indicate that environmentally relevant concentrations of mixtures have the potential to adversely impact early-life stage vertebrate development. Most importantly,

these studies highlight the utility of bridging environmental passive sampling with in vivo assessments as a tool to better protect human and environmental health.

MP42 Occurrence and Environmental Impact of Nonylphenol Ethoxylates and Their Biodegradation Metabolites in Wastewater Treatment Systems and Receiving Stream Water and Sediments. C.G. Naylor, G.M. Klecka, C.A. Staples, B.S. Losey, consultant, Austin, TX. Three conventional activated sludge wastewater treatment plants (WWTPs), receiving primarily residential influent, were monitored along with the aquatic ecosystems receiving their discharge to determine the occurrence of nonylphenol ethoxylates (NPE) and their biodegradation metabolites nonylphenol (NP), nonylphenol monoethoxylate (NPE1) and nonylphenol ether carboxylates (NPECs). The treatment plants were all of moderate size and operating normally when influent and effluent samples were taken to determine the removal efficiency of the parent NPEs, which ranged from 97.2% to 99.8%, and occurrence of the degradation metabolites. Samples of stream water, sediment and pore water were collected upstream, below the mixing zones, and far downstream from the WWTP outfalls to determine the occurrence of NPE and metabolites and to evaluate their potential impact on the receiving waters. US EPA ambient fresh water quality criteria (WQC) for NP (acute, 28 µg/L and chronic, 6.6 µg/L) were used as a metric to assess the potential for adverse effects on the streams, both from NP alone and from the toxicity-adjusted aggregate of all the metabolites. This analysis suggests that no effects on aquatic organisms within the three streams are expected. Keywords: nonylphenol; ether carboxylates; water quality criteria, effluents

MP43 Fate of Wood Preserving Chemicals in Landfills. D. Graham, Keller and Heckman LLP, San Francisco, CA. Disposal of treated wood waste has raised environmental concerns. California has considered restricting disposal of treated wood waste in lined portions of Class 2 and Class 3 (non-hazardous) landfills in California. To evaluate possible environmental impacts of the current method of disposal, leachate monitoring data from a variety of California landfills has been reviewed and concentrations of chemicals used in treated wood compared to screening levels. Data were gathered both from landfills that accept treated wood waste and from those which did not. Lined Class 2 and 3 landfills are engineered and managed to minimize the impact of leachate from any type of waste on ground and surface water. They provide a secure, monitored environment for disposal of many types of waste. While this study's focus is on the chemicals used to treat wood, treated wood waste is clearly not the only potential source of these chemicals in landfills. The metals, arsenic, chrome, copper, and zinc, exist naturally in soil and groundwater, and in many types of municipal and industrial waste. The polycyclic aromatic hydrocarbons, naphthalene and benzo(a)pyrene exist naturally in petroleum and coal, as combustion by-products and in normal municipal and industrial waste. Although the fraction of chemicals contributed by treated wood waste to landfill leachate is not known, conclusions about the levels of these chemicals found in leachate can still be made. These results support a conclusion that most metals from treated wood chemicals in landfill leachate are below drinking water standards and, therefore, present no significant risk of contaminating drinking water. Arsenic and the organic chemicals which might result from treated wood products were either below the drinking water standard or below the Limit Threshold Concentration Value modeled for landfills with composite liners using the U.S. Environmental Protection Agency's Tier I Industrial Waste Management Evaluation Model. The study supports the safety of the current practice of disposal of treated wood waste in Class II or Class III composite-lined landfills.

MP44 Do alkylphenol ethoxylates meet Persistent, Bioaccumulative and Toxic (PBT) criteria as defined by national and international conventions? C.A. Staples, Assessment Technologies, Inc., Spotsylvania, VA; G.M. Klecka, The Dow Chemical Company, Midland, MI; C.G. Naylor, Consultant, Austin, TX; B.S. Losey, RegNet Environmental Services, Washington, DC. Alkylphenol ethoxylates (APEs) are an important class of surfactants used primarily in industrial and household applications. Following their intended use, most spent surfactants are treated in wastewater treatment systems, which typically discharge into receiving waters. Traces of APEs and their degradation intermediates (alkylphenols, lower ethoxylates, and ether carboxylates) are detectable in surface waters and sediments, as well as occasionally in air and soil. Biodegradation studies have identified the major degradation intermediates of APEs and defined the overall degradation pathways. The degradability of APEs and their degradation intermediates has been established through numerous standardized tests, as well as in simulation

and field biodegradation studies. The bioaccumulation potential of the most accumulative of the degradation intermediates has also been measured in both conventional laboratory bioconcentration tests and in field studies examining residues in biota. The abundant environmental fate and bioaccumulation data for APEs and their degradation intermediates show that they are neither persistent nor bioaccumulative according to national and international criteria for identifying candidate PBT (persistent, bioaccumulative and toxic) substances.

MP45 Assessing the Aquatic Impacts of the Dust Suppressant Acidulated Soybean Soapstock, an Agricultural By-Product, using Laboratory Biomonitoring. M.B. Gopalan, A.R. Archer, J.L. Farris, Environmental Sciences, Arkansas State University, State University, AR. Unpaved rural roads are still a dominant feature in many areas of the United States and can contribute dust particles that reduce air and water quality via wind erosion. Airborne particles from such erosion can be a potential health hazard to both human and other ecological receptors. Acidulated soybean soapstock is one among several other products being integrated as a dust palliative in some areas of the U.S. A byproduct of soybean oil processing, it is categorized as an organic, non-petroleum based dust suppressant. The potential impacts of acidulated soapstock associated with surface runoff from gravel road stabilization was assessed for aquatic life using the standard testing organisms *Ceriodaphnia dubia*, *Pimephales promelas*, and *Chironomus dilutus*. Laboratory simulated Chemically Enhanced Water Accommodating Fraction (CEWAF) of the product was utilized in aqueous testing whereas, Black River sediment mixed with various concentrations of the product was utilized for sediment testing. Our test setup included various product preparation (mixing = 18, 24, and 48 hours) and settling times (6 and 12 hours). Significant differences were measured in organism survival between control and all product treatments. Acutely toxic soapstock concentrations ranged from 0.0050% to 0.03% for aqueous exposures, while LC50 values were > 2% for *C. dilutus* exposed to sediments mixed with the product. Concentrations causing partial mortality in *C. dubia* were not established during these tests as organism sensitivity was coupled to the threshold range of mixtures used. Based on the LOEC (*P. promelas* = 0.01%, *C. dubia* = 0.0075%), low concentrations of this product may pose acute risks to aquatic life and until more is known of the mode of toxicity and suitable management practices associated with its use, dust palliatives still require careful consideration in the absence of other interacting variables.

MP46 Combining QSAR, Empirical and Read-Across Data Sources for the Assessment of New and Existing Substances in Canada. M.A. Bonnell, New Substances, Environment Canada, Gatineau, Quebec, Canada; N. Davidson, D. MacDonald, Existing Substances, Environment Canada, Gatineau, Quebec, Canada. The grouping of chemicals and PB(i)T Categorization of existing substances on the Canadian Domestic Substances List (DSL) has recently been completed by Environment Canada and Health Canada (September 2006). Practically all of the categorization results were based on QSAR predictions as little empirical data were available for the myriad of substances on the DSL. Given the constraints posed by the regulatory timeframe, high cost and high animal usage, it was not practical to generate the needed data for all 23,000 DSL substances (although well rationalized non-testing alternatives were accepted for some chemicals classes from some industry groups). Consequently, given the paucity of experimental data, categorization of the DSL would not have been possible without the development and application of QSARs. For new substances, experimental data submitted by a notifier are routinely used in combination with multiple QSAR and analogue (read-across) values to determine an endpoint of chemical property to be used in a risk assessment. The application of QSARs for the categorization and risk assessment of substances under CEPA uses a stepwise process. The process involves data collection, generation, quality review, and selection for the purposes of determining a "pivotal value" for an endpoint or chemical property in the risk assessment. This process is intended to create a "weight of evidence" to reduce uncertainty associated with estimating parameters generated through the reliance on too few data. The widest body of data from experimental (including analogues) and QSAR models is collected or generated for each parameter to the degree that it is feasible or practical. There are many instances where QSAR values are the only data available for a substance (e.g., most of the DSL categorization), yet it is still preferable to create a weight of evidence that combines different lines of evidence. Accordingly, the practical and regulatory "realities" experienced in Canada from Categorization of 23,000 substances on Canada's DSL and

assessment of approximately 15,000 new substances will be discussed as well as the important role of "expert judgement".

MP47 Organochlorine and Organophosphorous Pesticides in the Lower Cacaluta River Area, Santa María Huatulco, Oaxaca, Mexico. C. Chapa-Balcorta, Oceanología, Universidad del Mar, Puerto Ángel, Oaxaca, Mexico; G. Aguilar-Zárate, Laboratorio de Cromatografía, Centro de Investigación en Alimentación y Desarrollo, Mazatlán, Sinaloa, Mexico. Organochlorine and organophosphorous pesticides were created to improve the production of agricultural products. However, many of them have significantly affected non target organisms. The lower Cacaluta River area, in Oaxaca, México, is home to the Huatulco National Park created to protect species of ecological importance. However, areas surrounding the park are traditionally used for agriculture of papaya, chili and corn. The organophosphate pesticides disulfoton, methyl-parathion, chlorpyrifos, malathion, ethion and diazinon and organochlorine compounds HCB, lindane, endosulfan A, endosulfan B, dieldrin, endrin, DDT, endosulfan sulphate were studied in groundwater from different sampled sites and a nearby wetland during the dry and rainy seasons. Ethion was more frequently found, with concentrations up to 3.92 µg/L⁻¹. In most cases, malathion, methyl-parathion chlorpyrifos and endrin, were below the detection limit. Nevertheless, the highest values reached 4.75 µg/L⁻¹, 2.38 µg/L⁻¹, 0.16 µg/L⁻¹ and 0.73 µg/L⁻¹ respectively. HCB, lindane, endosulfan A and B, dieldrin, endosulfan sulphate and DDT were not detected in the studied area. EPA water quality guidelines were surpassed in many cases, as were acute toxicity values for many species, therefore negative effects on sensitive species exposed are expected.

MP48 "What Exactly Are You Inferring?" A Closer Look at Hypothesis Testing. M.C. Newman, College of William & Mary, Gloucester Point, VA. This presentation outlines the confused application of significance tests in environmental toxicology and chemistry that often result in inferior inferences and indefensible regulatory decisions. Nine recommendations are put forward. The first is that confidence intervals be used instead of hypothesis tests whenever possible. Also useful are Bayesian techniques. The remaining recommendations are relevant if hypothesis test are used: (1) define and justify Type I and II error rates a priori, (2) set and justify an effect size a priori, (3) do not confuse P(E|H) and P(H|E), (4) design tests permitting Positive Predictive Value estimation, (5) publish negative results, (6) estimate a priori, not post hoc, power, (7) as warranted by study goals, favor null hypotheses that are not conventional nil hypotheses, and (8) avoid definitive inferences from isolated tests.

MP49 In vitro toxicity assay using human bronchial epithelial cell, Beas-2B, for the screening of toxicological risk of dioxin-like compounds sampled from Korean waste incineration plants. J. Choi, M. Ha, University of Seoul, Seoul, South Korea. To test the suitability of cell bioassay as a tool for screening the toxicological risk of dioxin-like compounds, an in vitro toxicity assay was performed using samples obtained from Korean waste incineration plants. Stress-related gene expression, cell viability, apoptosis, DNA damage and cell cycles were investigated as toxicological indicators of the polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDDs/DFs) exposed human bronchial epithelial cell, Beas-2B. Of the stress-related genes, the expressions of the aryl hydrocarbon receptor (AhR), cytochrome P450 (CYP) and p53 genes were most significantly induced by exposure to PCDDs/DFs. Exposure of Beas-2B cells to PCDDs/DFs sampled from waste incinerators was sufficient for the expression of noticeable cytotoxic and genotoxic effects. Increased number of cells in the G1 phase in PCDDs/DFs treated samples suggests PCDDs/DFs might lead to alteration in the cell cycle. Statistical tests revealed significant correlations between the PCDDs/DFs concentration and the AhR and CYP gene expression / cell viability / DNA damage. Different from numerous dioxin bioassays using AhR-mediated bioanalytical method in genetically modified cell line, the present study has been focused on the evaluation of toxicological effects of dioxin-like compounds in normal cell line. The results of this study have demonstrated that PCDDs/DFs samples from waste incinerators can be applied to cell bioassays for the evaluation of the toxicity of dioxin-like compounds obtained from field samples, and the use of stress-related gene expression assay and cytotoxic / genotoxic test systems would appear to be relevant for preliminary screening of the risk associated with dioxin-like chemicals from waste incinerators. Key words: PCDDs/DFs, cell bioassay, stress-related gene expression; cytotoxicity, genotoxicity Acknowledgement - This subject is supported by Korea Ministry of Environment as 'The Eco-technopia 21 project (091-071-025)

MP50 Fish community response to variation in water quality and habitat within incised warmwater streams. J.D. Maul, The Institute of Environmental and Human Health and Department of Environmental Toxicology, Texas Tech University, Lubbock, TX; C.D. Bishop, EA Engineering, Science & Technology, Inc., Sparks, MD; J.L. Farris, College of Science and Mathematics, Arkansas State University, State University, AR; S. Testa III, C.M. Cooper, National Sedimentation Laboratory, Agricultural Research Service, USDA, Oxford, MS. Streams draining into the Mississippi alluvial plain from adjacent loess hills have experienced dramatic geomorphological alterations triggered by poor land use practices and channelization at the watershed-level. Many of these stream systems have experienced large scale degradation from both stream bank and bed erosion that has affected quality of water resources and stream habitat, and subsequently has impacted biotic communities. The degree of deterioration varies from stream to stream and, thus, provides broad gradients in multiple environmental stressors. The objectives of this study were to: (1) examine variation in fish species composition and abundance along gradients of water quality and habitat to identify their effects on the structure and function of fish communities and (2) compare overall fish community patterns among stream reaches classified within different habitat degradation categories. A multivariate analysis approach was used to identify relationships among gradients of environmental stressors and fish communities. Results of this analysis suggest that water quality variables such as suspended sediments, nutrients, dissolved oxygen, and conductivity were important factors in structuring fish communities. Although some habitat variables such as bed substrate type and large woody debris influenced fish communities, other habitat variables had less influence on fish communities than essential water quality variables. In addition, stream reaches assigned to categories within two degradation classification schemes that are based on stream and channel morphology were not successfully distinguished by fish community composition. Because suspended sediments and nutrients have been shown to influence fish communities in these warmwater streams, resource managers working to improve water and habitat quality through stream restoration activities should consider practices that minimize or reduce these parameters.

MP51 Determination of organochlorine pesticides and degradation products in some food commodities (eggs, creams). L. Juc, Y. Bouvet, Institute of Environment and Ecodevelopment, University Claude Bernard Lyon 1, Villeurbanne, France. Two organochlorine pesticides (DDT and HCH) have been used a lot in Republic of Moldova in order to fight against different insects. After the ban of DDT and restriction use of HCH a lot of obsolete products remained in the stockpiles of the country without any supervise. In order to assess the risk for people living in the proximity of the storehouses we have evaluated the status of contamination of some food commodities (eggs and creams). The pesticide residues were assessed using ISO norms and gas chromatography (GC) with an electron capture detector (ECD). Results show that all the samples of cream were contaminated with p,p'DDE (100%). p,p'DDD was detected only in 5,8% of samples, α -HCH in 41,2% of samples and β -HCH in 47,1% of samples. Mean concentrations for p,p'DDD were 0,180 $\mu\text{g/kg}$ on a weight basis, 0,571 $\mu\text{g/kg}$ for α -HCH, 4,538 $\mu\text{g/kg}$ for β -HCH and 25,500 $\mu\text{g/kg}$ for p,p'DDE. Only in one sample of cream we have detected exceeding of european norms (3 times). A high percent of eggs were contaminated with p,p'DDT (100%) and p,p'DDE (100%), other metabolites of DDT were present approximately in 80% of samples. The most abundant isomer of HCH was β -HCH (89,5%). α -HCH and γ -HCH were found in 47% of samples of eggs. Mean concentrations ranged from 0,14 $\mu\text{g/kg}$ to 45,7 $\mu\text{g/kg}$ on a weight basis for Σ DDT and from 0,24 $\mu\text{g/kg}$ to 47,200 $\mu\text{g/kg}$ for Σ HCH. In three samples we have found values that exceeded european norms (1-13 times). Our results show that all the samples of food were contaminated with organochlorinated pesticides. The fact that residues of DDT and HCH are still present in different samples and only a few samples exceed European norms may be due to the atmospheric transport of chlorines from the storehouses or from a recent use of them against some insects. Our results confirm the necessity to repeat measurements and to evaluate actual intakes of pesticides to ensure that that public health is not on danger.

MP52 Regional-Scale Terrestrial and Aquatic Risk Assessment from Diffuse Emissions of Ethylene Oxide. C.A. Staples, Assessment Technologies, Inc., Spotsylvania, VA; W. Gullledge, American Chemistry Council, Arlington, VA. Ethylene oxide (EO) is mainly used as a chemical intermediate and as a fumigant and sterilizing agent. Through its manufacturing and intended uses, EO may be released into the environment. Therefore, an assessment of

the environmental significance of those potential emissions was conducted. Available terrestrial and aquatic toxicity data were used to calculate Critical Toxicity Values. Concentrations of EO in air, soil, water, and sediment were calculated using Level III fugacity-based modeling. Six scenarios were developed to account for different climatic conditions in various portions of the US. In the conceptual model that was developed in this assessment, EO diffuses into air, partitions between environmental compartments, is transported out of the different compartments via advection, and undergoes abiotic and biological degradation within each compartment. All known emissions within the continental USA were assumed to enter a modeled region roughly the size of the State of Ohio. Organisms (receptors) were assumed to dwell in both terrestrial and aquatic compartments. Receptors were assumed to include small mammals, soil invertebrates, water column (pelagic) organisms, and sediment benthos. The goal of this assessment was to characterize any potential adverse risks to terrestrial and aquatic wildlife populations. Hazard Quotients (HQ) were calculated by dividing estimated concentrations of EO in air, soil, water, and sediment by their Critical Toxicity Values. Maximum calculated HQ values in air were 1.52×10^{-7} , in soil were 1.37×10^{-5} , in water were 1.17×10^{-5} , and in sediment were 2.25×10^{-4} . The results of this assessment suggest that EO as currently manufactured and used does not pose adverse risks to aquatic or terrestrial wildlife. In all cases, the HQ values were much less than the maximum desired HQ value of 1.0 (4,400 to 6,600,000 times), indicating that the potential for diffuse emissions of EO to pose adverse risks in terrestrial or aquatic compartments is quite low.

MP53 Determination of site-specific ambient PCDD/PCDF concentrations at a fly ash/wood combustion site by polytopic vector analysis (PVA). E. Amweg, Arcadis BBL, San Francisco, CA; S.L. Huntley, B.R. DeShields, Arcadis BBL, Petaluma, CA; S.E. Holm, Georgia-Pacific, LLC, Atlanta, GA. Environmental samples frequently contain chemicals from multiple sources. In the case of naturally occurring chemicals, such as metals and certain organic chemicals, some proportion of the total concentration may also be due to background conditions. Resolving the relative contribution from each source is important to facilitate assessment and possible remediation. Polytopic vector analysis (PVA) is a multi-variate statistical tool, often referred to as an "unmixing" model, which has been used in recent years to determine the number of sources (end members) and relative contribution of each end member in estuarine sediment samples. At a former sawmill site where PCDD/PCDFs were generated as a result of incineration of both bark and municipal wood, PVA was used to develop site-specific congener profiles typical of ambient and source-related contamination, and the relative mixing proportions of each source in more than 70 soil and sediment samples collected at the site. Cumulative probability distributions of the congeners and the congener profiles and mixing proportions generated through PVA were used to distinguish ambient PCDD/PCDFs from source-related contamination and estimate site-specific ambient concentrations for each congener and total PCDD/PCDFs. The PCDD/PCDF source concentrations and congener profiles are or will be used to focus assessment and remediation efforts at the site. They were also beneficial in determining whether PCDD/PCDFs detected at an off-site location were site-related or ambient. Additional potential applications and limitations of PVA are also discussed. 1. ARCADIS BBL, 155 Montgomery St., Suite 1500, San Francisco, CA 94104 2. ARCADIS BBL, 1670 Corporate Cr., Suite 200, Petaluma, CA 94954 3. Georgia-Pacific LLC, 133 Peachtree Street NE, Atlanta, GA 30303 Key words: dioxins/furans, wood combustion, PVA

MP54 Environmental Assessments of a New Antibiotic Aquaflor (Florfenicol) For Use in Catfish and Freshwater-Reared Salmonids. J.F. Hobson, Morningstar Consulting, Germantown, MD; R.G. Endris, Schering-Plough Animal Health, Summit, NJ. Environmental Assessments (EA) are required by The Food and Drug Administration, Center for Veterinary Medicine, for all animal health drugs. The objective of these EA's is to determine a finding of no significant impact (FONSI) for each approved use. Recently FONSI's have been determined for two new uses of the antibiotic Aquaflor (florfenicol) produced by Schering-Plough Animal Health. The approved uses are for control of enteric septicemia (*Edwardsiella ictaluri*) in catfish and coldwater disease (*Flavobacterium psychrophilum*) in freshwater-reared salmonids. The exposure assessment is based on predicted environmental concentrations (PECs) at the effluent outfall from aquaculture facilities, i.e., end-of-pipe scenario, as determined by the use pattern, culture practices, environmental fate and physico-chemical properties. Aquaflor is administered in the diet at a rate of 10 mg florfenicol/kg body weight

per day for 10 days. This is the first antibiotic for use in aquaculture to be regulated under the Veterinary Feed Directive which requires a veterinarian's prescription prior to use. Florfenicol is readily metabolized and excreted by fish, and degrades readily in water and sediments. The roles of the use patterns and culture practices on the determination of the PECs will be discussed for catfish in freshwater ponds and freshwater-reared salmonids in raceway systems. PECs will be compared to the predicted no effect concentrations (PNEC) for the most sensitive aquatic and marine species including a range of fish, invertebrates, algae and microbes with emphasis on the most sensitive species. The risk characterization including the PEC/PNEC ratios will be presented and discussed.

MP55 Fabricating Data: How substituting values for nondetects can ruin results. D. Helsel, US Geological Survey, Lakewood, CO. The most commonly used method in environmental chemistry to deal with values below detection limits is to substitute a fraction of the detection limit for each nondetect. Two decades of research has shown that this fabrication of values produces poor estimates of statistics, hypothesis tests and trends. Papers using substitution may conclude that significant differences, correlations, and regression relationships do not exist, when in fact they do. The reverse may also be true. The primary problem with substitution is that it adds an invasive pattern to the data that is foreign to the original values. Fortunately, good alternative methods for dealing with nondetects exist, and are summarized here. Substituting values for nondetects should be used rarely, and should generally be considered unacceptable in scientific research. There are better ways.

MP56 Effects of land use on water quality and macroinvertebrate communities in the southern inner piedmont ecoregion of Georgia. D.R. Rouse, J. Overmyer, Department of Entomology, University of Georgia, Athens, GA; A. Fisk, Great Lakes Institute for Environmental Research and Department of Earth and Environmental Sciences, University of Windsor, Windsor, Ontario, Canada; D. Hughes, Soque River Watershed Partnership, North Georgia Technical College, Clarksville, GA. Watersheds in Georgia are subject to alteration and contaminant input due to the assemblage of diverse land uses present in this state. Land uses include, but are not limited to, residential, urban, poultry production, livestock grazing, row crop agriculture, and relatively unaltered national forest. In this study, ten streams were assessed to determine the effects of differing land uses on water quality and aquatic macroinvertebrate assemblages. Sites were selected in an effort to capture the diversity of land uses present in the inner piedmont ecoregion of Georgia. Stream assessment consisted of habitat assessment, collection of macroinvertebrates from riffle, pool and bank habitats, and water and sediment samples for analysis of heavy metals, organics, nutrients and various other water quality parameters. Data will be analyzed to determine which contaminants and water quality parameters are related to or affected by specific land uses and the potential impact these relationships have on macroinvertebrate community structure.

MP57 Reducing Uncertainty in Ecological Risk Assessment Using Site-Specific Measures of Bioavailability. T. Orr, Arcadis BBL, Chicago, IL; M. Pattanayek, Arcadis BBL, San Francisco, CA; B. DeShields, Arcadis BBL, Petaluma, CA; C. Baker, Entrix, Inc., Seattle, WA. Ecological Risk Assessments (ERAs) are often conducted without the availability of site-specific bioavailability data. This includes measures of bioavailability of chemicals in soil as well as site-specific prey tissue chemistry data. Typically, ERAs assume 100% bioavailability of chemicals in soil and rely on conservative models to estimate prey tissue concentrations from abiotic media. Uncertainty is inherently associated with the assumption of 100% bioavailability and the use of literature-derived bioaccumulation factors (BAFs), which may overestimate risk and ultimately lead to unnecessary remedial activities. A study was conducted at a former petroleum refinery measuring site-specific soil bioavailability for lead and prey tissue chemistry data in field-collected organisms for both organics and inorganics to 1) develop a site-specific bioavailability factor for lead in soil, 2) allow comparisons to reference area prey tissue data, 3) develop site-specific BAFs and Risk-Based Screening Levels (RBSLs), and 4) estimate dietary exposure of constituents of potential ecological concern (COPECs) with more certainty. The use of site-specific prey tissue data concentrated the focus of the ERA on specific COPECs determined to be site-related and reduced uncertainty associated with inherently conservative literature BAFs. Ultimately, the collection of site-specific data yielded efficiencies and cost savings by 1) dedicating resources to the evaluation of COPECs that are potentially site-related and present at

concentrations that may result in unacceptable risk to the environment, and 2) reducing uncertainty in the ERA as it pertains to the risk management decision process.

MP58 Development and Use of Site-Specific Bioaccumulation Factors in a Baseline Ecological Risk Assessment at Longhorn Army Ammunition Plant, Karnack, Texas. J. Lindberg, Shaw Environmental and Infrastructure, Knoxville, TN; M. Weisberg, Shaw Environmental and Infrastructure, Monroeville, PA. A food chain model using literature-based uptake values was used to estimate intake doses for aquatic and terrestrial wildlife receptors at Longhorn Army Ammunition Plant (LHAAP) in Karnack, Texas. Several chemicals in soil and sediment resulted in hazard quotients (HQ) greater than 1 for several receptors using this initial desktop model. To refine the assumptions used in the food chain model, site-specific soil-to-plant, soil-to-earthworm, and sediment-to-benthic invertebrate bioaccumulation factors (BAF) were developed using abiotic and biotic samples collected from areas of known contamination at the installation. Soil-to-plant BAFs were obtained by collecting co-located soil and plant (both leaves and grass) tissue samples. Soil-to-earthworm BAFs were developed by introducing earthworms (*Eisenia fetida*) to site soil for a 28-day bioaccumulation test. Sediment-to-benthic invertebrate BAFs were developed by introducing oligochaetes (*Lumbricus variegatus*) to site sediment for a 28-day bioaccumulation test. If the data were sufficiently robust, regression equations were developed to describe the relationship between abiotic and tissue concentrations. Otherwise, BAFs were calculated using the ratio of chemical concentrations in tissue divided by concentrations in soil or sediment. The site-specific BAFs were then used to calculate new HQs using a revised food chain model. This poster describes the methodology used to develop the BAFs, and depicts their use in the food chain model at LHAAP.

MP59 Heavy Metal Analysis and Benthic Invertebrate Diversity From the Chickasaw Creek/Mobile River Watershed, Alabama. B.P. Bohent, T.M. Rice, Biological Sciences, University of South Alabama, Mobile, AL; E.A. Cioffi, Chemistry, University of South Alabama, Mobile, AL. The Chickasaw Creek/Mobile River watershed (Mobile, Alabama) is the site of a large industrial presence consisting of marine terminals, ship yards, oil refineries, and paper mills. Contamination of surface water and sediment as a result of airborne emission and effluent discharge from these facilities is of great concern. The Alabama Department of Environmental Management (ADEM) conducted surveys of sediment metals in the watershed, but these studies are over 10 years old. Therefore, we conducted a chemical and biological assessment from 5 locations using some of ADEM's sites and a few unique areas of interest. Results indicate low levels of metals away from areas of high industrial density, while locations within the vicinity of industries contained higher concentrations of heavy metals. Comparisons to the previous ADEM studies indicated higher levels in some common sites but lower levels in other sites, thus implying some changes in sediment characteristics or metal loading in the last 10 years. Furthermore, some sites approach sediment toxicity guidelines for metals such as Pb, Cu, Ni, and Cr, indicating potential impacts on biota. Macroinvertebrate samples indicate abundant oligochaetes typically associated with impacted sediments and little diversity otherwise. In general, there appears to be cause for concern of heavy metal contamination in this watershed. We suggest more thorough and continuous monitoring of this important watershed.

MP60 Comparison of microbial communities among native, restored and pollutant-impacted salt marshes along Galveston Bay, Texas. D.E. Hinojo, T. Fink, D. Howard, University of Houston at Clear Lake, Houston, TX. Loss of coastal wetlands due to subsidence, development and industrial pollution has been an important issue in the Galveston Bay, Texas region for a number of years. A high priority has been to restore as many of the subsided and degraded marshes as possible. One of these sites, Pierce Marsh, along northern West Galveston Bay, consists of native and restored/created *Spartina alterniflora* marshes and at least two pollutant-contaminated marshes are located nearby. Several researchers have studied marsh regeneration and nekton recruitment, however, the reestablishment of the marsh microbial communities has not been investigated. This purpose of the present study was to determine if a microbial community is present in these marshes that is able to perform the mineral recycling and degradation processes necessary for a healthy salt marsh. We compared two native unimpacted marsh sites with four restored/created sites in Pierce Marsh and two pollutant-impacted marshes less than 1 mile away. Microbes were extracted from sediment collected from nine stations at each site. Colonies were grown on plate count agar, then subjected

to nine different substrates to discriminate among general types of microbes. Preliminary results indicated that more substrates were utilized by microbial communities sampled from the native marshes than from the restored or impacted marshes. Differences in the microbial communities, which form the foundation of the marsh ecosystem, may help explain the observed differences in the associated benthic and nektonic groups.

MP61 Use of bioassays to predict toxicity at Hurricane Katrina impacted sites. K.L. Willett, J. Weston, A. Chaudhary, K. Argote, B. Emerson, Pharmacology and Environmental Toxicology, University of Mississippi, University, MS; J.A. Roling, S. Manning, M. Brouwer, Coastal Sciences, University of Southern Mississippi, Ocean Springs, MS. The goal of our study was to assess the toxicological impact following the storm surge caused by Hurricane Katrina which hit the Mississippi Gulf Coast in August 2005. We had hypothesized that the more heavily debris-impacted sites (Biloxi and Gulfport) would elicit higher bioassay responses compared to the more eastern sites in Grand Bay or Mobile Bay. Water and suspended sediment samples were collected monthly from September 2005 - 2006 from ten sites along the Gulf Coast: Mobile, AL, and Biloxi, Grand Bay, Gulfport, Ocean Springs, and Pascagoula, MS. Water samples (2 L) were filtered and extracted for analyses of estrogenic potential in the yeast estrogen screen and to measure CYP1A induction with the H4IIE rat hepatoma EROD assay. In addition, water and suspended sediments collected in April 2007, were tested in the in vivo sheepshead minnow early life stage toxicity assay. Maximal estrogen equivalencies and BaP equivalencies were 5.5 ng/L and 297 µg/L, respectively. In vitro bioassay results were variable between sites and months, and when averaged over the year, the majority of the sites were not significantly different. Similarly, there was no significant difference between percent hatch, mortality, or malformations in sheepshead minnow larvae exposed to water collected from Grand Bay or Back Biloxi Bay. In contrast to BaP equivalency results, estrogen equivalents did decrease in the months following the hurricane. Results from these assays do not support a significant long term impact of Hurricane Katrina with respect to waterborne CYP1A inducers or estrogenic compounds. Supported by NOAA-NIUST and NOAA NA05NOS4261163.

MP62 Development of new biological toxicity index (ATI) to assess the effluent from metal plating industry with incorporating of the effect of hardness, pH, and dissolved organic carbon. H. Mo, Department of Agricultural biology, Korea University, Seoul, South Korea; J. Jung, K. Cho, Division of Environmental Science and Ecological Engineering, Korea University, Seoul, South Korea; K. Shin, Department of Statistics, Hankuk University of Foreign Studies, Yongin, South Korea. To overcome the weakness of chemical assessment, various biological-assessment techniques using living organisms have been developed. Among them, Toxicity Unit (TU) is easy to understand instinctively the strength of toxicity and calculated by 100/LC50. But, if the LC50 is extremely large or small, reversely the TU is extremely small or large. In addition, when we use multi species to assess the WET, total TU is just the sum of each TU of each test organism. Consequently, TU is not proper in the biological toxicity test when multi species are tested. In this test, new biological-toxicity index has been developed, and its name is ATI (Area upper curve Toxicity unit Index). ATI has several benefits; 1) ATI value range from 0 to 1; 2) ATI is not affected seriously by one extreme value in multi-species test. For the study, two kinds of metal plating wastewater were diluted for 100, 50, 25, 12.5, 6.25, and 3.125% concentration. The ATI was calculated and the risk of wastewater was assessed using indigenous invertebrates to Korea, *Chironomus yoshimatsui* Martin et Sublette, *Ephemera orientalis* McLachlan, *Daphnia* sp. But, when an ecotoxicity test using living organism is conducted, there are many factors modifying toxicity. The combined effect of changes in pH, hardness, and dissolved organic carbon and the possible interactions among these parameters on ATI were investigated. Based on a central composite design, models were developed that can explain the observed variation in ATI as a function of these toxicity modifying factors. This research shows the applicability of ATI and may contribute to improve the assessment procedure of WET.

MP63 A Practical Decision Process for Calculating Exposure Point Concentrations for Spatially Explicit Risk Assessments. P.E. Goodrum, M. Kohberger, T. Negley, ARCADIS BBL, Syracuse, NY; T. Orr, ARCADIS BBL, Chicago, IL; B. DeShields, ARCADIS BBL, Petaluma, CA; J. Gleason, Trihydro Corporation, Laramie, WY. It is generally recognized that the estimated Exposure Point Concentration (EPC) can be a major source of uncertainty in risk assessments, especially if spatial information inherent in both the sample data as well as the activity patterns of receptors are ignored.

Statistical methods and software tools for incorporating spatial information into sampling designs as well as exposure assessments are becoming increasingly available. However, some methods can be costly to implement and may introduce uncertainties comparable to non-spatially explicit methods. Determining which methods and tools to implement after sampling has occurred can be especially challenging for large area sites with many receptor populations and chemicals of potential ecological concern. A practical decision process is proposed to guide site investigation teams in the selection of methods for calculating the EPC for soils. Factors that are considered include knowledge of site contamination processes, recent USEPA guidance on calculating 95UCLs for left-censored data, spatial and statistical properties of the data, the likelihood that non-spatial methods may lead to false positive or false negative outcomes, and expertise and resources available to implement the methods and recognize their limitations. Case studies are presented to compare the performance of "non-spatial" EPCs and "spatially-weighted" EPCs using Thiessen Polygons, Inverse Distance Weighting, Kriging, and Sequential Gaussian Simulation.

MP64 Monitoring of biological conditions within regulatory mixing zones in the U.S. H. Latimer, J. Diamond, K. Pavlik, Tetra Tech, Inc., Owings Mills, MD; G. Bailey, Washington Department of Ecology, Olympia, WA. Mixing zones are specified areas downstream of a wastewater discharge that are authorized under a state's National Pollutant Discharge Elimination System (NPDES) program as an area of effluent dilution, in which certain state water quality standards may be exceeded. However according to U.S. EPA guidance, standards can be exceeded in the mixing zone only if: (1) there is no acute toxicity (lethality) to organisms that might pass through the zone (i.e., the mixing zone can not be a barrier to migration or organism movement); and (2) designated uses are not impaired. State mixing zone policies often contain conflicts in that state standards are permitted to be exceeded (including, at times, standards for toxicity) within these zones, however beneficial uses must be protected and acute lethality is prohibited within these same areas. The limited size of mixing zones is a factor commonly thought to minimize any such impacts. Public concern regarding potential impacts within mixing zones, and particularly zones of initial dilution (ZID) within which acute water quality standards may be exceeded (including, at times acute WET limits) continues to increase. A survey was conducted in which EPA Regions and states were contacted for information regarding studies conducted to evaluate the biological communities within mixing zones. This survey determined that actual monitoring of the communities within regulatory mixing zones is rare. Most states (46 of 50) have no program to monitor the biological condition within mixing zones. Of those states that do regularly conduct such monitoring, only two appear to use standardized bioassessment methods in these studies. Other states appear to conduct such evaluations on an "as needed" basis and using sampling and analysis methods of varying rigor. As a result, there is often no monitoring data available to ensure that the mixing zone restrictions set forth (e.g., state standard or permit limit) are satisfied.

MP65 Aquatic Risk Assessment of Photosystem II Inhibitors in South Florida Ecosystems. L. Schuler, G. Rand, SERC, Florida International University, North Miami, FL. Widespread use and subsequent off-site transport of herbicides, specifically Photosystem II inhibitors (PSII), on agricultural and non-cultivated lands in south Florida has resulted in frequent detections in the aquatic environment. The potential impact of the individual herbicides to exposed biota was examined using a probabilistic risk assessment approach. Risk was characterized from ten PSII herbicides (four triazines-ametryn, atrazine, simazine, and prometryn; two triazinones-hexazinone and metribuzin; two substituted ureas-diuron and linuron; a pyridazinone norflurazon; and a uracil-bromacil) by comparing the overlap of 90th percentile concentrations from the exposure distribution to the 10th percentile of effects determined from species sensitivity distributions. Overall, the risks of the individual herbicides were generally low. A multiple substance potentially affected fraction (msPAF) assessment model also was utilized to examine the toxicity of the herbicide mixtures. The risk associated with the herbicide mixture was determined to be high for several counties in south Florida. This highlights the need to consider chemical mixtures as part of an ecological risk assessment.

MP66 Aquatic Risk Assessment of Copper in Freshwater and Saltwater Ecosystems of South Florida. L. Schuler, T. Hoang, G. Rand, Florida International University, North Miami, FL. A screening-level aquatic risk assessment was conducted for copper in south Florida's freshwater and saltwater environments. Risk was quantified by comparing the overlap

between the probability distributions of copper exposure from surface water and sediment with the probability distributions of effects data obtained from laboratory studies. Copper concentrations in surface water and sediment in south Florida were summarized by county. For surface water, the highest concentrations of copper were found in Martin and St. Lucie counties for freshwater and saltwater, respectively. From the exposure probability distributions, the 90th percentile values were estimated at 14.0 $\mu\text{g/L}$ and 15.4 $\mu\text{g/L}$ in freshwater and saltwater, respectively. Copper concentrations in sediment were evaluated from a probability distribution from the predicted pore water concentrations. The 90th percentile values of pore water concentrations from freshwater sediments ranged from 5.0 $\mu\text{g/L}$ in Palm Beach County to 71.7 $\mu\text{g/L}$ in Broward County. In saltwater sediments, the 90th percentile values for pore water ranged from 26.1 $\mu\text{g/L}$ in St. Lucie County to 27.4 $\mu\text{g/L}$ in Miami-Dade County. Ecological effects data were obtained for acute and chronic copper effects in freshwater and saltwater. The 10th percentile values (concentration protective of 90% of species) for acute effects data were 21.2 $\mu\text{g/L}$ and 9.8 $\mu\text{g/L}$ for freshwater and saltwater species, respectively. For chronic effects, the 10th percentile values were 3.8 $\mu\text{g/L}$ and 3.9 $\mu\text{g/L}$ for freshwater and saltwater species, respectively. The ecological risk from copper exposure was examined for each county in south Florida. The acute risk from copper exposure in surface water was generally low; however, the potential for ecological risk from chronic copper exposure was moderate to high in several counties including Lee, Martin, and St. Lucie counties. The risk from acute copper exposure from freshwater sediments also was low with the exception of St. Lucie County. Saltwater sediments posed a significant acute risk in Miami-Dade and St. Lucie counties. Chronic risk from freshwater and saltwater sediments was high in all counties with sufficient data available to calculate risk.

MP67 Accessible Information and Tools for Determining the Causes of Impairments. S.M. Cormier, G.W. Suter, P. Shaw-Allen, Office of Research and Development, USEPA, Cincinnati, OH; S.B. Norton, K. Schofield, S. Marcy, Office of Research and Development, USEPA, Washington, DC. Updates in 2007 to the USEPA's Causal Analysis/Diagnosis Decision Information System (CADDIS) add new information and analytical tools to the original framework for evaluating the causes of undesirable biological effects in aquatic systems. The Candidate Cause module helps practitioners (1) choose what to list, what not to list and what to defer, based on sources, site information, and observed biological effects, (2) write reports by providing conceptual models and supporting text that can be copied or modified to explain the source-to-impairment pathways for an impaired site, and (3) make useful site observations in the field. Commonly encountered causes of impairments to aquatic systems are characterized including: metals, sediments, nutrients, flow alteration, temperature, toxics, ionic strength, and low dissolved oxygen. CADDIS includes Conceptual Models that diagram relationships among sources, stressors, and biological effects. An Interactive Conceptual Model for phosphorus links the diagram with supporting literature citations. The Analytical Tools module helps practitioners analyze data sets and interpret results as evidence within the USEPA causal assessment process. Downloadable tools include a GUI-based statistical package (CADStat), programs for use with the freeware R statistical package, and a Microsoft Excel template. These tools can be used to quantify associations between any cause and any biological impairment using innovative methods such as species-sensitivity distributions, biological inference indices, conditional probability analysis, and quantile regression analysis. The updates have expanded the Web site from a causal analysis framework to an interactive causal analysis worksite.

MP68 Calculation of Predicted No Effect Concentrations for Bisphenol A using Species Sensitivity Distribution Methods. C.A. Staples, Assessment Technologies, Inc., Spotsylvania, VA; K.B. Woodburn, G.M. Klecka, The Dow Chemical Company, Midland, MI; E.M. Mihaich, ER2, on behalf of GE Plastics, Durham, NC; L. Ortego, Bayer CropScience, Research Triangle Park, NC; N. Caspers, Bayer Industry Services, Leverkusen, Germany; S.G. Hentges, Polycarbonate/BPA Global Group, Arlington, VA. Bisphenol A (BPA, CAS RN 80-05-7) is a high production volume chemical used as an intermediate in the production of polycarbonate plastic and epoxy resins. During its manufacture and use, some emissions to surface waters are anticipated. Chronic predicted no effect concentrations (PNEC) for aquatic systems are used to support the assessment of potential risks to aquatic organisms in receiving waters. PNECs for a compound are considered protective of populations, communities and ecosystems. Traditionally, PNECs are derived by taking the lowest no-observed effect concentration (NOEC)

from a set of toxicity studies and dividing by an assessment factor (e.g., 10 to 1000). This traditional approach is appropriate for substances with few data, but can be overly conservative for substances with many valid studies. For well-studied substances, statistical approaches can be used to calculate a refined PNEC that makes use of the full distribution of available NOEC values. Bisphenol A has an extensive set of aquatic toxicity studies covering diverse taxa including algae, hydra, rotifers, mollusks, crustaceans (both benthic and pelagic), insects, annelids, fish and amphibians. The full chronic data set is used to calculate PNEC values using four methods: 1) the Hazard Concentration (HC5) approach developed by RIVM, 2) the USEPA water quality criteria procedure, 3) SigmaPlot (Systat, 2000) commercial software, and, 4) a distributional method consistent with that used by Environment Canada. Using these approaches, refined PNEC values for BPA range from 11 to 71 $\mu\text{g/L}$. Refined PNECs and traditional PNEC values are then compared to concentrations of BPA that have been measured in North American and European surface waters. A risk assessment performed using the various PNEC values demonstrates that adverse risks to aquatic organisms are not anticipated from measured concentrations of BPA in North American and European surface waters.

MP69 Evaluating bisphenol A concentrations in North American and European environments: comparison with predicted environmental fate. K.E. Clark, BEC Technologies Inc., Aurora, Ontario, Canada; G.M. Klecka, The Dow Chemical Company, Midland, MI; C.A. Staples, Assessment Technologies, Inc., Spotsylvania, VA; N. van der Hoeven, ECOSTAT, Leiden, Netherlands; D. Thomas, PlasticsEurope, Brussels, Belgium. Bisphenol A (BPA, CAS RN 80-05-7) is an intermediate in the production of polycarbonate and epoxy resins and may be released to the environment during the manufacturing, processing, and use of a variety of products. Measurements of BPA in surface water, sediment, soil, air, and wastewater, in North America and Europe have been assembled. All studies reporting measurements of BPA were reviewed for data and analytical quality and were input to a database. The objective of the work was to assess the range of concentrations of BPA in each of the above media and to compare them for different geographic regions. The majority of available measurements are for surface water, followed by wastewater and sediment. Very few studies report measurements of BPA in soil or air. As a large proportion of the measured values (between 50% and 80% in surface water) are reported as "not detected", the treatment of these non-detect values affects the overall characterization of the concentration of BPA in the environment. An evaluation of the fate of BPA in air, water, sediment, and soil was previously conducted and the information used to predict concentrations of BPA in different media. The majority of BPA is predicted to be present in surface water and sediment. An attempt is made to compare calculated with measured concentrations. The measured concentrations are also compared with Predicted No-Effect Concentrations (PNECs) for surface water.

MP70 A statewide sediment and water quality approach to characterize pollution in Wadeable streams of South Carolina. A.J. Jones, E.R. Carraway, S. Klaine, Clemson Institute of Environmental Toxicology, Clemson University, Pendleton, SC; M.C. Scott, South Carolina Department of Natural Resources, Pendleton, SC. Nationwide, the importance of small aquatic ecosystems to overall water quality is gaining attention. In South Carolina, the Department of Natural Resources is conducting a biological survey of approximately 300 small scale watersheds in an effort to "... design an effective and efficient management strategy to protect, conserve, and restore the aquatic resources of the State of South Carolina." In support of and collaboration with that effort, the work presented characterizes sediment and water quality through measurement of several organic and metal pollutants within those watersheds. Sites are randomly selected using known streams and GIS to determine watersheds of appropriate size (less than 150km²). GIS is then used to determine the land use distribution for each watershed. Water and sediment samples are collected and analyzed using GC-MS, ICP-MS, and Cold Vapor AAS. Organic compounds of interest include 17 α -ethynylestradiol, 4-nonylphenol, caffeine, triclosan, atrazine, and selected polycyclic aromatic hydrocarbons, while metals of interest include aluminum, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, and zinc. Results indicate a small number of sites that exceed the USEPA constant contamination concentration and contaminant maximum concentration for waterborne cadmium, copper and nickel. Organic compounds of interest have been below detection limits at all sites sampled thus far. Dissolved and sediment bound metals are correlated with land

use activities in watersheds indicating that changes in land use can increase pollutant loads and impact the quality of the stream.

MP71 Oysters (*Crassostrea virginica*) as sentinels for coastal water quality and landuse in Georgia, USA. J.S. Smith, S.C. Megan, M.E. Frischer, Skidaway Institute of Oceanography, Savannah, GA; S.C. Megan, Savannah State University, Savannah, GA; K.A. Maruya, Southern California Coastal Water Research Program, Costa Mesa, CA. The eastern oyster (*Crassostrea virginica*) is one of the most abundant bivalve species inhabiting the eastern U.S. coastal zone. Because they accumulate chemical and microbial contaminants and thus integrate exposures via the water column, bivalves including *C. virginica* have been used as integrative water quality bioindicators for decades. The overall objective of this project is to initiate an environmental observation system for coastal Georgia (USA) water quality based on this ecologically relevant indicator species. Oysters were collected from 21 viable beds with differing landuses (pristine, harvesting bed, residential, marina, and industrial) in the six coastal GA counties and analyzed for a suite of heavy metal and organic contaminants, as well as bacterial indicators of chemical contamination. Metals indicating anthropogenic inputs ($\Sigma Ag + Cu + Pb + Zn$) were highest for residential ($540 \pm 87 \text{ ug/g}$; mean $\pm$ SE) and industrial ($484 \pm 52 \text{ ug/g}$) land use sites. Total Cr, Cu, and As ($\Sigma Cr + Cu + As$) was highest at marina sites ($26.4 \pm 7.8 \text{ ug/g}$). Preliminary results of organic analyses indicate that marina sites had the highest concentration of total petroleum hydrocarbons or TPH (409 ug/g lipid), whereas industrial sites had the highest concentration of total PAHs ($872 \pm 394 \text{ ng/g lipid}$). The bioluminescence ratio (BLR), which is the ratio of bioluminescent to total bacteria, was used as an indicator of chemical contamination in water and oysters. Results of the BLR suggest chemical contamination in marina and industrial sites are higher relative to pristine locations. In general, shellfish harvesting beds and pristine sites had lower concentrations of both heavy metals and organic compounds than other sites.

MP72 Development of New Guideline to Assess the Primary and Ultimate Biodegradation of Chemicals Discharged to Wastewater. T. Federle, N. Itrich, Central Product Safety, The Procter & Gamble Company, Cincinnati, OH; E. Shaeffer, Wildlife International, Easton, MD. A comprehensive testing strategy to assess the fate of chemicals disposed to wastewater is currently under review by OECD as a new biodegradation guideline. This guideline consists of 5 simulation tests that focus on scenarios where biodegradation can occur following discharge of a chemical to wastewater including the sewer, activated sludge reactor, anaerobic digester and mixing zones where wastewater or treated effluent enter surface waters. These simulation tests directly measure the rates of primary (biotransformation) and ultimate biodegradation under realistic conditions. They have been utilized successfully for test materials with a large range of physical-chemical characteristics, including materials that are volatile, toxic in standard ready tests and biotransformed through cometabolic processes. Test materials have included surfactants, biocides, fragrance materials and pharmaceuticals. The resulting rates can be used to parameterize exposure models and establish the potential for a chemical to undergo wide scale transport from its site of initial release, allowing one to determine if the bulk of the chemical used and discharged will biodegrade prior to reaching habitats in which persistence is of particular concern. Model predictions using rates determined in these tests have shown excellent correspondence to field monitoring studies.

MP73 Environmental Fate of Mosquito Adulticides in Wetlands of the Sacramento Valley, CA, USA. C. Johnson, U.S. Fish and Wildlife Service, Sacramento, CA; M. Wolder, U.S. Fish and Wildlife Service, Willows, CA; S. Lawler, D. Dritz, University of California, Davis, CA. Wetlands in California have been drastically reduced of their original acreage. Those that remain provide critical habitat for a variety of wildlife some of which are rare and endemic or listed as threatened/ endangered. The Sacramento Valley is one of the most important areas for wintering waterfowl in the Pacific Flyway supporting three to five million ducks, geese, and swans during the fall and winter months. These managed wetlands have the potential to produce populations of several mosquito species that are of concern to local Mosquito and Vector Control Districts (Districts). Recent land use changes including sprawling urban development, wetland restoration, and rice straw decomposition practices (e.g. flooding vs. burning) have likely resulted in more interaction between humans and mosquitoes. These trends along with new mosquito-vectored diseases such as West Nile Virus spreading to California have caused increased concern by Districts regarding the control of mosquitoes. The objective of this study is to quantify and evaluate the

cumulative water and sediment concentrations of mosquito adulticides applied within the Sacramento National Wildlife Refuge Complex along wetland levee roads by a District. Pyrethrin 5-25 was used by the District as the primary mosquito adulticide during this study because local mosquito populations were developing resistance to malathion. Pyrethrin is a 5% mix of pyrethrin I & II and 25% piperonyl butoxide. Background samples were collected 1 week prior to the beginning of the fall treatment period. Adulticide application occurred twice a week for approximately six weeks in the evening. Water and sediment samples were collected within 12 hours after each application from treatment and control areas. Samples were also collected two weeks after the abatement practice concluded. Samples were analyzed via LC-MS within 48 hours of collection by the California Department of Fish and Game Water Pollution Laboratory, Rancho Cordova, CA.

MP75 Decision framework for incorporating multiple lines of evidence into ecological risk assessments. R.A. Pastorok, D.S. Becker, D. Nielsen, Integral Consulting Inc., Mercer Island, WA. Ecological risk assessments typically involve multiple lines of evidence (LOEs) to evaluate risks relative to each assessment endpoint. Ecological risk assessors use weight of evidence schemes to evaluate and integrate multiple LOEs during risk characterization. Hull and Swanson (2006) proposed using sequential analysis of LOEs to increase the efficiency of ecological risk assessments. However, relatively little attention has been given to decision frameworks for ordering LOEs in a sequential analysis. We propose one approach to organize and order LOEs that may also include decision flowcharts. In this approach, LOEs are identified for selected receptors and assessment endpoints in broad habitat categories, such as riverine, reservoir, riparian, and upland habitats. Decision flowcharts are then developed initially for broad receptor groups, including plankton, benthic macroinvertebrates, fish, terrestrial plants, soil invertebrates, amphibians, birds, and mammals. Initial evaluations included in the flowcharts may include habitat characterization and analysis of sources of chemical contaminants to aquatic, riparian, and upland areas. Elements of each decision flowchart include data types (data collection and literature), LOEs and risk characterization approaches, decision points, and products such as identified receptors at risk, chemicals of potential concern, and spatial patterns of unacceptable risk. LOEs used in the final evaluations may include screening of chemical concentrations in environmental media with toxicity thresholds (benchmarks), tissue residue analysis, exposure estimation and other modeling, toxicity testing, and population or community surveys. The decision flowcharts can help guide site investigations and risk characterization based on a consensus among stakeholders about key LOEs and how they will be used in the risk assessment. Moreover, the proposed approach can increase the efficiency of ecological risk assessments and provide the logic and transparency for decisions about the ordering of exposure and effects studies and about which LOEs are used in the final weight of evidence analysis.

MP76 Environmental Assessment of Copper Sulfate use in Channel Catfish Ponds. D.L. Straus, Harry K. Dupree - Stuttgart National Aquaculture Research Center, U.S. Department of Agriculture, Agricultural Research Service, Stuttgart, AR; J.A. Steeby, Thad Cochran National Warmwater Aquaculture Center, Mississippi State University, Belzoni, MS. Copper sulfate (CuSO_4) is used worldwide as a waterborne disease therapeutant in commercial and ornamental fish culture. However, it is not approved by the U.S. Food and Drug Administration (FDA) for therapeutic use in aquaculture; regulatory action on the use of CuSO_4 has been deferred pending the outcome of ongoing research. A New Animal Drug Application is being prepared in order to gain approval for use of CuSO_4 as a disease therapeutant to control mortality associated with ichthyophthiriasis on channel catfish (*Ictalurus punctatus*) cultured in earthen ponds. The levels of copper entering the receiving environment will be dependent on the use-pattern of CuSO_4 and the environmental fate characteristics of copper. The amount of CuSO_4 applied (i.e., concentration, timing, frequency and duration of application) will be determined by the biology of the protozoan parasite (*Ichthyophthirius multifiliis*) that causes ichthyophthiriasis. From survey data taken in 2001, the major use of CuSO_4 to treat ichthyophthiriasis is in food-size fish production ponds rather than in fingerling ponds. This is expected as food-size fish production ponds also represent approximately 88% of the total pond area in catfish aquaculture. The use of CuSO_4 in these ponds serves as a 'worst-case scenario'; however, these ponds may be in continuous production for up to 10 years. The total value of fingerling channel catfish lost to ichthyophthiriasis was approximately US \$824,000 and the total amount of CuSO_4 used to treat infected fingerlings was about 19,000 lbs. (9.5 tons or 8.6 metric tons). The

total value of food-size fish lost to ichthyophthiriasis was approximately US \$386,000 and the total amount of CuSO_4 used to treat infected fish was about 74,000 lbs. (37 tons or 33.6 metric tons).

MP77 RICEWQ: Pesticide Risk Assessment Model for Rice. W.M. Williams, A.M. Ritter, Waterborne Environmental, Inc., Leesburg, VA. RICEWQ is a pesticide fate and transport model developed to simulate the flooding conditions, overflow, and controlled releases of water associated with rice production. This poster presents features in the latest version and highlights the application of the model in rice producing areas throughout the world. Besides simulating rice agriculture, the model has been used for aquaculture and can be used to simulate other aquatic crops such as cranberries or watercress.

MP78 Evidence of Pesticide Fishing in Burma/Myanmar. S. Tan, National Zoological Park, Smithsonian Institution, Arlington, VA; C. Orazio, J. Meadows, R. Gale, D. Papoulias, Columbia Environmental Research Center, US Geological Survey, Columbia, MO; M. Win, Student, Davidson College, Davidson, NC; M. Soe, Chatthin Wildlife Sanctuary, Ministry of Forestry, Chatthin, BURMA. Scientists from the Smithsonian Institution are studying the practice of pesticide fishing in Burma (Myanmar). Pesticide fishing involves introducing a commercial pesticide into a lake or river, by forming a pesticide mud or meat ball and throwing it into the water. The fisher then waits for the dead or stunned fish to float to the surface. Initial studies in December of 2003 were done in the Chatthin Wildlife Sanctuary, in northern Burma. This sanctuary contains a man-made lake of 1200 acres called Kye-In connected to a river that runs outside the park. Surveys of Burmese fishermen indicate they are using pesticides to kill fish collected for personal consumption and for selling in the markets. Pesticide market surveys and interviews with fishermen revealed that pesticides used may include endrin, DDT, monocrotophos, malathion, deltamethrin, and endosulfan. In 2006, the Smithsonian Institution and the US Geological Survey conducted an exploratory study to determine whether these pesticides are present in fish from rivers and lakes where fishing with pesticides is suspected. The fish chosen for study were several snakehead species that are abundant in Burma, including *Channa striata*, *Channa gachua*, *Channa marulius*, and *Channa panaw*. These species were chosen because they are carnivorous and will more likely bioaccumulate fat soluble pesticides. They are also highly prized by humans for consumption. Fish and sediment samples were collected from six water bodies in Burma. Fish health was visually examined, samples of tissues were taken for histology, and samples of intestinal fat for pesticide analysis were dried with sodium sulfate in glass vials. Bed sediment was obtained from the lake or river and sealed in a glass vial. Fish fat and sediment samples were extracted and purified for dual-column gas chromatographic analysis for pesticides. The data from this exploratory study indicate that fish from some of the lakes and rivers have significant residues of some of the pesticides suspected of being used to harvest fish. A very high concentration of DDT was found in the fish fat from one of the sites. The ratio of DDT related compounds in the fish fat indicated recent exposure to commercial DDT.

MP79 Hydrogen Fluoride Through the Air: From Emission to Uptake. S. Peterson, M. Garrison, ERM, Exton, PA. Hydrogen Fluoride (HF) is a reactive gas that can enter the terrestrial ecosystem from the air through different pathways: directly through plant stomatal or cuticular uptake, or indirectly through deposition on the ground with uptake through the roots of forage, cultivated crops, and other types of plants. The uptake of HF by forage and cultivated crops is of interest due to the potential for increased fluoride exposure in cows. Although exposure is possible through other routes, the exposure that may occur due to airborne industrial emissions of HF has been the subject of studies conducted in areas surrounding facilities with HF emissions. The proposed poster will examine the transport, dispersion, transformation, and deposition of HF from both a theoretical and empirical perspective: theoretical based on established principles of atmospheric transport and dispersion, and empirical based on available data collected during one EPA-sponsored study at an industrial facility. The uptake of HF by cultivated crops will also be addressed from both a theoretical and empirical perspective, namely, by summarizing approaches to estimating uptake available in the literature but also comparing estimates of uptake based on different HF concentration levels in the air compared to uptake that can be inferred from data derived from the EPA study. The differences between theoretical and empirically-derived estimates of uptake will be highlighted and reasons for the differences proposed and discussed.

MP80 Evaluation of Pesticides, PCBs and Elements in Invasive Bigheaded Carps of the Missouri River at Easley, Missouri USA, 2005. C. Orazio, D.C. Chapman, T.W. May, J.C. Meadows, M.J. Walther, K.R. Echols, Columbia Environmental Research Center, US Geological Survey, Columbia, MO; E.S. Dierenfeld, Saint Louis Zoo, Saint Louis, MO. Efforts are underway to promote the commercial harvest of invasive bigheaded carps (*Hypophthalmichthys*) as a population control measure, with some uses being food for people, pets and zoo animals. Fish in general are a good source of protein and essential nutrients, however fish are also known to bioaccumulate certain toxic elements and persistent organic chemical pollutants. It is critical to understand potential risks associated with their consumption. The objective of this study was to measure chemical contaminant levels in bigheaded carp from a section of the lower Missouri River for comparison to human and animal consumption guidelines. In September of 2005, we collected 30 bighead (*H. nobilis*) and 30 silver (*H. molitrix*) carps from the lower Missouri River near Easley, Missouri USA. Whole-fish composites and skinless boney fillet composites were analyzed for polychlorinated biphenyls (PCBs), organochlorine pesticides, polybrominated diphenyl ethers (PBDEs), dioxin-like compounds, and sixty elements. Percent lipids were measured in whole fish, skin-on fillets, skinless fillets, heads, ovaries, gonads, and belly meat of silver carp tissue samples: Silver carp tissues were three times higher in lipids than bighead carp, for example skinless fillets were 1% versus 0.3% lipid. The bonier bighead carp contained twice the calcium as silver carp. Concentrations of the following chemicals, in both species of bigheaded carp, were below levels of concern for humans, fish and wildlife, or domestic animal foods: total-PCB, sum-DDT, total-chlordane, dioxin-like compounds, lead, cadmium, arsenic, and selenium. PBDEs in whole silver and bighead were 30 and 10 ng/g ww, respectively. Mercury concentrations in silver carp fillets (0.07 $\mu\text{g/g ww}$) were within Missouri's unlimited consumption by sensitive populations category (<0.088 $\mu\text{g/g ww}$). However, under the more conservative advisory of the National Fish and Wildlife Contamination Program of USEPA, 3 fish meals/week limit is recommended; bighead carp fillets averaging 0.21 $\mu\text{g/g}$ mercury were in the USEPA's 1 meal/week range. Silver carp mercury concentrations were well within limits for domestic animal consumption however bighead levels were near the maximum tolerable limits.

MP81 Historical Use Pesticides in the atmosphere of the Chesapeake Bay. A. Goel, EA Engineering Science and Technology, Sparks, MD; A. Goel, A. Torrents, Civil and Environmental Engineering, University of Maryland, College Park, MD; L. McConnell, Agricultural and Research Services, U.S. Department of Agriculture, Brooklyn, NY. Weekly air ($n=271$) and event based rain samples ($n=489$) collected for the period 2000-2003 from three locations in the Delmarva Peninsula (MD and DE) were utilized to determine levels and temporal trends of POPs in the atmosphere. The goal was to assess the contribution of atmospheric input of POPs to the Chesapeake Bay where the water quality and bio-diversity of associated wetlands is on a continued decline. The samples were analyzed for 15 historical use pesticides (HUPs) using gas chromatography-mass spectrometry (GC-MS). Low frequency of detection (<10%) combined with low concentrations reveals that wet deposition is not a significant source of HUPs to the region. HUPs occurred very frequently in gas phase samples (chlordane and HCHs were ubiquitous while other HUPs > 75%), at levels that are consistent with the N-S descending transect (lower than in the Great Lakes) and appear to be decreasing at a faster rate (half lives < 3 yr). Levels of one of the most toxic HUPs, p,p'-DDT, were below our method detection limits. The results suggest that HUPs levels will decrease more rapidly in the Chesapeake Bay region than in the Great Lakes region. Temperature alone did not account for the variability in air concentrations and suggests that long range transport is not the sole source of these compounds to the Peninsula. Transport from local sources (agricultural areas where they were used and urban areas such as Baltimore) corresponding to changes in wind direction appeared to influence air concentrations on the Delmarva Peninsula.

MP82 Concentrations and Patterns of Lipophilic Pollutants in Bottlenose Dolphins (*Tursiops truncatus*) as a Function of Geographical Scale and Implications to Dolphin Health. J. Kucklick, A. Guichard, J. Yordy, Hollings Marine Lab, NIST, Charleston, SC; J. Yordy, Medical University of South Carolina, Charleston, SC; J. Litz, National Marine Fisheries Service, Miami, FL; R. Wells, Chicago Zoological Society, Sarasota, FL; R. Wells, Mote Marine Laboratory, Sarasota, FL; A. Hohn, L. Hansen, National Marine Fisheries Service, Beaufort, NC; T. Rowles, National Marine Fisheries Service, Silver Spring, MD; E. Zolman, L. Schwacke, National Ocean Service,

Charleston, SC; C. Berry, National Marine Fisheries Service, Pascagoula, MS; P. Rosel, National Marine Fisheries Service, Lafayette, LA. The bottlenose dolphin (*Tursiops truncatus*) is one of the most cosmopolitan toothed whales inhabiting temperate and tropical waters around the world. Because of the high degree of site fidelity exhibited by some bottlenose dolphins, this species has been suggested for use as an indicator of local or regional environmental conditions. A large project has been undertaken in the U.S. to non-lethally sample bottlenose dolphins in order to understand how persistent organic pollutant concentrations differ spatially and the implications of these differences to dolphin health. Blubber samples were obtained from bottlenose dolphins inhabiting seven locations on the U.S. East Coast and four locations on the Gulf of Mexico and analyzed for persistent organic pollutants (POPs) including legacy compounds, such as PCBs and DDTs, and currently-use brominated flame retardants, such as PBDEs and HBCDs. Data from males and juveniles were combined for the analyses. There were generally higher concentrations of most POPs in East Coast versus Gulf of Mexico bottlenose dolphins. Within a subpopulation of dolphins inhabiting the same embayment, groups occupying different habitats can have up to five-fold differences in POP concentration. These results indicate that exposure of dolphins to POPs varies spatially and impact of these contaminants on dolphin health also likely varies by location.

MP84 The Perils of Predictive Risk Assessment. S. Goldacker, M.M. Phillips, Gartner Lee Limited, Guelph, Ontario, Canada. Predictive risk assessments (RAs) are often conducted prior to construction of large undertakings, or in advance of major process changes at existing facilities. Unlike contaminated-site RAs, where chemical concentrations can be characterized with sampling, predictive RAs rely on modelled predictions. The use of predicted data adds significant uncertainty to the assessment process. Very little guidance is available for dealing with this uncertainty. Detailed guidance for contaminated-site RAs is available from numerous authorities, but it does not address the specific issues of predictive RA. Because predictive RAs use much of the same data, they are closely allied with environmental impact assessments, for which there is a great deal of guidance, but the two are very different disciplines. RA has been criticized as being a means of rationalizing pollution. Contaminated-site RA can be justified as a tool to direct money and resources toward alleviating the most pressing problems; however, the justification for predictive RA is not as clear because it assesses future impacts. In the environmental assessment of a proposed undertaking, the practitioner is obliged to consider every alternative to the undertaking, including the "do nothing" alternative. The ethics of the environmental assessment process are clearly laid out: in the end, undertakings should only go forward if the benefits outweigh the costs. But what are the ethics of, and rationale for predictive RA?

MP85 Design and application of a transparent and scalable weight-of-evidence framework: an example from Wabamun Lake, Alberta, Canada. B. Wernick, B. McDonald, A. de Bruyn, P. Chapman, Golder Associates Ltd., North Vancouver, British Columbia, Canada; L. Patterson, CN Environment, Surrey, British Columbia, Canada. Weight-of-evidence (WOE) reasoning is increasingly being employed in environmental assessment and risk assessment to organize and prioritize the rapidly-expanding range of assessment tools available to evaluate possible ecological impacts. Numerous approaches to WOE have been proposed, but a general consensus has not yet emerged as to the best way of incorporating best professional judgement concerning the quality, extent and congruence of data. A WOE framework was developed to evaluate potential impacts to the aquatic ecosystem of Wabamun Lake (Alberta, Canada) associated with the release of Bunker 'C' oil following a train derailment in August 2005. The wide variety of stakeholders and interested regulatory agencies made it necessary to develop a clear, consistent and transparent approach to assessing ecological impacts on a range of ecosystem components within the lake. The resulting WOE framework used a combination of benchmarks and reference conditions to evaluate a total of 38 different LOE, a set of a priori and a posteriori factors to differentially weight these LOE, and a combination of numeric and non-numeric rating systems to integrate the LOE for five ecosystem components. This poster will describe the development of this WOE framework, with emphasis on techniques that enhance the consistency and transparency of the application of best professional judgement.

MP86 In Situ Experimental Assessment Of Lake Whitefish Development Following A Freshwater Oil Spill. B. Wernick, A. de Bruyn, B. McDonald, B. Rudolph, P. Chapman, Golder Associates Ltd., North

Vancouver, British Columbia, Canada; L. Patterson, CN Environment, Surrey, British Columbia, Canada. Wabamun Lake (Alberta, Canada) has been subject to ongoing contamination with polycyclic aromatic hydrocarbons (PAHs) from multiple sources for decades, and in August 2005 was exposed to ca. 149,500 L of Bunker 'C' oil following a train derailment. Sublethal effects of chronic PAH exposure in developing fish embryos have been shown in numerous laboratory studies but field-based assessments are rare. The objective of our study was to bridge the gap between laboratory studies and field observations with an in situ experimental incubation. We compared the pattern, frequency and severity of deformity in larvae of lake whitefish (*Coregonus clupeaformis*) incubated in situ in areas of Wabamun Lake exposed only to 'background' PAH contamination and in areas additionally exposed to PAHs from the oil. All sites in the lake (including reference areas) showed incidences of deformity higher than are typically observed in laboratory studies. A small number of oil-exposed sites showed higher incidences of some teratogenic deformities and a tendency to exhibit deformities of higher severity than sites not exposed to oil. The frequency of moderate to severe deformities in 8 of 16 classes was correlated with PAH exposure. Nonmetric multivariate ordination of deformity data showed a general pattern of increasing incidence and severity of several skeletal (lordosis, scoliosis) and craniofacial (ocular, jaw) deformities at sites with relatively high exposure to oil-derived PAHs. A simultaneous consideration of incidence, severity and pattern of deformity enabled us to detect a consistent (overall ~5% above background) response to the oil despite high variability and high 'background' deformity rates in this historically contaminated environment.

MP87 Ecological Risk Transfer Factors for Environmental Samples Near a Hazardous Waste Incinerator in a Semi-Arid Environment. V.L. Harter, Environmental, Washington Group International, Hermiston, OR; A.L. Bunn, T.B. Miley, Pacific Northwest National Laboratory, Richland, WA. Emissions from hazardous waste incinerators can result in metals and organics entering the environment from deposition as well as through transport within environmental media and biota. A comprehensive monitoring program was established at a hazardous waste incinerator in northeastern Oregon to assess concentrations of chemicals potentially disseminated from operations, and to determine if concentrations in the environment remained at or below values predicted during a preliminary ecological risk assessment. Data collected over the last eight years offer an opportunity to evaluate transfer of chemicals from atmospheric deposition onto soil and plants and into biota in a shrub-steppe, semi-arid environment. A total of 19 sampling locations have been included in this assessment, and those locations were selected based on predominant wind flow and population centers. Sampling sites were grouped into zones around the incinerator: within a 12 km radius, 50 km radius, and 100 km radius. Soil, vegetation, insects and small mammals were collected at each site on a quarterly basis. Data collection began 3.5 years prior to operation of the incinerator (14 quarterly sampling events) and continued for over 3 years of incinerator operations (13 quarterly sampling events). Analyses included dioxins and furans, polychlorinated biphenyls, metals, and semivolatile compounds. Ecological risk transfer factors were only calculated for contaminants above detection for at least 50% of the sampling events. The subset of contaminants evaluated for transfer factors were four metals and two dioxins in all four media. The influence of seasonal variability and distance to the emission source were evaluated within the data set. Two recent quarters of data were used to confirm the methodology for calculating transfer factors. Transfer factors will be applicable for assessing impacts of air deposition at other hazardous waste incinerators in semi-arid environments.

MP88 Comparison of Benthic Macroinvertebrate Communities Among Native, Restored, and Pollutant-Impacted Salt Marshes in the Galveston Bay System. K.L. Farmer, J. Dobberstine, C.L. Howard, Environmental Science, University of Houston Clear Lake, Houston, TX; J. Dobberstine, Galveston Bay Foundation, Houston, TX. The Galveston Bay, Texas system ranks among the most productive estuaries along the Gulf Coast; however, it is threatened by chemical contamination, subsidence, and development. The Galveston Bay Management Plan has established one of its highest priorities to restore and remediate contaminated and damaged marshes. Benthic macroinvertebrate communities are often used as indicators of estuarine health as they contribute to the food web and nutrient cycling within the marshes. Although contamination effects on benthic communities are well known, there is a lack of information on benthic establishment in restored marshes and the exacerbating effects of pollution. This study compared benthic macroinvertebrate species composition, abundance and diversity

among nine sites representing native, restored, and pollutant-impacted salt marshes. At each site, five 2" x 4" core samples were collected at 5-m intervals along a T-shaped transect. Samples were sieved through a 0.5 mm mesh screen and preserved with 10% buffered formalin, then were identified to the lowest possible taxon and enumerated to determine diversity and abundance. Benthic data were analyzed alongside sediment chemical data for each site. The preliminary results indicate that abundance and diversity varied among marsh types and species composition and structure were affected by sediment chemistry. The ultimate data from this project may be used by management agencies to answer questions concerning the health of restored and impacted Galveston Bay marshes.

MP89 Practical experiences and value added uses of the NHDPlus dataset. C.G. Hoogeweg, C.M. Holmes, R. Vamshi, Waterborne Environmental, Inc., Leesburg, VA; J. Prenger, P. Miller, Waterborne Environmental, Inc., Champaign, IL. The poster describes practical experiences using the NHDPlus dataset as well as value-added uses from a programmable perspective to delineate upstream watersheds. The updated National Hydrography Dataset (NHDPlus) was released by USGS in 2006. It provides an invaluable new resource that allows for a dynamic analysis of hydrologically consistent stream networks and their corresponding drainage basins. The NHDPlus dataset and tools have integrated the flowline and catchment data such that users can analyze catchment areas upstream of monitoring locations or other points of interest. For any selected flowline, the NHDPlus Navigation Tool traverses its stream network, which can be joined to the catchment geography to create a watershed for use in risk assessments and spatial analysis. This method is limited to identifying one watershed at a time for a manually selected flowline. For regional analyses, an automated process to create spatially unique watersheds are crucial for environmental assessments. A GIS tool for delineating watersheds was developed for the NHDPlus dataset. The dynamic link library (*.dll) file provided by the NHDPlus team is embedded in this tool in order to traverse stream networks, as well as a process of elimination to ensure that watershed delineations are unique (i.e., no multiple upstream delineations for the same point). Utilizing the downstream flowline linking field, the watershed dataset can be used with the full range of NHDPlus data including land use, flow estimates, etc. Practical experiences using the NHDPlus dataset in relation to flowline navigation will also be illustrated and discussed.

MP90 Mobile Technology for Real-Time Pesticide Application for Vegetation Management. C.M. Holmes, C.G. Hoogeweg, Waterborne Environmental, Inc., Leesburg, VA; A. Barefoot, DuPont Crop Protection, Newark, DE. This novel approach uses mobile GIS technology to inform operators in the field of nearby restricted areas related to pesticide applications. The device utilizes a handheld computer connected to a GPS receiver, and running ESRI's ArcPad software. This system is designed for use with railroad right-of-way vegetation management and the identification of the California Ground Water Protection Areas (GWPA). California has established these areas as vulnerable to the movement of pesticides to ground water. Application restrictions apply within these areas and it is important for operators to know when they are approaching or entering a GWPA. While in operation, the system checks as each GPS signal is received and compares the current location to the nearest GWPA. When the current location is within a specified distance of a GWPA, a signal is given to the operator. Although, developed for California, the system can easily be implemented and tailored for other uses (e.g., stream buffers, endangered species locations, specific soil properties, etc.). This technology represents a flexible, affordable, and easy-to-use system for pesticide application management.

MP91 A Multi-tiered Chemical and Ecological Assessment of Southern Alabama Streams. V.D. Tollett, C. Bedwell, J. McCreadie, T.M. Rice, Biological Sciences, University of South Alabama, Mobile, AL. The Mobile/Tensaw Delta is one of the largest deltas in the United States, comprising 2/3 of the state of Alabama and portions of Georgia, Mississippi and Tennessee. The Mobile River contains several EPA Superfund areas. Other non-point pollution sources include agriculture, forestry and urbanization. The results presented here are included in a comprehensive assessment of the health of 27 streams that feed into the Delta. Physico-chemical parameters were measured to provide general stream characteristics. Surface water and sediment samples were collected at each stream and analyzed for inorganic and organic contaminants. As an ecological endpoint, a survey of benthic macroinvertebrates provided species diversity comparisons among streams. Assessments were conducted in spring and summer for seasonal comparisons.

Contaminant analysis indicates that inorganics and organics are detectable but in most cases below water or sediment criteria values. In particular, mercury in sediments is very low despite being a serious concern in other areas of the watershed. Benthic diversity analysis indicated a variety of species expected for this type of habitat. Principle Components and Cluster Analysis were used to determine if the chemical profiles could be predicted based on the biodiversity indices. In general, most streams appear to be relatively intact, but some differences between the developed Mobile side and the under-developed Tensaw side were detected.

MP92 Toxicity of runoff from two urban highways in Los Angeles. C. Stransky, Nautilus Environmental, San Diego, CA; M. Kayhanian, Center for Environmental and Water Resources Engineering, Department of Civil and Environmental Engineering, University of California, Davis, Davis, CA; S. Lau, M. Stenstrom, Department of Civil and Environmental Engineering, University of California, Los Angeles, Los Angeles, CA. The toxicity of stormwater runoff from urban highways was evaluated for a number of storm events at three locations in Los Angeles during the 2004-2005 rainy season. Grab samples, collected at 15 to 60-minute intervals were tested individually. Composite samples, consisting of up to 12 grabs from a single location during each storm event, were also tested for comparison. Chronic toxicity was evaluated using the freshwater cladoceran, *Ceriodaphnia dubia*, and the fathead minnow, *Pimephales promelas*. Results showed that toxicity often varied substantially throughout the storm events for both species. In general, the first few samples were more toxic compared to those collected during the later stages of a given storm. More specifically (in most cases), 90% of observed toxicity occurred during the first 30% of storm duration. In addition, over 40% of the toxicity was associated with the first 20% of the total runoff volume. However, while both species responded to a first-flush effect in individual grab samples, composite samples were non-toxic. Thus, results obtained indicate that treatment of the first-flush portions of stormwater will best benefit the quality of highway runoff. Toxicity identification evaluations, which were conducted to aid in BMP development/selection, identified copper and zinc as the primary cause of toxicity in most samples tested. Surfactants were also identified as a primary cause of toxicity in at least one sample.

MP93 Water Quality Impacts by Golf Courses. R.D. Baris, J. Lam, S.Z. Cohen, N. Barnes, Environmental & Turf Services, Inc., Wheaton, MD. Interest in water quality impacts by golf courses has grown significantly in the last two decades, due partly to the intense public scrutiny proposed golf courses receive during the local permitting process. Results from permit-driven studies are frequently not published nor is there usually widespread knowledge about them. We previously reported on an assessment of data from 36 golf courses (Cohen et al., 1999). We now have data from 80 golf courses. Forty-six studies from a 20 year period passed our quality control and other review criteria and were incorporated into a detailed data review. A total of 36,195 data points from pesticide, metabolite, total phosphorus, and nitrate analyses of surface water and ground water were reviewed. There were approximately 166 organics analyzed in the surface water database and approximately 137 organics analyzed in the ground water database. Widespread and/or repeated water quality impacts by golf courses are not happening at the sites studied. None of the authors of the individual studies concluded that toxicologically significant impacts were observed, although HALs, MCLs, or MACs were occasionally exceeded. The percent of individual pesticide database entries that exceeded HALs/MCLs for ground water and surface water are 0.07% and 0.35% respectively. The percentages would be higher if they could be expressed in terms of samples collected rather than chemicals analyzed. The MCL (10 mg/L) for nitrate-nitrogen in surface water was exceeded in 40 entries (~0.02%), and only 19/1,317 (1.4%) of the samples exceeded the MCL in ground water. There were 26 exceedances of the total phosphorus ecoregional criteria in three ecoregions -- 18 for rivers and streams, and eight for lakes and reservoirs. We are evaluating the data to determine whether there are trends for detected pesticides to be more persistent and more mobile than pesticides that were not detected. The inclusion of the EPA's ecoregional criteria, specific ground water regions, climate zones, as well as additional data for golf courses in the northwestern, mid-continent, and southwestern portions of the country provide a more comprehensive analysis of water quality impacts by golf courses compared with the 1999 meta-analysis.

MP94 Mining effects confound urban biomonitoring signal in lichens in Huascarán National Park, Peruvian Andes. A. Almenara, Risk and Environmental Monitoring, Golder Associates Ltd., Calgary, Alberta, Canada; J.P. Bennett, Nelson Institute for Environmental Studies, University

of Wisconsin, Madison, WI. Lichen biomonitoring of atmospheric emissions is used world-wide to detect elevated levels of elements in the environment. We explored their use to biomonitor urban impacts on lichens in Huascarán National Park (HNP), Peru by sampling 6 different lichen species at 18 localities inside and outside the park. HNP is an interesting case study because of its location in one of the most important cities in the highlands of Peru (Huaraz) a center of commercial activities for the highlands, and an important agriculture and mining area. Several causes of urban and non urban pollution were analyzed to identify whether urban impacts can be identified through lichen biomonitoring. The traffic analyses suggested that Ag, Al, As, Cd, Cr, Cu, Pb, S and Sb increase with the increase of traffic, including in one of the national park internal roads which has higher levels of arsenic, lead and antimony. Except for silver and antimony, the other elements are known to come from vehicle exhausts fumes. Agriculture decreases with elevation (the national park is at the higher elevation sites) and also with distance from the HNP, therefore we were expecting to see effects from agriculture pollution through the elevation variable. Bromine was the only element showing a significant decrease with elevation in the analyses by elements. From the location of current mines surrounding the National Park, relationships between some elements and some of the factors were found. Ag, Ca, Cu, Ni, and Pb showed a pattern of higher concentrations in the sites near the southeast area of the park where intense mining activity is being carried out. Unfortunately we found that the emissions of several metals, in special Zn and Cu from large mining operations within and near the park are so large they mask the concentrations caused by urban emissions. Further analyses of Pb, S and As concentrations may yet reveal an urban signal separate from the mines. Maps of lichen tissue concentrations of these elements will be presented showing the geographic relationships between them and the cities and mines of the area.

MP95 Stressor identification and health assessment of fish exposed to wastewater effluents in Miho Stream, South Korea. D. Yeom, Korea Institute of Toxicology, Daejeon, South Korea. This study evaluated the effects of an industrial wastewater treatment plant (IWTP) and a municipal wastewater treatment plant (MWTP) effluents on a variety of bioindicators ranging from biochemical, organism, and population-level responses in pale chub (*Zacco platypus*) and fish community structure. The Index of Biotic Integrity (IBI) indicated that the site upstream of these wastewater treatment plant discharges is in fair-good condition and downstream of the plant is in poor condition. The EROD (ethoxyresorufin-O-deethylase) activity, condition factor, and liver somatic index were significantly increased at the downstream site compared to those of the upstream site. The most significant change observed in pale chub population in the downstream site of the Miho Stream, relative to the upstream population, was the total absence of younger age group. Stressors impacting the downstream site were identified as mostly organic or nutrient enrichment and habitat degradation associated with wastewater treatment plants. The results of causal analysis suggest that the primary causes affecting fish population in the downstream site are through both size-selective mortality caused by ammonia toxicity and recruitment failure caused by habitat degradation and reproduction problem due to an IWTP and a MWTP effluents.

MP96 Intersex in *Littorina littorea* as a Measure for Ecological Risk from TBT Exposure in Dutch Marine Coastal Waters. C. Schipper, RIKZ, Den Haag, Netherlands; M. Smit, TNO, Den Helder, Netherlands. In order to increase the ecological relevance of intersex (ISI) in periwinkle (*Littorina littorea*) as a biomarker for tributyltin (TBT) pollution, this study investigates the relationship between ISI values and the concentration TBT in the environment. Periwinkles were selected because they are ubiquitous in areas of the Dutch coastal zone with heavy shipping. We assessed the spatial distribution of TBT concentrations in sediments, in suspended matter (SPM) in relation to the experimentally determined prevalence of ISI in periwinkles. To determine the relationship between the prevalence of intersex (ISI) in periwinkles in the Dutch coastal zone and harbours and levels of TBT ($6.2 - 3800 \mu\text{g Sn/kg dw}$), we measured TBT concentrations in a number of compartments water, suspended matter, sediment, dredging material and biota in year(s). The results of this field study show that raised ISI levels rarely occur outside harbour areas. In open waters (TBT; $6.2 - 73.2 \mu\text{g Sn/kg suspended matter}$), ISI levels never exceed 0.05. However, relatively high ISI values occurred in parts of the harbours where periwinkles were present. The ecological risk expressed as the PAF (Potentially Affected Fraction) of periwinkles on basis of spatial distributions of measured TBT ranged from

4.2% to 15.3% for open coastal waters, and from 3.5% to 26.9% for harbours. Based on this study it is suggested that the absence of periwinkles in harbours can be explained by relatively high TBT concentrations.

MP97 The Use of a Tritium Labeled Test Material to Evaluate the Biodegradation of the Commercial Surfactant Mixture, High Solubility Alkyl Sulfate (HSAS), in Simulation Tests. T. Federle, N. Itrich, E. Schwab, Central Product Safety, The Procter & Gamble Company, Cincinnati, OH. High Solubility Alkyl Sulfate (HSAS) is an anionic surfactant, which has laundry applications and can facilitate cold-water washing. It is a complex mixture of homologues with an average of 1.7 methyl substitutions randomly distributed along a predominantly linear alkyl chain. Using standard ^{14}C labeling techniques, it was impossible to assess the biodegradation of all homologues within the mixture. Consequently, the precursor fatty alcohol mixture was tritiated and then sulfated to form a full tritiated commercial mixture of HSAS. This made it possible to follow the disappearance of parent molecules, formation and subsequent disappearance of intermediates, uptake into biomass and mineralization of the mixture under realistic conditions in raw sewage, activated sludge, anaerobic digester sludge and an effluent-surface water mixing zone as well as in aerobic and anaerobic sediments. In these tests, formation of tritiated water rather than radiolabeled carbon dioxide served as the measure of ultimate mineralization. Primary biodegradation of HSAS was rapid in all these habitats and was associated with extensive mineralization. The resulting rates were indicative of efficient removal during wastewater treatment, resulting in very low levels of HSAS being present in effluent or sludge leaving a typical wastewater treatment plant. Furthermore, the study showed the utility of tritium labeling for quantifying the primary and ultimate biodegradation of commercial mixtures as well as any chemical released to wastewater using the procedures outlined in the new guideline describing simulation tests for assessing the biodegradation of such chemicals, which is currently under development within OECD.

MP98 Assessing the status of the dog whelk (*Nucella lapillus*) in the Dutch coastal zone (1923-2006). C. Schipper, RIKZ, Den Haag, Netherlands; R. Laane, RIKZ, Den Haag, Netherlands. Hormone-disrupting effects of tributyltin compounds (TBT) in marine gastropods *Buccinum undatum*, *Nucella lapillus* and *Littorina littorea* have been observed also in the Netherlands. Various studies have shown that *L. littorina* is well suited for TBT effect monitoring in harbours because it is a common organism and tolerant to relatively high TBT levels. The dog whelk *Nucella lapillus* is more sensitive to TBT and therefore ideally suited to monitor effects of TBT in less polluted coastal areas of the North Sea. In 2006 a baseline study of the occurrence of *Nucella lapillus* was started in the coastal zone of the Netherlands. The spatial distribution was systematically monitored on approximately 100 sampling sites and compared with old data (1923-2005). Dog whelks were only found to breed successfully in the Delta area in the S.W. of the Netherlands from 1923 to the seventies diminishing in the eighties and nineties and recovering slightly in the last 10 years. No *Nucella lapillus* were found along the coastline between Hook of Holland-Den Helder and at the Wadden Sea island in the last decades although they were found the period 1923-1970. From these observations alone it is unclear whether this was caused by the relatively high levels of TBT or other stress factors (e.g. salinity, excessive sand transport, etc). To establish whether or not TBT is indeed the cause of the decline and absence of the dog whelk population in certain areas along the Dutch coastal zone, both the presence of *Nucella lapillus* and the incidence of TBT imposex (VDSI) has to be monitored annually.

MP99 Non-target Deposition and Losses of Chlorothalonil in Irrigation Run-off Water From a Commercial Foliage Plant Nursery. P.C. Wilson, C.G. Rolan, Soil and Water Science, University of Florida/IFAS, Fort Pierce, FL. This study characterized non-target deposition of the fungicide chlorothalonil on ground surfaces, and subsequent losses through surface runoff water during irrigation events. The study area was located at a commercial foliage plant nursery in Florida. This area was used for palm production, and was located within a hydrologically defined section of the nursery. To estimate non-target deposition, Teflon targets were deployed along transects within the production area prior to fungicide application. Daconil Ultrex® (85% chlorothalonil) was applied at a rate of 4,583 L-mixture/ha using a commercial sprayer. Following application, the Teflon targets were retrieved and stored at -17°C prior to extraction and analysis. Chlorothalonil was extracted using pesticide grade ethyl acetate, and analyzed using an HP 5890 Series II Gas Chromatograph equipped with dual electron capture detectors (ECD). To estimate chlorothalonil losses in runoff water, samples

were collected every 15 minutes throughout the first irrigation event following application. Volume of water discharged from the area was estimated by measuring flow depth every five minutes in calibrated weirs. Chlorothalonil was extracted from the 200 ml sample aliquots using a modification of EPA method 3535, solid-phase extraction (SPE). Extracted chlorothalonil was analyzed as previously described. Results indicate that non-target deposition is relative to distance from sprayer, plant type, and density. Total non-target deposition ranged from 9.8% to 53.6 % of total applied. A total of 0.53% of the estimated chlorothalonil deposited on the non-target ground surfaces was lost in irrigation runoff water during the first irrigation event. Chlorothalonil concentrations ranged from 3 to 500 $\mu\text{g/L}$. These results will be useful for estimating impacts of chlorothalonil on non-target biological processes.

MP100 Evaluation of the Reliability of Fate and Exposure Characterization Factors Using Sensitivity Analysis. M. Margni, R.K. Rosenbaum, CIRAIG, Montreal, Quebec, Canada; T.E. McKone, LBNL, University of California, Berkeley, CA; O. Jolliet, University of Michigan, Ann Arbor, MI. The goal of this paper is to illustrate and apply a process for evaluating the reliability of characterization factors (CFs) derived from environmental fate and exposure models. Reliability refers to both accuracy and precision, but our focus here is primarily on precision. Sensitivity and uncertainty analyses are procedures that are frequently carried out during development and application of models. We use sensitivity analysis here to investigate effects of lack of knowledge and other potential sources of error on the relative magnitude of CFs. This work builds on a recent comparison of five fate & exposure models where typical variation across models was one to two orders of magnitude. We then use a single model with two databases covering the same substances but with different property data to assess the uncertainty and sensitivity to variation in these databases, where we find up to four orders of magnitude differences—high compared to inter-model variation. Critical and often missing information are data on degradation half lives. We will discuss in detail which half-life plays a significant role depending on chemical properties, exposure pathways, and how to focus data collection efforts on the most significant parameters. In this process we find that sensitivity analysis has value in the model development phase to establish model goals and examine the advantages and limitations of alternative algorithms.

MP101 Terrestrial Risk Assessment of Triclosan in Land-Applied Biosolids. J.L. Lyndall, T. Barber, ENVIRON International Corporation, Burton, OH; M. Capdevielle, Colgate-Palmolive Company, Piscataway, NJ. Triclosan is an antimicrobial compound that is widely used in personal care products in concentrations ranging from 0.1% to 0.3% active ingredient by weight. A terrestrial ecological risk assessment was conducted to evaluate the potential risks to terrestrial organisms from the normal use and disposal of triclosan. The conceptual site model included disposal down the drains, sewage conveyance to wastewater treatment plants, and the production of sludge, which may be applied to land as biosolids. Biosolids (and any associated triclosan) are spread and mixed with the surficial soil. Therefore, soil functions as the primary source of triclosan exposure to ecological receptors. Following uptake by terrestrial organisms (e.g., soil and litter invertebrates, plants, and mammals), biota tissue functions as a secondary source of exposure to upper trophic level receptors. The terrestrial risk was assessed by comparing predicted exposure concentrations and effects toxicity thresholds for each receptor of interest. Modeled exposures were evaluated probabilistically, in order to account for variability in each exposure factor parameter and to account for stochastic events in the environment. The benefit of using probabilistic methods in risk assessment is that they fully characterize risk, rather than providing a best estimate or a conservatively biased estimate of risk. Soil concentrations were used to assess direct contact and ingestion soil exposures for trophic level 1 (e.g., grasses) and trophic level 2 (e.g., soil invertebrates, litter invertebrates) receptors. Plant, invertebrate, and trophic level 3 mammal (e.g., deer mouse) tissue concentrations were used to as estimated dietary concentrations to determine dietary doses for trophic level 3 and 4 birds (e.g., kestrel) and mammals (e.g., red fox). Effects in terrestrial receptors of interest were characterized by calculating ecotoxicity thresholds based on published and unpublished exposure studies. The risk characterization compared the exposure concentration, dose, body burden, or dietary concentration to appropriate ecotoxicity thresholds and dose-response curves. All predicted environmental concentrations were below the derived ecotoxicity thresholds, indicating that environmentally relevant risks of triclosan in land-applied biosolids are negligible.

MP103 Occurrence of Pharmaceuticals and Personal Care Products (PPCPs) in Aquatic Ecosystem in Japan and Influence of Chlorination on PPCPs. R. Kubota, M. Tahara, K. Shimizu, H. Tokunaga, T. Nishimura, Division of Environmental Chemistry, National Institute of Health Sciences, Tokyo, Japan; T. Suzuki, Tama Branch Institute, Tokyo Metropolitan Institute of Public Health, Tokyo, Japan; M. Seki, Kurume Laboratory, Chemicals Evaluation and Research Institute, Fukuoka, Japan. Recently, worldwide concern on pharmaceuticals and personal care products (PPCPs) has increased markedly. PPCPs and their metabolites are continually introduced into aquatic ecosystem and are prevalent at detectable concentrations, which can affect water quality and potentially impact drinking water supplies. However, comprehensive survey has not been conducted on PPCPs in aquatic ecosystem in Japan. Moreover, the information about removal techniques, such as chlorination and ozonization, on PPCPs is limited. In this study, we investigated the occurrence of fifteen PPCPs in water samples (sewage water and river water) collected from urban and rural areas of Japan, and evaluated the influence of chlorination on PPCPs. PPCPs (except erythromycin, paroxetine, and fluvoxamine) were detected in almost all sewage water samples from urban area of Tokyo. Although, detection frequencies of fenofibrate and triclosan were relatively low, other PPCPs were detected at high frequency (80-100%) in raw sewage water samples. On the other hand, detection frequencies of PPCPs in treated sewage water (66.7-100%) were similar or lower than those of raw sewage water samples. Concentrations of detected PPCPs in sewage water were ranged from 7.3ng/L to 18.3 $\mu\text{g/L}$. The highest value was observed in bezafibrate in raw sewage water sample. Moreover, roxithromycin, diclofenac, mefenamic acid, ethebamide, and carbamazepine were detected at comparatively high concentrations. Influence of chlorination on PPCPs was examined. Among fifteen PPCPs, almost PPCPs decreased by chlorination to 0% of the initial concentration in 0.5 hours, or to less than 20% of the initial concentration in 4 hours. On the other hand, fibrates, ethebamide, carbamazepine, and fluvoxamine were remained to 54-100% of the initial concentration in 4 hours. Further study should clarify the removal ability of these PPCPs by activated carbon treatment and ozonization. This study was supported by Grants-in-Aid from CERI Collaborative Research Program.

MP104 Load to Aqueous Environment in Urban Area by Sewage Treatment Water on Pharmaceutical and Personal Care Products. T. Nishimura, R. Kubota, M. Tahara, K. Shimizu, H. Tokunaga, Environmental Chemistry, National Institute of Health Sciences, Tokyo, Japan. The compounds with the bioactivities of pharmaceutical and personal care products (PPCPs) were detected in the water samples in the aqueous environment. In a knowledge reported at present, the measured environmental concentrations and effect/no observed effect concentration ratio were low level except several compounds. However, it is important that the emission sources are identified and then controlled in order to reduce potential risk more. In Japan, the percentage of the flush toilet has reached over 85% and the coverage of sewerage has reached over 65%. Therefore, PPCPs in the excrement seem to pass through the sewage-treatment plants and then flow out into aqueous environment in urban area. We selected three rivers flowing in the urban area near Tokyo, Tama River, Sagami River and Koyama River. The monitoring about eleven PPCPs was carried out in order to clarify the emission sources in winter. In Tama River, eleven kinds of PPCPs were all detected. In Koyama River, four kinds of PPCPs were detected and the concentrations of these PPCPs were lower level than those in Tama River. In Sagami River, none of PPCPs were detected. In Sagami River, water was sampled at the upstream from the outfall of the sewage treatment plant. There were six outfalls of the sewage treatment plants from the sampling site to the upstream in Tama River, and two outfalls of the sewage treatment plants in Koyama River. Eleven kinds of PPCPs were all detected in the discharge from the sewage treatment plant, and the concentrations of these PPCPs were about ten times those of the river water in Tama River. From these results, it was indicated the discharge from sewage treatment plant in the urban area greatly contributed as a main inflow source of PPCPs to the river. In the future, it is necessary to also monitor the river water flowing in other urban area and rural area and to examine the emission sources. Additionally, it is necessary to monitor the rivers assumed the load from the stockbreeding. The research was supported by Grants-in-Aid from the Ministry of Health, Labor and Welfare of Japan.

MP105 Fate and Partitioning of Triclosan in Wastewater Treatment Processing. J.L. Lyndall, T. Barber, ENVIRON International Corporation,

Burton, OH; M. Bock, ENVIRON International Corporation, Portland, ME; M. Capdevielle, Colgate-Palmolive Company, Piscataway, NJ. The fate of triclosan during wastewater treatment processing was assessed to determine triclosan partitioning within the wastewater treatment plant (WWTP) system. Triclosan in personal care products is most frequently disposed down the drain where it is conveyed to WWTPs for processing. Wastewater treatment plants generally consist of preliminary, primary, secondary, and tertiary treatment compartments as well as solids handling. Wastewater treatment processes remove triclosan to a very high degree of efficiency via biodegradation and sorption to solids. Although sorption and degradation are clearly key factors in the removal of triclosan from WWTPs, the relative magnitude of their roles is uncertain. To help clarify this issue, a fugacity model (based on STPWIN model) was used to conduct a triclosan mass balance within the WWTP compartments. This model uses WWTP compartment-specific input parameters to estimate the total removal and three contributing processes (biodegradation, sorption to sludge, and volatilization) for a standard system and set of operating conditions. Additionally, a probabilistic analysis was conducted to assess the significance of various operational parameters and biodegradation rates. Results are consistent with field measurements and confirm the high removal efficiency of triclosan. Of the removed triclosan, approximately two thirds was sorbed to sludge and one third was biodegraded. Volatilization was negligible in all treatment compartments. Most sorption to sludge occurred in the primary treatment phase, when settleable solids were removed. Secondary treatment accounted for the remainder of sorption, as the triclosan would likely sorb to the activated sludge in this phase. Triclosan sorbed to primary sludge is likely to be landfilled, whereas triclosan sorbed to secondary sludge is typically composted and applied to land as biosolids.

MP106 Determination of Ecologically Relevant Pharmaceuticals and Selected Metabolites in Effluent and Surface Water using UPLC/MS/MS. A.L. Batt, M. Kostich, J.M. Lazorchak, National Exposure Research Laboratories, U.S. Environmental Protection Agency, Cincinnati, OH. The frequent detection of many pharmaceutical compounds in the environment has become an increasing concern due to their potential to cause undesirable ecological effects. Presently, wastewater treatment plants (WWTPs) are not designed remove trace levels of contaminants, such as pharmaceuticals, and these compounds are consequently released into surface waters. Solid-phase extraction (SPE) and ultra performance liquid chromatography in combination with triple quadrupole mass spectrometry (UPLC/MS/MS) conditions were optimized for the analysis of over 60 pharmaceuticals belonging to a multitude of different classes in wastewater effluent and surface water. The target analytes represent many classes of prescription pharmaceuticals, including corticosteroids, hormones, antidepressants, calcium channel and beta blockers, statins, and antibiotics. The single-cartridge extraction step was developed using a mixed mode cartridge (Oasis MCX), with the majority of the recoveries being between 80% and 120% with relative standard deviations of 15% or lower. To maximize sensitivity, the analysis was divided into multiple chromatographic runs allowing for longer dwell times for each transition, with the majority of the method detection limits being in the low ng/L range. The methods will be used in future studies to assess the impact of pharmaceuticals typically present in WWTP discharges on the ecological health and quality of surface waters.

MP107 Spatial and Temporal Variability of Dissolved Trace Metals and Its Impact on the Water Quality in the Godavari river, India. K. Balakrishna, G. Mugeraya, G. Srinikethan, Chemical Engineering, National Institute of Technology Karnataka, Mangalore, India. Water quality studies in India have neglected to quantify and monitor the changes in dissolved trace metal concentrations in rivers mainly for want of advanced instrumental facilities and the cost involved. But studies have pointed out that certain toxic metals like lead and cadmium can affect the human body even at parts per billion level concentrations in the water. This study has filled this gap with respect to the largest peninsular Indian river, Godavari, at Rajahmundry, and hopes that the information generated in this study would help the decision makers and analysts to redraft their water quality monitoring strategy. Eleven bi-monthly field trips were made between September 2003 and June 2005 and 47 surface water samples are collected near the Godavari river water end member at Rajahmundry. This was done to study both spatial and temporal variations. These samples are analysed for major ions, dissolved organic carbon, and trace metals (24 metals) using the facilities available at my host institute, CMFRI Mangalore, NGRI Hyderabad, and University of Southern Mississippi, USA.

Peak flow season brings in weathering products rich in rare earths and trace metals leading to an order of increase in concentrations of Cr, Fe, Mn, Cs, Co, Ni and rare earths compared to moderate and low flow seasons. Therefore, with an increase in discharge, there is an increase in the concentration of these metals. pH, alkalinity, dissolved oxygen are uniform through out the year, and does not control the variability of dissolved trace metals in the Godavari river. Spatial variations in dissolved trace metals highlight station PM (downstream of the site where treated paper mill effluents are discharged) with very high concentrations in all the metals except rare earths, Cr, Fe, Li and Cs, compared to the rest of sampling stations. Due to possible adsorption and settling with the particulates, the stations downstream do not reflect their concentrations. Spatial variations in major ions pointed out two sampling stations PM and VIP (downstream of PM) that showed concentrations higher than the rest of the samples. The station PM receives treated effluents from the paper mill with concentrations 4.6 (SO₄) to 37 times (Cl) higher than that of the rest of the samples, while station VIP attracts domestic effluents contributing to an increase in pH, alkalinity, and high Mg.

MP108 Selenium Concentrations and Speciation in Prairie Waters. X. Hu, F. Wang, M.L. Hanson, Environment and Geography, University of Manitoba, Winnipeg, Manitoba, Canada. Selenium is an essential micronutrient in animals and humans, though it can cause toxicity which is dependent on not only its concentration but also its speciation. Irrigation-dependant agriculture is wide spread in western Canada, and considered to be a possibly significant source of selenium. The objective of the present study was to assess selenium levels and speciation in prairie wetlands, and provide important insight into potential ecological risk of elevated selenium in prairie ecosystems. Samples of surface water, sediment, sediment porewater, and aquatic plants were collected from three sites in southern Manitoba: Delta Marsh, Stephenfield Reservoir, and the South Tobacco Creek Watershed. The selenium levels in the surface water were relatively low (0.4-2.4 µg/L), but seasonal variation was observed in the South Tobacco Creek Watershed, where ~11 µg/L of selenium was found in the surface water during the spring fresher season. A mesocosm study with selenite (⁸²SeO₃²⁻) addition was conducted in Delta Marsh, Manitoba during the summer of 2007. By tracing the concentration of ⁸²Se in different selenium species in the surface water, sediment and sediment porewater, the transformation and transportation of selenium in prairie wetlands were better understood. A HPLC-ICP-MS method was developed which was capable of separating and analyzing Se(IV), Se(VI), and methylselenocysteine at a detection limit of ~0.3 µg/L in natural field waters.

MP109 Development of a zinc stable isotope technique to determine metal pathways and bioavailability to aquatic organisms. A. Todd, R. Wolf, P. Lamothe, K. Smith, USGS, Denver, CO; S. Brinkman, Colorado Division of Wildlife, Fort Collins, CO; J. Ranville, Colorado School of Mines, Golden, CO. Aquatic organisms are known to retain and accumulate dissolved heavy metals from their environment, with levels of uptake dependent on both exposure concentration and duration. In freshwater fish, the gill is widely considered to be the primary site of acute toxicity for many metals, and it has been proposed that accumulated metal can be used as an indicator of toxicity. The measurement of zinc accumulation on gill tissue is complicated by inherent difficulties in distinguishing between endogenous metals and metals accumulated during experimental exposures. The radioisotope ⁶⁵Zn has been utilized in several studies as a tracer to quantify Zn kinetics at the gill; however, there are diverse factors limiting the widespread employment of this technique. This research utilizes commercially-available enriched stable isotopes of Zn as a promising alternative method for the quantitative evaluation of Zn uptake. Juvenile rainbow trout (3 - 5 grams) were exposed in moderately hard water to a range of ⁶⁷Zn-enriched waters. At sampling times of 0.5, 1.5, 3.0, 24, 48, and 72 hours, select fish were harvested, and fish gills were removed and separated from gill rakers within 24 hours of fish death. Gill tissue was digested via closed-vessel microwave digestion, and resultant samples were analyzed for total zinc, ⁶⁷Zn / ⁶⁶Zn and ⁶⁷Zn / ⁶⁴Zn isotopic ratios on a Dynamic Reaction Cell-Inductively Coupled Plasma-Mass Spectrometry. Significant differences were observed in accumulated gill zinc levels at the different exposure levels and durations. With the radio- and stable-isotope approaches, results are compared with those of previous experiments using the ⁶⁵Zn radioisotope tracer under similar exposure conditions.

MP110 In situ Microwave Assisted Versus Room Temperature Derivatization of Tetramethyllead for GC-ICP-MS Analysis of Aqueous Samples. L. Cox, R. Hannigan, Graduate Program in Environmental Science,

Arkansas State University, State University, AR. Total metal concentrations, defined as the sum of metal species concentrations (free, inorganic, organic) in any given environmental media (soil, water, sediment, etc.), are often the first parameters quantified in any study of metal biogeochemical cycles. However, more information beyond total metal concentrations is needed to accurately assess the role of metals in aquatic ecosystems. Microwave assisted derivatization solvent extraction techniques are thoroughly reviewed for soil and sediment samples; however, little attention has been paid to aqueous samples with suspended particles such as stream water. This preliminary study tested the hypothesis that in situ derivatization/extraction of tetramethyl lead (TML) can be acceleration using microwave energy and applied to organometal speciation in stream water samples from black shale draining streams. This is because the soft, easily-weathered shales have high metal loads as well as high organic content that are reflected in water in contact with them. There is no statistically significant difference for the peak area counts (p -value= 0.93, α = 0.05) and percent recovery (p -value= 0.613, α = 0.05) for TML standards derivatized at room temperature (RT) and in the microwave (MW) at the parameters used. The calibration curve (Concentration vs. peak area counts) of TML at RT had an R^2 = 0.994 and p -value= 0.004. The MW TML calibration had an R^2 = 0.992 and p -value= 0.003. However, the peak areas for the derivatized stream samples were below the calculated y -intercept at both RT and MW. The y -intercept for the MW calibration curve is lower than the RT calibration curve. The chromatographs of the microwaved stream water sample had a less noisy baseline. This may mean that the MW method has the advantage to suppress the background in stream water samples and may eventually lead to better method detection limits when the optimal microwave conditions are found.

MP111 Direct Determination of Trace Levels of Organoarsenicals in Soils by Chromatoprobe-Gas Chromatography with Pulsed Flame Photometric Detection. D.T. Qadah, J.H. Aldstadt, Dept. of Chemistry & Biochemistry, Univ. of Wisconsin-Milwaukee, Milwaukee, WI. We will describe a new method for fast, selective, and sensitive analysis of organoarsenicals in soil, sand, and humic substances. The method is based on Varian's direct sample introduction device, the Chromatoprobe™ for gas chromatography (GC), with detection by the pulsed flame photometric detector (PFPD). The Chromatoprobe is fitted to the temperature-programmable injector of the GC. Sampling with the Chromatoprobe is based on the introduction of milligram quantities of dried solid samples that are placed in a small glass vial. Sample delivery is controlled by the injector temperature and the split flow ratio. Starting from a temperature of 150 C, the injector is ramped to 450 C at a rate of 200 C/minute to efficiently vaporize the analytes for transfer to the PFPD. Results obtained for triphenyl arsine (TPA) as a model organoarsenical will be described. TPA was spiked at low mg/L levels into sand, several soil types, and humic materials (5-10 mg sample mass). Studies of key factors (e.g., temperatures, desorption time, flow, etc.) will be discussed. After the desorption of TPA from the solid sample, TPA was separated by capillary GC in under 10 min. The Chromatoprobe-GC-PFPD combination provides a number of novel features that have the potential to enhance the analysis of organometallics compounds in general in complex matrices: (a) Extraction-free analysis can be achieved with the Chromatoprobe, which could serve as an effective alternative to other methods of extraction, clean-up and derivatization; (b) Higher sensitivity can be provided by the selective PFPD, with detection limits for As in the ppb range; (c) Interferences such as carbon-, phosphorous-, or sulfur-containing compounds can be minimized with the PFPD in its As-selective detection mode, using methodology that exploits differences in the dependence of the C, P, S, and As pulsed flame emission processes.

MP112 Comparison of Metal Speciation Tools at a Superfund Site. W.E. Hillwalker, K.A. Anderson, Oregon State University, Corvallis, OR. Seasonal and episodic influences on dissolved metal species, including Cu²⁺, Cd²⁺, and Zn²⁺, were assessed in a model urban river (the lower Willamette, Oregon) during a multi-year study. Metal species concentrations obtained from diffusive gradients thin film (DGT) samplers, a time-averaged in situ collection device, were compared to the biotic ligand model (BLM) species output, modeled using river water chemistry data. Though the results from these site-specific metal assessment tools indicated differences between model outputs for the metal species studied, they did reveal relationships between water chemistry parameters and metal species in real-time dynamic aquatic systems.

MP113 Determining bioaccessibility/bioavailability of metal contaminants in soils using Caco-2 cells. L. Vasiluk, B. Hale, Department of Land Resource Science, University of Guelph, Guelph, Ontario, Canada. The uptake of soil-bound contaminants has been tested mainly in vivo, and the data suggest that bioavailability can be considerably less than the total. Therefore, the risk posed by xenobiotics in soil may be overestimated and adjustments for oral bioavailability needed to be considered in human risk assessment. There is an urgent need to validate against in vivo models an accurate and relatively inexpensive in vitro method that could predict relative oral bioavailability of matrix-bound contaminants. The overall aim was to evaluate a suite of soils and dusts using particle size separation combined with simulated gastrointestinal digestion in vitro and characterization of the uptake of metals from the digestate into human cultured enterocytes, Caco-2 cells. Naturally weathered soils receiving smelter emissions with elevated metal concentrations were subjected to gentle grinding and screened to exclude particles greater than 250 μ m, then separated into four fractions of particle size. NIST SRM 2710 and 2584 were included in the study. Two extractions of metals were carried out: hot acid Teflon-vessel digestion and PBET, followed by exposure of Caco-2 cells. Particles of two size fractions (<70 μ m and 150-250 μ m) comprised most of bulk soil and both were moderately elevated in Cu and Ni. The relationship between particle-size and metal concentration varied; sometimes the smallest particles were the most contaminated, which also associated with the highest organic matter content and sometimes the least, which suggests was differences in speciation or associations of the metals that might explain differences in bioaccessibility. When Caco-2 cell monolayers were exposed to PBET digestate using some of the soil with these particle size fractions, Ni was absorbed at concentrations below detectable limit of graphite furnace atomic absorption spectroscopy. The relative bioavailability of Cu was higher, for particles 150-250 μ m than 70 μ m. We speculate that metal speciation varies with particle size, and that these relationships would be useful inputs with human health risk assessment where not all particle sizes similarly adhere to children hands, and foods.

MP114 Lability and molecular size distribution of Zn and Cu complexes in wastewater treatment plant effluent. G. Chaminda, I. Kasuga, Department of Urban Engineering, The University of Tokyo, Tokyo, Japan; E. Nakajima, Environmental Science Center, The University of Tokyo, Tokyo, Japan; H. Furumai, K. Futoshi, Research Center for Water Environment Technology, The University of Tokyo, Tokyo, Japan. The municipal wastewater effluent is an important pathway for heavy metals toward the natural water environment. WWTP effluent also contains considerable amount of dissolved organic matter (DOM), which controls the metal speciation in the water environment. In this study, we determined the size distribution of Zn and Cu and their complexation by organic ligands in WWTP effluent. Chlorinated final effluent was collected from a WWTP in Tokyo in August, November (2006), and January (2007). They were subjected to consecutive filtration through 0.5 μ m PTFE membrane, 10 kDa, 1 kDa and 500 Da ultra filtration membranes (regenerated cellulose and cellulose acetate). From the difference between the results in two filtrates, we determined concentrations of Zn, Cu, and DOC in the particulate (> 0.5 μ m), large colloidal (between size 0.5 μ m and molecular weight 10 kDa), medium colloidal (1 to 10 kDa), small colloidal (500 Da to 1 kDa) and dissolved (< 500 Da) fractions. Empore TM chelating disk cartridge was used to analyze the labile metal concentration. The fractional concentration of complexed Zn and Cu were calculated based on total and labile concentrations (= total-labile). The result shows that more than 60% of total Zn and Cu were complexed in the final effluents, leaving 4.8~7.4 μ g/L as labile Zn and 2.0~2.7 μ g/L as labile Cu. Major part of Cu was found in the < 1 kDa fraction in all samples while majority of Zn species were found in < 1 kDa in August, 10 kDa – 1 kDa in November and 1 kDa – 500 Da in January. Relative binding of Cu to organic carbon in each fraction shows that DOC in <500 Da fraction have more affinity for Cu. However, highest relative binding of Zn to organic carbon were observed in <1 kDa in August, 10 kDa – 1 kDa in November and 1 kDa – 500 Da in January. Labile Cu and Zn was detected not only in the smallest fraction (< 1kDa) but also in the larger molecular fractions, suggesting that labile species in the effluent is not equivalent to free metal ions which are believed to be most toxic. The labile Zn concentration in < 500 Da was negligible in November and not detected in January. This indicates that no free Zn ion exists and almost all the Zn are bound to either weak or strong ligands.

MP115 Total and Labile Trace Metal (Pb, Cu, Cd and Cr) Concentrations in Berry's Creek Estuary, Meadowlands, New Jersey, USA.

K. Ellickson, Science and Technology, Alverno College, Milwaukee, WI; **A. Jimonet**, J. Reinfelder, Environmental Science, Cook College, Rutgers University, New Brunswick, NJ. Uptake by phytoplankton of the bioavailable pool of trace metals is one of the main limiting factors for biomagnification within an aquatic ecosystem. Valuable information about the bioavailable pool can be garnered from knowledge of free metal concentrations. For this reason, we present results of unfiltered, dissolved and free metal concentrations from Berry's Creek Estuary (BCE). Berry's Creek is a highly contaminated tidal creek that empties into the Hackensack River. The major contaminant of concern was from a historical industrial source of Hg. Samples were collected along BCE and in the Hackensack River, during 4 sampling trips from June 2002 to July 2003. The described work is an investigation of Pb, Cd, Cu and Cr concentrations using both a method to total concentrations of that metal and a modified cation exchange method that was used for speciation analysis. Total metal concentrations in un-filtered samples ranged from 1.90 - 11.22 $\mu\text{g L}^{-1}$, 0.03 - 1.43 $\mu\text{g L}^{-1}$, 1.43 - 10.86 $\mu\text{g L}^{-1}$ and 1.57 - 13.8 $\mu\text{g L}^{-1}$, in Pb, Cd, Cu and Cr respectively. Total dissolved metal concentrations ranged from 0.2 - 3.81 $\mu\text{g L}^{-1}$, 0.06 - 0.24 $\mu\text{g L}^{-1}$, and 0.99 - 3.91 $\mu\text{g L}^{-1}$ in Pb, Cd and Cu respectively. Filtered samples that were analyzed using the cation exchange equilibrium model ranged in free metal concentrations (a) (total dissolved metal concentrations (b)) from 10.71 (8.69) - 11.88 (9.00), 10.15 (7.81) - 10.68 (7.53) and 11.7 (8.54) - 12.8 (8.02) for pCd, pCu and pPb respectively. Unfiltered concentrations of Cr, Cu and Pb decreased downstream suggesting point sources of these metals, whereas Cd remained relatively constant. Unfiltered aqueous concentrations of Cd, Cu and Pb in BCE were elevated as compared to unfiltered concentrations found in samples from the Hudson River, where dissolved concentrations of Cu and Pb were similar. Unfiltered aqueous concentrations of Pb and Cd were associated with aqueous TSM. Free Cu and Cd were positively associated with doc. By comparing the free metal concentrations found in this study to other similar studies, we found that the surface water ecosystem maintained low free Cd and Pb, but not Cu in BCE. (a) where $\text{pCu} = -\log [\text{Cu}^{2+}]$ and $[\text{Cu}^{2+}]$ units are molar. (b) where $\text{pCu} = -\log [\text{Cu}]$ and $[\text{Cu}]$ units are molar.

MP116 Understanding the high Cd and Zn concentrations in the scallops *Chlamys nobilis*. **K. Pan**, W. Wang, Department of biology, Hong Kong University of Science and Technology, Hong Kong, China; **W. Wang**, Atmospheric, Marine and Coastal Environment (AMCE) program, Hong Kong University of Science and Technology, Hong Kong, China. Scallops are known to accumulate very high concentrations of Cd and Zn in their bodies. Bioaccumulation of Cd and Zn as well as the influences of metal subcellular partitioning on metal dietary assimilation were investigated in the scallops *Chlamys nobilis*. The dissolved uptake constants in the scallops were $0.359 \text{ l g}^{-1} \text{ day}^{-1}$ for Cd and $1.186 \text{ l g}^{-1} \text{ day}^{-1}$ for Zn, and the assimilation efficiencies (AEs) were in the range of 53.4-83% for Cd and 47.4-58.2% for Zn, respectively. These uptake rates were generally comparable or higher than those measured in other species of marine bivalves such as oysters, mussels and clams. The efflux rates of Cd in scallops were lower ($0.005 \sim 0.009 \text{ day}^{-1}$), while the efflux rates of Zn were comparable with those of other bivalves. There was no absolute support for a generalized conclusion that any of the subcellular fractions (cell debris, organelles, heat sensitive protein, and heat stable protein or their combinations can represent that form of phytoplankton metal that is bioavailable for trophic transfer to the scallops. We examined the effect of the body size on both of the dissolved and dietary uptake of the metals. We demonstrated that the high assimilation efficiency and low efflux rate of Cd may be responsible for the high Cd concentration in the scallops. Kinetic modeling showed that the predicted size allometric coefficients were comparable to the actual measurements, and that dietary exposure was the predominant route for Cd and Zn accumulation in the scallops.

MP117 A comparison of dietary and aqueous uptake and accumulation of uranium in freshwater midge (*Chironomus tentans*) larvae and juvenile amphipods (*Hyaella azteca*). **K. Liber**, J.L. Hunt, Toxicology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Delineating and quantifying the routes of metal uptake in freshwater invertebrates are important for understanding metal bioaccumulation and toxicity. However, the dietary route of metal accumulation and toxicity in freshwater invertebrates has, until recently, largely been overlooked. Some researchers have assumed aqueous exposure to be the major route of uptake, while others have suggested that the dietary route can be a significant contributor to total bioaccumulation of metals in benthic invertebrates. The uranium (U) mining and milling industry in northern Saskatchewan, Canada, can lead to localized increases

of U in aquatic systems due to release of effluent. We investigated the dietary bioaccumulation of U in *C. tentans* larvae and juvenile *H. azteca* fed Nutrafin[®] fish food prepared to contain 100 and 1500 mg U/kg d.w. The experiment was 10 d in duration, with complete water and substrate renewal every 48 h (*C. tentans*) or 120 h (*H. azteca*) to keep the aqueous concentration of U low. Test endpoints included growth, survival, and U bioaccumulation. Since low levels of U were found in the exposure water (desorption from the food), the aqueous contribution to total U bioaccumulation was investigated separately using a water-only study with a similar test design, and aqueous U concentrations based on those measured in the dietary experiment (2 and 20 $\mu\text{g/L}$ for *C. tentans* and 1 and 27 $\mu\text{g/L}$ for *H. azteca*). Dietary U bioaccumulation resulted in growth inhibition in *C. tentans* and decreased survival in *H. azteca* when fed 1500 mg U/kg, but not 100 mg U/kg. No growth or survival effects were observed from the aqueous exposures. The dietary U contribution was calculated from the total bioaccumulation in the dietary study minus the aqueous contribution. Keywords: Dietary exposure, Chironomus tentans, Hyaella azteca, uranium, bioaccumulation

MP118 Internal speciation of zinc in rainbow trout (*Oncorhynchus mykiss*): crosstalk between waterborne and dietborne exposure pathways. **C. Kamunde**, S. Ravinder, Biomedical Sciences, Atlantic Veterinary College, Charlottetown, Prince Edward Island, Canada. Zinc is an essential trace metal required for the normal physiology and development in fish but it is potentially toxic when accumulated in excess of cellular requirements. In fish, zinc uptake occurs via two pathways: gills (for waterborne metal) and gastrointestinal tract (for dietborne metal). The understanding of zinc toxicology in fish therefore requires adequate knowledge of the nature of the crosstalk between the waterborne and dietborne uptake pathways. To date the few studies that have investigated this crosstalk have been done at the organ/tissue level. We sought to gain a deeper understanding of the interaction between waterborne and dietary zinc uptake by investigating its internal speciation (i.e. intracellular localization) in liver, gill, and gut tissues, which constitute the key organs of metal homeostasis. Juvenile rainbow trout were exposed to waterborne (150 and 600 mg/L) and dietborne (1000 and 4000 mg/kg) zinc singly and in combination for 40 days. The liver, gill and gut tissues were then subjected to differential centrifugation and zinc localized in the isolated subcellular compartments was quantified. While there were significant tissue-specific differences in the subcellular localization of Zn, our data show that irrespective of exposure route, the nuclear fraction is the main site for intracellular Zn accumulation. We use the results to discuss the significance of internal metal speciation in zinc homeostasis and toxicity in fish.

MP119 The Effect of Dietary and Waterborne Arsenic on Swim-up Rainbow Trout and Fathead Minnows. **R. Hockett**, R.J. Erickson, T.L. Highland, C.T. Jensen, D.R. Mount, U.S. EPA, Duluth, MN. Rainbow trout fry and 30-d old fathead minnows were exposed to arsenic in water only, diet only, or in both water and diet, in 28-d studies assessing survival and growth. Arsenic was incorporated into the diets by exposing *Lumbriculus variegatus* to multiple concentrations of waterborne arsenate for 7d, then feeding the oligochaetes to test fish in measured daily rations. Food rations were increased periodically to account for fish growth, and any uneaten ration was removed and quantified. When exposed to waterborne arsenate, rainbow trout showed reduced survival at 16 and 32 mg As/L, but not at 0.5 to 8 mg As/L; growth was also reduced at 16 and 32 mg As/L, and at 8 mg As/L in one experiment but not another. When trout were exposed to As through the diet only, growth was reduced in fish fed oligochaetes previously exposed to 4 and 8 mg As/L, but not to 0.5 to 2 mg As/L; survival of rainbow trout was not affected by the highest dietary As concentration (oligochaetes exposed to 8 mg As/L; higher dietary concentrations were not tested because of arsenate toxicity to the oligochaetes). When trout were exposed to both waterborne (8 to 32 mg As/L) and dietary (worms exposed to 4 and 8 mg As/L) arsenic, dietary arsenic did not increase the lethality of the waterborne exposure, but did cause additional decreases in trout growth. Similar exposures of fathead minnows showed some interspecific differences. While fathead minnows were more sensitive to waterborne arsenate (reduced survival at 8 mg As/L), they did not show reduced growth in response to the highest dietary As concentration tested (oligochaetes exposed to 8 mg arsenate/L). These results show that dietary arsenic may be an important component of exposure for at least some fish species in As-contaminated systems. This abstract does not necessarily reflect EPA policy.

MP120 Comparison of Arsenic Concentrations in Carcass and Viscera of Swim-up Rainbow Trout Exposed to Dietary and Waterborne Arsenic. C.T. Jensen, R.J. Erickson, T.L. Highland, J.R. Hockett, D.J. Hoff, D.R. Mount, EPA, Duluth, MN. Rainbow trout fry were exposed to arsenic in water only, diet only, or both diet and water in 28-d studies evaluating survival and growth. Diets consisted of *Lumbriculus variegatus* that were exposed to multiple concentrations of waterborne arsenate for 7d and then fed to test fish in measured daily rations. When trout were exposed only to waterborne arsenate at 0.5 to 32 mg As/L, survival and growth were reduced at 16 and 32 mg As/L and growth was also reduced in one of two exposures at 8 mg As/L. For diet-only exposures, rainbow trout growth was reduced when fed diets that had been exposed to 4 or 8 mg As/L. For combined exposures, contaminated diets did not result in increased mortality, but did result in greater reductions in growth, compared to the water-only exposures. To better understand the difference in effects among these exposures, arsenic concentrations in the viscera and the rest of the fish were analyzed for selected surviving fish. Differences in this internal distribution of arsenic due to exposure route and concentration will be presented and related to the magnitude of effects observed. This abstract does not necessarily reflect EPA policy.

MP121 Study Design of an Exposure System to Determine the Effect of Cold Temperature on the Toxicity of Selenium to Juvenile Bluegill Sunfish. D.O. McIntyre, W.H. Clement, Columbus, GLEC, Columbus, OH; D.J. McCauley, M. Garton, Traverse City, GLEC, Traverse City, MI; C. Delos, Health and Ecological Criteria Division, EPA, Washington DC, DC. The final chronic value of 7.91 µg/g dw recommended in the 2004 Draft Update of the Aquatic Life Ambient Water Quality Criteria for Selenium is based on one study (Lemly 1993) in which juvenile bluegill underwent "winter stress syndrome." Data from Lemly's study indicate that over-wintering fish may be more susceptible to the effects of waterborne and dietary selenium due to increased sensitivity at low temperature. Lemly exposed juvenile bluegill sunfish in the laboratory to waterborne (1:1 selenite:selenate; nominal 5 µg Se/L) and food borne (seleno-L-methionine in TetraMin; nominal 5 µg Se/g dw food) selenium for 180 days with temperatures decreasing from 20 to 40°C. Given the importance of the data from the Lemly study in deriving the tissue-based final chronic value for selenium, the goal of the project presented here is to determine effect levels (selenium in juvenile bluegill tissue) for selenium exposure over a simulated winter season at two temperature regimes, 20 to 40°C and 20 to 90°C. Besides the additional temperature regime, two other differences in the current study include (1) a range of six selenium concentrations (aqueous and diet) to determine protective effect levels and (2) bluegill were fed *Lumbriculus* in which target levels of selenium were accumulated by feeding the worms selenized yeast. A separate system exposed juvenile bluegill to aqueous selenium and seleno-L-methionine in TetraMin under a 20 to 40°C temperature regime. The 180-day study is currently underway. Details of the study design will be presented and illustrated in this poster. The statements expressed in this abstract are those of the authors and do not necessarily reflect the views or policies of EPA.

MP122 Reproductive Effect of Copper in the Euryhaline Copepod *Acartia tonsa*: Waterborne Versus Dietborne Exposure. M.M. Lauer, Pós-Graduação em Ciências Fisiológicas - Fisiologia Animal Comparada, Fundação Universidade Federal do Rio Grande, Rio Grande, RS, Brazil; A. Bianchini, Departamento de Ciências Fisiológicas, Fundação Universidade Federal do Rio Grande, Rio Grande, RS, Brazil. In the present study, we evaluated the effect of waterborne and waterborne plus dietborne copper exposure on egg production in the euryhaline copepod *Acartia tonsa* acclimated to salinity 5, 15 and 30 ppt. For the dietborne exposure, the diatom *Thalassiosira weissflogii* was pre-contaminated with copper for 24 h at the same concentrations used in the waterborne exposure. Every day, male and female copepods were separately exposed to waterborne copper for 12 h, transferred to non-contaminated water, and fed with either non-contaminated algae (waterborne exposure) or contaminated algae (waterborne plus dietborne exposure) for the remaining 12 h. A control treatment for each salinity was also tested. After copper exposure (6 days), groups of 3 females and 1 male were formed and eggs produced after 24 h were counted. After waterborne exposure, the 6 d-EC50 value was 4.65 (3.25 – 6.12), 36.28 (30.51 – 42.52), and 61.21 (52.43 – 71.78) µg Cu/L for salinity 5, 15 and 30 ppt, respectively. After waterborne plus dietborne exposure, these values were 52.62 (41.73 – 76.92), 95.53 (75.11 – 140.22), and 163.45 (133.89 – 224.75) µg Cu/L, respectively. These results show that salinity alone has a protective effect against the chronic toxicity of both waterborne and waterborne plus dietborne

copper. They also indicate that dietary copper reduces the effect of waterborne copper exposure on egg production in *A. tonsa*. Supported by International Copper Association.

MP124 A metal-specific mechanistic bioaccumulation model for aquatic species. K. Veltman, M. Huijbregts, J. Hendriks, Department of Environmental Science, Radboud University, Nijmegen, Netherlands. Bioaccumulation of organic compounds has long been linked to their octanol– water partition coefficient (Kow). This partition coefficient is one of the key parameters that quantitatively explains differences in accumulation kinetics between neutral, organic compounds. For metals, however, no bioaccumulation models exist that predict internal concentrations based on the physical – chemical properties of metals. In the present study, we propose a model that predicts metal bioaccumulation based on the metal-specific covalent index. For this purpose, we developed quantitative relationships relating metal accumulation kinetics, i.e. absorption and elimination rate constants, to the metal – specific covalent index, based on a large number of aquatic species. These relationships are combined with principles and equations of the biotic ligand model (BLM) to provide more fundamental understanding of the mechanisms behind BLM. The model is thought to facilitate environmental risk assessment as it provides an estimate of bioaccumulation when no empirical data are available. Additionally, the model may provide insight in mechanisms of absorption and elimination of metals.

MP125 A new direction for multiplexed quantification of microorganisms in mixed target samples using oligonucleotide microarrays. A. Pozhirkov, M. Brouwer, University of Southern Mississippi, Ocean Springs, MS; G. Nies, B. Kleinhenz, D. Tautz, Genetics, University of Cologne, Cologne, Germany; P.A. Noble, Civil and environmental engineering, University of Washington, Seattle, WA. Quantitative identification of microorganisms in polymicrobial samples is crucial for assessment of biothreats and infectious agents in water and domestic samples. To date, accurate quantification of specific nucleic acid sequences in target mixtures has been problematic, primarily due to nonspecific target binding (i.e., crosshybridization), which affects interpretation and downstream analyses of oligonucleotide arrays. Several approaches have been used to minimize or eliminate nonspecific binding, such as designing highly specific probes, subtracting nonspecific signal using mismatch probes, and/or removing nonspecific duplexes by scanning through a range of wash stringencies, but none of these approaches have been shown to be optimal. We developed an alternative approach that, in contrast to previous approaches, uses nonspecific target binding as a source of information. Specifically, the new approach uses hybridization patterns (fingerprints) to quantify specific nucleic acid targets in mixtures. We evaluated the approach by mixing together in vitro transcribed RNA targets at varying concentrations (0.1 nM to 2.5 nM) and hybridizing the mixtures to microarrays (n=3,160 probes, in duplicate). Eight Latin-square-designed experiments with 6 targets revealed accurate quantification. The linear regression between actual concentration of targets and those determined by the approach was found to be highly linear (e.g., R²=0.90, n=6 targets x 8 mixtures). The new approach offers tremendous potential for the simultaneous quantification of multiple nucleic acids in a sample.

MP126 Protecting the Nation's Food Supply: Use of chemical profiling to determine the origin of food commodities. K.A. Hobbie, A.L. Perez, B.W. Smith, K.A. Anderson, Environmental & Molecular Toxicology, Oregon State University, Corvallis, OR; B.W. Smith, Statistics, Oregon State University, Corvallis, OR. The accurate labeling of the origin of food is crucial for securing the nation's food supply to increase public health security and bioterrorism preparedness. Truth in labeling also boosts consumer confidence, where food origin is used as an economic marketing tool to convey the agricultural practices, quality, and value of foods. Isotope ratio analysis, elemental analysis, and computational evaluation provide scientific foundations to cost effectively authenticate the geo-location of a broad range of foods based upon their chemical signature. Our lab has successfully used elemental analyzer-isotope ratio mass spectrometry and inductively coupled plasma spectroscopy, as well as classification techniques; such as principal component analysis, canonical discriminant analysis, discriminant analysis, and neural network modeling; to classify origin of potatoes, coffee, pistachios, pears, blueberries and strawberries. These tools provide multiple lines of evidence to not only successfully differentiate food origin by continental growing location with greater than 95% certainty, but also differentiate to finite scales, such as regional location; independent of variety, cultivar and growing season.

MP127 The Effects of Sodium Bisulfite Dechlorination on the Toxicity of Pentachlorophenol and Copper Sulfate in the Microtox® Test. D.E. Trader, L.M. Brennan, W.E. Dennis, W.H. van der Schalie, United States Army Center for Environmental Health Research, Fort Detrick, MD. Biologically-based toxicity sensors, including the Microtox® test, have been used for evaluating potential chemical hazards in source water and finished drinking water samples. But since most toxicity sensors are highly sensitive to chlorine and chloramines, their use with water samples treated with these disinfectants is problematic. A mild reducing agent, such as sodium bisulfite, is commonly used to remove chlorine-related toxicity, but the effect of reducing agents on toxicity has received little attention. This study determined the effects of dechlorination using sodium bisulfite on the toxicity of an organic pesticide (pentachlorophenol) and a metal (copper sulfate) in the Microtox® test. Concentration-response relationships for decreased light output in the Microtox® test were evaluated for sodium bisulfite, chlorine, and chloramine. In addition, the concentration of sodium bisulfite required to reduce chlorine and chloramine toxicity was determined. Next, the toxicity of pentachlorophenol and copper sulfate was determined in sodium bisulfite-reduced chlorinated and chloraminated water. Sodium bisulfite, at a concentration sufficient to reduce chlorine and chloramine, had little effect on the pentachlorophenol 15-minute IC₅₀, but decreased copper toxicity. Increasing concentrations of sodium bisulfite caused greater decreases in copper toxicity, but had little additional effect on pentachlorophenol toxicity. These data demonstrate the need to minimize reducing agent use when evaluating dechlorinated water samples to avoid altering the toxicity of the original sample.

MP128 Optical Fiber Sensors with Microsphere-Templated, Porous Fiber Claddings for Remote Measurement in Aqueous Environments. P.E. Henning, M. Rigo, P. Geissinger, Chemistry, University of Wisconsin Milwaukee, Milwaukee, WI. Optical fibers can be employed for remote monitoring in harsh environments. The entire fiber length may be utilized for sensing by placing fluorescent sensor molecules outside of the fiber core. Such fluorosensors may still be excited by the evanescent fields of the light propagating in the fiber core; conversely, light emitted by sensor molecules may be captured by evanescent fields and guided to the fiber ends. Pulsed laser excitation and time-resolved detection allow for pinpointing the location of a sensor along the fiber. Thus, many different parameters may be monitored simultaneously and spatially resolved. The sensor density may be increased significantly by adding a second fiber that forms orthogonal fiber-fiber junctions with the first fiber at the sensor regions. The second fiber provides an optical delay, which results in the desired increase in spatial resolution. Small displacements between the fibers, however, can result in large signal changes due to the exponential decay of evanescent fields away from the fiber core/cladding interface. In aqueous environments, the hydrogel resins used in the past as sensor active claddings frequently produced weak and inconsistent results, as the swelling of the resin may change the fiber-fiber spacing. We used microsphere templating to create pores and channels in non-swelling, hydrophobic polymers that allow analyte passage to the evanescent field regions close to the fiber core. This yields rigid fiber-fiber junctions with significantly enhanced signal repeatability and reproducibility as well as sensor longevity.

MP130 How do we understand toxic effects of metal mixture? M. Kamo, Research Center for Chemical Risk Management, Advanced Industrial Science and Technology, Tsukuba, Ibaraki, Japan. According to rapidly developing biotic ligand model (BLM), we can predict the toxicity of heavy metals in various water qualities. The basic assumptions of BLM is that living organisms have positively charged biotic organs (such as gills), which is responsible for the calcium ion uptake and negatively charged heavy metal ions also bind to the organs, and death occurs when the amount binding metals exceeds a certain threshold. Current versions of BLM can predict toxicity of single metal only, and not able to predict toxicities when organisms are exposed to multiple metals. In this paper we aim to understand the toxic effects of metal mixtures. Toxic mechanisms of the toxic mechanism are not completely understood yet. However, it is widely known that heavy metals inhibit a calcium uptake resulting hypocalcemia, which is now considered to be the major mechanism of acute toxicity in some metals. If toxic mechanism of heavy metals is hypocalcemia, we can predict toxicity of metals by computing the amount of calcium uptake, and it can be done by using BLM's theoretical framework with a tiny modification. Estimating toxicity by the amount of calcium uptake has two merits. First, toxicity of one metal can be translated into others by

searching metal concentrations leading to the same calcium uptake. Second, toxicity of metal mixtures can be estimated by developing a theoretical framework for calcium uptake when multiple metals exist. We concentrate on binary mixture of zinc, cadmium and copper in rainbow trout acute toxicity data sets, and find synergism in binary mixture in zinc and cadmium, and antagonism in zinc and copper. We also find that these non-additive effects are more pronounced in softer water. Our approach is also feasible for the risk reduction strategies in metal polluted area such as mining place.

MP131 Statistical Modeling of Vitellogenin Expression in Fathead Minnows Exposed to Wastewater Treatment Effluents. T.D. Hunter, S. Sivaganesan, Mathematical Sciences, University of Cincinnati, Cincinnati, OH; M.A. Mills, B. Boulanger, ORD/NRMRL, U.S. Environmental Protection Agency, Cincinnati, OH. Effluents from wastewater treatment plants are a major source of steroid hormones and other endocrine disrupting chemicals (EDCs) in the aquatic environment. These chemicals are known to be capable of impacting the reproductive systems of fish, but little is known about the contributions and interactions of the individual EDCs to the overall level of impact. In this study, fathead minnows were exposed for 24 hours to effluents from wastewater treatment plants around the US. Then their vitellogenin expression levels were modeled as a function of the levels of eight steroid hormones in the wastewater samples. Predictive models for male fish were very promising while the female vitellogenin expression levels could not be successfully modeled as a function of the wastewater chemistry. Further studies using improved methodology and additional EDCs will be used to refine these models.

MP132 Rhizosphere Microbial Communities Analysis in Petroleum Sludge Land-farming Remediation with Multi-Processes Phytoremediation System (MPPS). W. Wang, J. Gurska, X. Huang, B.M. Greenberg, Biology, University of Waterloo, Waterloo, Ontario, Canada. In the past two years, a multi-process phytoremediation system (MPPS) has been developed in our lab to remediate petroleum-sludge contaminated land farming soils. Several procedures, such as using plant growth promoting rhizobacteria (PGPR) to promote plant growth and inoculation of petroleum degrading bacteria to accelerate the degradation of petroleum are incorporated into this system to improve the efficiency of phytoremediation. Field experiments have demonstrated that approximately 50% of total petroleum hydrocarbons (TPH) can be removed in one growth season. In this paper, culture-dependant and culture independent methods (DGGE, qPCR) were used to investigate the diversity and structure of microbiological communities and to track the kinetics of introduced plant growth promoting bacterium during phytoremediation of TPH contaminated soils. Samples obtained from contaminated sites were directly analyzed by counting the microbial number (CFU) of different groups of contaminant-degrading microbes using plate count or MPN method. The PAH degrading microbes, hexadecane degrading bacteria were further identified with 16s and 18s rRNA sequence. Fresh soil samples were also used for DNA extraction. The most variable V6 region of bacterial 16s rRNA and full fungal 18s rRNA were amplified from genomic DNA isolated from different soil samples. The results show that phytoremediated soil support 10 to 100 times more culturable microbes of all groups than unplanted contaminated soil and more microbial population are detected in the soil samples closer to roots. DGGE analysis of PCR-amplified 16S- or 18s rRNA genes revealed that there is high similarity in bacterial diversity between phytoremediated and unplanted samples. However, fungal diversities were greatly enhanced during the phytoremediation process. No significant differences of microbial population and diversity were observed between samples with PGPR and that without PGPR. Induced PGPR, *Pseudomonas putida* (UW4 strain), can survive, clone in rhizosphere and stimulate plant growth. These results demonstrate that phytoremediation greatly enhance the contaminant degrading microbial population in contaminated soil and accelerate the biodegradation of petroleum contaminants. PGPR may enhance the biodegradation rate of pollutants in soil by stimulating the root growth, making root reach more soil and increasing microbial population in root-reached rhizosphere.

MP133 In Situ Accumulation of Polychlorinated Biphenyls (PCBs) in Target Plant Species During Exposure to Contaminated Soil. J.E. Low, B. Zeeb, Environmental Sciences Group, Royal Military College of Canada, Kingston, Ontario, Canada; A. Rutter, School of Environmental Studies, Queen's University, Kingston, Ontario, Canada. PCB contamination reduces property values and hinders redevelopment efforts at numerous sites across North America. Current remediation technologies are intrusive, destructive

and costly, and therefore research into alternative technologies such as phytoextraction have increased. Successful phytoextraction involves movement of contaminants from the contaminated media (e.g. soil) into plants roots, shoots and leaves through normal physiological processes. Originally, highly hydrophobic compounds such as PCBs were thought to be too strongly sorbed to soil particles for phytoextraction to be successful. However, recent studies have demonstrated the possibility of phytoextraction of PCBs from soil with the use of various plant species. Subsequent harvesting of the plant and biomass reduction reduces the total volume of contaminated waste while leaving the soil matrix intact. The present field study examines the uptake of Aroclor 1248 in pumpkin (*Cucurbita pepo* cv. Howden), tall fescue (*Festuca arundinacea*), spreading oval sedge (*Carex normalis*), switchgrass (*Panicum virgatum*), and various native colonizers throughout the 2006 season at an industrial site located within the City of Kawartha Lakes (Lindsay), Ontario. Plant and soil samples were harvested and PCBs were extracted using soxhlet prior to GC-ECD detection. Although, mean soil concentration was only 4.1 µg/g PCB, pumpkins accumulated 15-79 µg/g and 12-38 µg/g of PCBs in the root and shoot tissues, respectively. Taking plant biomass into account, this translates into 27-149 µg and 26-63 µg total PCBs extracted into the root and shoot tissues, respectively. In comparison, the grass and sedge had lower [PCB] in the range of 4-31 µg/g in the roots, and 1-2 µg/g in shoots, translating into PCB extractions of 9-170 µg in the roots, and 2-9 µg in shoots. Native colonizers showed some promise with concentrations from 4-22 µg/g in the root (15-36 µg), although very low concentrations were found in the shoots (0.7-1.8 µg/g representing 3-9 µg PCBs).

MP134 Pharmaceuticals and aquatic plants; A review of targets, effects and risks. R.A. Brain, L.N. Sharma, K. Chambliss, B.W. Bryan, Environmental Studies, Baylor University, Waco, TX. Pharmaceuticals are biologically active ubiquitous low-level contaminants which are continually introduced into the aquatic environment from a variety of human and veterinary sources. The pharmacological modes of action of these compounds are generally well established and understood, though the toxicological modes of action in non-target organisms are comparatively less characterized. Due to this consideration it is important to consider evolutionary conservation of metabolic pathways and receptors across multiple levels of biological organization, particularly in the case of plants which present a number of targets for pharmaceuticals due largely to the bacterial ancestry of plastid and mitochondrial organelles. Homologous targets for several antibiotics including fluoroquinolone (chloroplast replication), tetracycline macrolide, lincosamide, β-aminoglycoside, and pleuromutilin (transcription and translation), sulfonamide (folate biosynthesis) and chlorophenol (fatty acid biosynthesis) as well as statin blood lipid regulators have been identified in plants. Susceptibility to antibiotics from these compounds has been demonstrated in blue-green algae, green algae and aquatic higher plants, though sensitivity varies markedly in a rather inconsistent manner, with the exception that cyanobacteria are generally the most sensitive group. The differential susceptibility among aquatic plants is likely a consequence of differences in metabolism, uptake and translocation. Applying the USFDA risk assessment paradigm to the available toxicity data potential hazards are evident for blue-green algae exposed to several classes of antibiotics, particularly triclosan which consistently posed the greatest hazard to both blue-green and green algae. Generally, however, antibiotics pose comparatively little hazard to green algae and higher plants. A holistic perspective on the effects of pharmaceuticals on aquatic plants will be presented with specific focus on mode of action. In addition data regarding the mechanism of toxic action and uptake of sulfamethoxazole will be discussed.

MP137 Re-examining the relationship between plant uptake of organic chemicals and octanol water partition coefficients. E. Dettenmaier, W.J. Doucette, B. Bugbee, A. Hall, Utah Water Research Laboratory, Utah State University, Logan, UT. The uptake of most xenobiotic organic compounds is believed to a passive process where compounds in the transpiration stream must pass through lipophilic root membranes before they can be translocated to the shoot. The relative ability of an organic compound to be translocated from root to shoot has typically been described by a transpiration stream concentration factor (TSCF), the ratio between a compounds concentration in the xylem to that in the solution outside the root. Bell-shaped curves relating TSCF to the lipophilicity of the chemical as described by its octanol/water partition coefficient (log Kow) have been reported for several small sets of chemicals (n<12). The shape of the curve implies that there is an optimal lipophilicity for translocation and compounds that are either highly polar or

are very lipophilic are not expected to be significantly translocated. However, more recent experimental data reported in the literature and generated in our laboratory suggests that these relationships may not be appropriate, especially for neutral, highly polar organics. To re-examine the applicability of bell-shaped relationships between TSCF and log Kow, 100 values for nearly 75 compounds were compiled from the literature. Using all values, no significant relationship between TSCF and Log Kow (n=93) was observed. However, separating the literature TSCF values into groups based on experimental approach gave a statistically significant linear relationship (low log Kow high TSCF) for the pressure chamber derived TSCF values (n=38) but not for hydroponically grown intact plants. The lack of relationship for the intact plants may be due to differences in exposure duration and plant age that are minimized in pressure chamber approaches. Using only the TSCF values generated in our laboratory, significant linear relationships with log Kow were observed for pressure chamber and intact plants both separately (n = 14) and when combined (n=36). Overall, the results suggests that the commonly used bell-shaped relationship between TSCF and log Kow are likely not appropriate for neutral, highly polar organics. However, until additional plant uptake data is generated in a consistent experimental manner, the ability to improve existing relationships between plant uptake and chemical properties or structure will be severely limited.

MP138 Polycyclic Aromatic Hydrocarbon Uptake Pathways of Crop Plants. C. Collins, Dept of Soil Science, University of Reading, Reading, United Kingdom; Y. Gao, College of Resource and Environmental Sciences, Nanjing Agricultural University, Nanjing, China. Plant uptake of industrial organic chemicals is a key pathway when considering the human and ecological risks from contaminated sites. In a series of laboratory and glasshouse experiments the pathways of PAH uptake by a range of crop plants, which compose the majority of the vegetables in the UK diet, have been quantified. In hydroponic experiments significant differences were observed between crops in the uptake of PAHs by both their roots and their shoots and the bio-concentration factor of the PAHs declined as the concentration in the solution culture increased. In shaded plants where the transpiration stream flux was reduced the uptake of PAH was also reduced and there was no transfer between roots grown in contaminated solution to those in clean solution. This indicates that the xylem not the phloem is the major transport system for the transfer PAHs within plants. Additionally there was no detectable contamination of the shoot as a consequence of vapour transfer from the PAH contaminated solution. The implications of these results for the modelling of plant uptake of organic chemicals are discussed.

MP139 Presence of Pharmaceuticals in Groundwater Down Gradient from Lagoons Receiving Partially Treated Wastewater. S.T. Glassmeyer, USEPA, Cincinnati, OH; C. Kenah, Ohio EPA, Columbus, OH; E.T. Furlong, USGS, Denver, CO; D.W. Kolpin, USGS, Iowa City, IA. Wastewater can contain traces of the pharmaceutical compounds that are used within a given household or community. These chemicals can act as markers of the wastewater, and their presence can help determine potential sources of contamination of water resources. For this study, groundwater samples were collected up and down gradient from an unlined wastewater treatment plant lagoon serving 400 households. All samples were analyzed for 16 pharmaceuticals using liquid chromatography/ mass spectrometry. The study consisted of two phases. In Phase I (August 2005), 13 different boring locations were drilled, and samples were collected at two to three depths within each hole to determine the boundaries of the leachate plume. In addition, the treated effluent, the municipal lagoon, and the community's drinking water were also sampled. Monitoring wells (MW) were installed adjacent to three of the bore holes, one up gradient, and two down gradient. During Phase II, the three MWs, the lagoon, and the drinking water source were sampled four additional times over a 14 month period (January, April, July and October 2006) to examine seasonal trends in chemical concentrations. Thirteen of the 16 target pharmaceutical compounds were detected at least once. Carbamazepine and sulfamethoxazole were the most commonly detected, occurring in every sample collected from the two down gradient MWs. The carbamazepine concentrations in the MW proximate to the lagoon (MW 2) had concentrations which ranged from 0.316 to 0.642 µg/L, median 0.513 µg/L, which were greater than the concentrations we measured in the lagoon samples (0.02 to 0.557 µg/L, median 0.044 µg/L). The concentrations in MW 2 were even greater than the treated wastewater effluent samples collected in 2002 (max = 0.270 µg/L). The samples collected from multiple depths within each boring location tended to exhibit the

highest concentrations of pharmaceuticals in the shallower samples (25-45 feet below the surface), with decreasing concentrations with increasing depth. Disclaimer: Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy.

MP140 Loadings of Pharmaceutical and Personal Care Products (PPCPs) and Endocrine Disrupting Chemicals (EDCs) from Small Rural Streams into an Urban Drinking Water Source. T.B. Huff, Environmental Science and Policy, George Mason University, Manassas, VA; J. Liu, Shared Research Instrumentation Facility, George Mason University, Manassas, VA; G.D. Foster, Chemistry and Biochemistry, George Mason University, Fairfax, VA. Pharmaceutical and personal care products (PPCPs) and endocrine disrupting chemicals (EDCs) have been investigated for their potential to disrupt aquatic ecosystems. Current research also focuses on their potential to impact human health through incomplete removal in some drinking water treatment systems that rely on surface water sources that are also receiving sewage effluent and runoff from agricultural practices. Effective mitigation will require knowledge of existing concentrations and loadings from tributaries into drinking water supplies. Water and suspended sediment samples were obtained on a monthly basis during storm and base flow conditions from Cedar Run and its smaller tributaries. Cedar Run is a creek that drains 242 sq km of rural Fauquier County in Virginia's Piedmont region. The county land use consists of cattle and corn agricultural operations as well as small towns with septic tank systems. Discharge from Cedar Run has been measured at USGS gauging station number 01656000—the primary sampling location—at greater than 62 cubic meters per second during storm events. This discharge enters the Occoquan River which is the source of drinking water for Fairfax County, Virginia, an urban-suburban county with a residential population of over 1 million. Samples were analyzed for a suite of 50 common PPCPs and EDCs including antibiotics, estrogenic steroids and household chemicals. Extractions of dissolved phase samples were performed using Oasis solid-phase extraction cartridges (Waters Corp., Milford, MA). Extractions of filtered suspended sediments were performed using a MARS (microwave accelerated reaction system; CEM Corporation, Matthews, NC). Extracts were analyzed by a combination of GC-MS and LC-MS protocols. Agricultural EDCs such as atrazine and its metabolites and PPCPs such as trimethoprim, sulfamethoxazole and caffeine were frequently detected in concentrations ranging from ng to ug per liter. Instantaneous and seasonally estimated loadings of detected analytes are presented here.

MP141 Estrogen receptor antagonist assay for wood extractives in paper mill wastewater. M. Terasaki, M. Makino, Institute for Environmental Science, University of Shizuoka, Shizuoka, Japan; H. Fukazawa, Shizuoka Institute of Environment and Hygiene, Shizuoka, Japan; F. Shiraishi, National Institute for Environmental Studies, Tsukuba, Japan. The paper mill wastewater was fractioned by solid-phase extraction combined with the C18 disk and florisil cartridge. Estrogen receptor (ER) antagonist activity of the fractions was assessed using a yeast two-hybrid assay by incorporating the human estrogen receptor α . The fractions that exhibited a positive assay response were analyzed by GC-MS. Water samples (600 mL) were acidified with 6 mL acetic acid/methanol 1/9 (v/v), filtered with GF/A, and passed through C18 under reduced pressure. After drying, the C18 disk was consecutively eluted with methanol. The eluent was collected in a test tube, evaporated using a nitrogen stream, and reconstituted into 5 mL hexane/dichloromethane 3/1 with ultrasonic bath. The extract was siphoned through a vacuum manifold onto the conditioned florisil cartridge; subsequently, the cartridge was dried for 1 min. This was followed by sequential elution with 5 mL of hexane/dichloromethane 3/1 (FL-W fra.), acetone/dichloromethane 5/95 (FL-5% fra.), 10/90 (FL-10% fra.), 20/80 (FL-20% fra.), and methanol (FL-RM fra.). All the fractions were collected in a test tube, evaporated using a nitrogen stream, and dissolved in 60 μ L DMSO. The working range of the assay was the concentration ratio from 0.78-fold to 100-fold for the water samples, and the activity was recorded as their IC50 values. FL-RM fraction was the most active fraction, and the IC50 value corresponded to the concentration ratio of 8.4-fold. Both FL-20% and FL-10% fractions showed activities that were 1/8 that of the FL-RM fraction. In the FL-RM fraction, ethyl pimarate, methyl dehydroabietate, methyl abietate, pimaric acid, isopimaric acid, dehydroabietic acid, and abietic acid that are known as wood extractives were identified by GC-MS. Additionally, 4-(1-phenylethyl)phenol, bisphenol A, and 2,4-bis(1-phenylethyl)phenol that are used for manufacturing thermal paper were detected. The yeast two-hybrid assay of the selected 4 compounds showed antagonist activity; their IC50 values were 260 nM, 290 nM, 390 nM,

and 3300 nM for isopimaric acid, dehydroabietic acid, abietic acid, 2,4-bis(1-phenylethyl)phenol, respectively. The present study provides evidence regarding the use of certain diterpenes and additives of thermal paper as potent ER antagonists.

MP142 Seasonal variations in levels of major veterinary antibiotics in Kyungahn stream, Korea. Y. Kim, K. Choi, School of Public Health, Seoul National University, Seoul, South Korea; C. Park, M. Kim, Research Institute of Public Health and Environment, Seoul, South Korea; J. Park, Korea Environment Institute, Seoul, South Korea; P. Kim, Yongin University, Yongin, South Korea; P. Do Hyeon, Dept. of Biochemistry & Health Science, Changwon University, Changwon, South Korea; K. Young Lim, Dept. Health & Environmental Science, Eulji University, Seongnam, South Korea. Veterinary pharmaceuticals would reach the water environment through various pathways, e.g., effluents from wastewater treatment plant, runoffs from agricultural land, or directly from fish farms. To understand the occurrences and seasonal variations of major veterinary antibiotics in Kyungahn stream, one of the key upstream sources of pollution load to the mainstream Han River, Korea, we measured thirteen major veterinary antibiotics such as three tetracyclines, six sulfonamides, and four other antibiotics. Over approximately 560 km² watershed of Kyungahn stream, many intensive animal feeding operations are in practice, and hence their contribution of antibiotics to the stream is of concern. Thirty seven water samples were collected in each of three sampling events representing normal, wet and dry seasonal water flow characteristics. Detection frequency during the low flow season increased by 50 percent compared to the normal flow. Especially, enrofloxacin and sulfamethoxazole were 3 to 4 folds higher than in normal season, respectively. This could be explained by lower water level of receiving water. Furthermore this increase in detection frequency and concentration of pharmaceuticals could be soared up at the end of dry season when the lowest water level of streams. Interestingly, tetracycline, oxytetracycline and chlortetracycline showed higher mean concentrations during wet season. This could be explained by direct contribution of runoff from agricultural area which livestock manure composted in or from cattle sheds. The most frequently detected antibiotics were sulfamethoxazole in normal and dry season and sulfamethazine in wet season. Seasonal variation of pharmaceuticals in water reflects high coefficient of river regime in Korean rivers. Development of receiving water specific estimation model for pharmaceuticals in water is needed for better risk management.

MP143 Pharmaceuticals in combined sewage system of Korea. Y. Kim, K. Choi, School of Public Health, Seoul National University, Seoul, South Korea; C. Park, M. Kim, Research Institute of Public Health and Environment, Seoul, South Korea; J. Park, Korea Environment Institute, Seoul, South Korea; P. Kim, Yongin University, Yongin, South Korea; K. Young Lim, Dept. Health & Environmental Science, Eulji University, Seongnam, South Korea; P. Do Hyeon, Dept. of Biochemistry & Health Science, Changwon University, Changwon, South Korea. The levels of pharmaceuticals in sewage treatment plant (STP) influents and effluents reported worldwide were often high enough to cause damages on aquatic organisms. In this study pharmaceuticals in influents and effluents of the six STPs located in Seoul and Gyeonggi, Korea were measured during normal, wet and dry seasons. Among 294 publicly owned STPs in Korea, approximately 56% receive wastewaters from a combined sewer system, hence the amount of sewage tends to increase in wet seasons because of the runoff. For example, the flow rate of Nanji STP with 100 percent combined sewage system was increased by up to 24 percent in wet season. on the other hand, the concentrations of pharmaceuticals in STP influents and effluents were greater during the dry season. Especially influent concentration of sulfamethazine in Nanji STP in dry season was two times higher than normal and eight times higher than wet season. Roxithromycin, ranged from 28 to 241 ng/L in dry season, increased up to 14 fold higher than the wet season levels. i.e., 3 to 190 ng/L. The efficiency of pharmaceutical removal varied according to sampling time. Sulfamethoxazole and trimethoprim showed low mean STP removal rate of 47 and 50 percent while the other compounds were removed over 90 percent by sewage treatment. Removal efficiency decreased during wet season, but increased during dry season than normal season, except for trimethoprim. Roxithromycin was detected in higher concentration in effluent than in influent, implying activation of conjugated components. The most frequently detected pharmaceuticals in effluent were trimethoprim, sulfamethazine, sulfamethoxazole and roxithromycin, and their 90 percent upper confidence limits reached 77.2, 108.7, 376.8 and 120.1 ng/L, respectively. These levels

are about from one to three orders of magnitude lower than their respective predicted no effect concentrations, suggesting little ecological concerns.

MP144 Effects of dissolved organic matters (DOM) isolated from WWTP effluent on the sorption of 17 β -estradiol and its estrogenic activity. J. Lee, B. Lee, S. Kim, Environmental Science and Engineering, Gwangju Institute of Science and Technology, Gwangju, South Korea. The presence of endocrine disrupting chemicals (EDCs) in waters discharged from wastewater treatment plant (WWTP) causes serious endocrine disruption effects such as the increase of vitellogenin (VTG) and alteration of reproduction function. Among EDCs, E2 has the most estrogenic potency even with low concentration of ng/L in water environment. It has been widely recognized that the sorption and bioavailability of E2 are influenced by the properties of DOM. The aim of this study is to determine the sorption coefficient of E2 with different size and hydrophobic & hydrophilic characteristics of DOM isolated from WWTP effluent by fluorescence quenching method and to estimate its estrogenic activity by E-screen assay. The size of 0.2 μ m DOM filtrate isolated from WWTP effluent showed a little higher E2 sorption coefficient (i.e., $67 \pm 8.8 \times 10^3$ L/Kgoc $\sim 264 \pm 75 \times 10^3$ L/Kgoc), bounded with E2 in the range from 29% to 63%, than other size fractions. Estrogenic response of E2 to DOM was also significantly decreased by four-fold compared with that of control ($p < 0.01$). This may be due to the inhibition of DOC toward E2 binding with estrogen receptor onto cell. Furthermore, hydrophobic DOM showed a higher E2 sorption coefficient (i.e., $40 \pm 2.8 \times 10^3$ L/Kgoc $\sim 566 \pm 118 \times 10^3$ L/Kgoc), bound with E2 in the range from 46% to 75%, than that of hydrophilic DOM. The estrogenic activity of hydrophobic DOM was significantly low by twice as that of hydrophilic DOM ($p < 0.05$, $r^2 > 0.67$). Consequently, the determination of the characteristics of DOM is important to evaluate the sorption coefficient and estrogenic activity of E2.

MP145 Monitoring of the EDCs concentration and estrogenic activity using E-Screen assay in river water and sewage treatment plants, Korea. B. Lee, H. Kim, J. Lee, C. Duong, J. Ra, K. Kim, J. Jeon, S. Lee, S. Kim, Department of Environmental Science and Engineering, Gwangju Institute of Science and Technology, Gwangju, South Korea; K. Hwang, N. Jang, Yeongsan River Environment Research Center, Gwangju, South Korea. The purpose of this research is to monitor the occurrence and distribution of endocrine disrupting chemicals (EDCs) detected in 26 river water and 5 wastewater treatment plants (WWTPs) in Korea by using chemical and biological methods. Estrogenic activity and several substances were monitored in upstream and downstream in Yeongsan and Seomjin river including influent and effluent of WWTPs. Chemical monitoring of EDCs such as nonylphenol, bisphenol A, octylphenol, E1, E2, EE2, and genistein was performed with GC/MS that can widely used to analyze the steroid hormones discharging from human and animal. E-screen method with MCF-7 cell as in vitro assay was used to estimate the degree of estrogenic activity on aquatic environment. The level of nonylphenol and bisphenol-A showed high in influent and effluent of WWTPs, indicating the low removal efficiency of these compounds. In general, the detected concentrations of EDCs at confluence sites of rivers may show higher than those at upstream because of the pollutions from treated effluents. In this study, the targeted EDCs were detected at high concentration in midstream comparing to those detected in upstream and downstream (i.e., 5~20 times higher for nonylphenol and above 10 times higher for bisphenol A). In these sites, E1, E2, EE2, genistein were relatively detected at low concentration ranging from ND to 3 ng/L. E-screen assay for estimating the estrogenicity of river water and WWTPs has been conducted and the dose-response curves of 7 compounds based on the EC50 value were obtained. It showed high sensitivity to the river water and WWTP effluents which have very low estrogenicity.

MP146 Aerobic Degradation Rates and Pathways of 17 α - and 17 β -Trenbolone in Agricultural Soils. B. Khan, S.A. Sassman, L.S. Lee, Agronomy, Purdue University, West Lafayette, IN. Abstract: Trenbolone acetate (TBA) is a synthetic androgenic steroid hormone administered as a subcutaneous implant for growth promotion in beef cattle. Once in the blood stream it is hydrolyzed to active 17 β -trenbolone. The primary metabolites of 17 β -trenbolone present in manure from implanted cattle are 17 α -trenbolone and trendione. To aid in predicting the persistence of trenbolone in the environment, aerobic degradation studies of 17 α - and 17 β -trenbolone in a low organic carbon (OC) sandy soil and a higher OC silty clay loam soil were conducted at different initial concentrations (0.1 to 10 mg/kg). Both isomers degraded to trendione in a similar manner and exhibited slower degradation at higher initial concentrations with half lives ($t_{1/2}$) ranging from a few hours to 2

days. A first-order exponential decay model derived assuming transformation is irreversible and no impact of sorption on availability for degradation generally resulted in good model fits to the data. Trendione whether directly applied or produced from trenbolone persisted longer than trenbolone (approximately 5 days) and appeared biphasic. A small amount (1.5%) of conversion of trendione back to 17 β -trenbolone was observed during aerobic incubation at the higher applied concentrations. Conversion of 17 α -trenbolone back to the more potent 17 β -trenbolone, presumably through trendione, was not observed in the aerobic soil environment.

MP147 Plant Uptake of Antimicrobials Triclosan and Triclocarban by Food Crops. M. Schultz, S.E. Schostarez, S.P. Gollwitzer, D.R. Klein, C.N. Koechli, K.L. Long, Department of Chemistry, The College of Wooster, Wooster, OH. Pharmaceuticals and personal care products are of scientific and public concern as newly recognized class of environmental pollutants including antimicrobials such as antibiotics, disinfectants, and antiseptics. Triclosan (2,4,4'-trichloro-2'-hydroxydiphenyl ether) is an antimicrobial agent that is commonly found in personal care products and is one of the most commonly detected wastewater contaminants in rivers and streams in the United States. With reclaimed water and land application of biosolids being more widely used, there is a potential route for wastewater contaminants, like triclosan, to enter the food chain via food crops. Quantitative methods were adapted for the determination of triclosan in plant tissue by accelerated solvent extraction, followed by solid-phase extraction, and analysis by gas chromatography/mass spectrometry. Hydroponics experiments were performed with radish and lettuce seedlings to determine whether plant uptake of triclosan is driven by plant water content or lipid availability. Controlled laboratory exposure experiments were also performed, and triclosan was readily absorbed by both the lettuce and radish plants at low parts-per-billion concentrations. Hydroponics and controlled exposure experiments are currently being extended to another broad-spectrum antimicrobial triclocarban (N-(4-chlorophenyl)-N'-(3,4-dichlorophenyl) urea).

MP148 Evaluating Methods for Measuring Hormones in Livestock Waste. J. Hemming, S.W. Geis, C.J. Hedman, A.L. Prash, M.G. Mieritz, J.J. Schauer, M.M. Shafer, Wisconsin State Lab of Hygiene, University of Wisconsin-Madison, Madison, WI; T.P. Barry, Animal Science, University of Wisconsin-Madison, Madison, WI; J.J. Schauer, M.M. Shafer, Environmental Chemistry and Technology, University of Wisconsin-Madison, Madison, WI. The overall goal of this research is to determine the presence, persistence and biological effects of natural and synthetic hormones that may be released into the environment from Concentrated Animal Feeding Operations (CAFOs), and evaluate the effects of different animal waste disposal practices on the fate and activity of these compounds. This research will help to evaluate whether CAFO waste is an important source of endocrine disrupting chemicals in the environment. The first goal is to evaluate the sample preparations and analytical procedures involved in measuring hormones in the wide variety of matrices relevant to livestock waste. Samples are prepared with solid phase extraction techniques along with accelerated solvent extraction where necessary, followed by steroids analyses using LC-MS/MS and/or GC-MS. The target analytes include naturally occurring androgens, estrogens and progesterones, and synthetic hormones such as trenbolone. Experiments to evaluate several different solid phase sorbents are being conducted, and results from a variety of spiked matrices will be presented to evaluate recoveries of hormones during the various extraction procedures. To evaluate potential biological activity of hormones, a suite of molecular and cellular-based bioassays (e.g. E- and A-screens and androgen-, estrogen- and progesterone-transfected yeast assays) will be used. Concentration-response curves will be presented from the various bioassays with the target hormones in order to estimate potencies of the hormones. In addition, the bioassays will also be conducted on some of the spiked matrices to evaluate the extraction procedure in comparison to bioassay performance.

MP149 Occurrence of Endocrine Disrupting Compounds in Galveston Bay Salt Marshes. X.V. Sanchez, C.L. Howard, Environmental Science, University of Houston Clear Lake, Houston, TX. Many studies suggest that exposure to environmental endocrine disrupting compounds (EDCs) leads to defects in reproduction and developmental functions that alter survival of estuarine taxa. Most EDCs have been detected in surface water ecosystems including lakes, bays, estuaries, creeks, and wetlands. There is no information regarding EDCs in the coastal wetlands bordering Galveston Bay; therefore, the purpose of this study was to assess the risk of EDCs to

estuarine wildlife species. We analyzed estrogenic activity in the surface water, sediment and mussel tissue from nine sites representing native, restored and pollutant-impacted salt marshes in the Galveston Bay. Estrogen activity was determined by the in vitro bioassay ER-Lux and the YES assay. These assays measure luciferase or LacZ activity as a function of estrogen receptor-ligand binding interactions. The number of mussels contaminated with EDCs, and sediment and surface water levels of EDCs were determined in five samples per site. The levels of estrogen were used to evaluate the effects of EDCs in wetland restoration by correlation analysis among estrogen levels and plant environmental parameters and growth characteristics. These results can be used as preliminary data to monitor both regulatory and policy frameworks of EDCs in Galveston Bay area.

MP150 A new understanding of the term endocrine disruption by regarding natural estrogen in algae as the background level. Y. Hida, Y. Yamada, H. OOkura, T. Shibata, T. Kurata, Ecosystem Studies, The University of Shiga Prefecture, Hikone, Japan. Much of the research on endocrine disruption in aqueous environments has been conducted based on the early research on endocrine disruption instituted by Colborn et al. These studies failed to determine the magnitude of the influence of endocrine-disrupting substances considering the relative background level of substances of natural origin, disregarded other possible exposure factors, and made rough value judgments based on the awareness of the issues. It is important not to narrow the target substances and simplify the problem based on existing hypotheses, and to examine the action mechanism and exposure route considering various possibilities based on field studies. Using medaka estrogen receptor alpha-based yeast two-hybrid assays, the Cyanophyceae and Chlorophyceae were found to exhibit estrogenic activity about 50-fold higher on a unit weight basis than that of commercial fish feed containing soybean oil cake, which is thought to be a source of exogenous estrogens. The frequency distribution of the gonadosomatic index (GSI) in juvenile round crucian carp, which were cultivated during an extreme eutrophic pond under high estrogenic activity conditions, was similar to that of wild juveniles when they were subsequently released into Lake Biwa. Moreover, the addition of *Chlorella* influenced gonadal development during laboratory breeding from 160 to 310 days post-fertilization with the use of commercial feed, supporting the phenomenon observed in the field study. We propose a natural estrogen exposure scenario that involves algae. The natural background level of estrogenic action in an aqueous environment is determined by the level of exposure of fish to estrogenic substrates contained in algae, which are present universally and which the fish cannot avoid ingesting. This implies that endocrine disruption be assessed as a phenomenon that principally involves hormonal interactions between organisms. This scenario has features that are not only of scientific interest, but also lead to a perspective that overcomes the unease over the risk of endocrine disruption.

MP151 Identification of new estrogenic products transformed from fenthion under photo irradiation and evaluation of the agonist potency. K. Yamada, M. Terasaki, M. Makino, Graduate School of Nutritional and Environmental Sciences, University of Shizuoka, Shizuoka, Shizuoka, Japan. In the present study, we investigated the photo-degradation rate of fenthion (FN), a well-known organophosphorus insecticide, and the estrogen receptor-mediated activity of the transformed products, including FN itself. The irradiation was carried out with a high-pressure Hg lamp for 320 min, and the wavelength was limited using a glass filter to a range of 300 to 400 nm. The identification of transformed products was performed using NMR, GC/MS, and fast atom bombardment/mass spectrometry (FAB/MS) instruments, and the estrogenic activity was detected using a yeast two-hybrid (YMCE) assay that incorporated the human estrogen receptor- α (hER α) and was evaluated on the basis of equivalence concentration of 17 β -estradiol (E₂C). First, we observed the concentration change of FN under irradiation. It was found that the decrease in FN concentration obeyed good first-order kinetics, and the rate constant was calculated as 0.33 hr⁻¹. Next, we identified the transformed products in the irradiated solution by using authentic compounds as follows; fenthion sulfoxide, 3-methyl-4-(methylthio)phenol (MMP), 3-methyl-4-methylthioanisole (MMA) and 3-methyl-4-methylsulfinylphenol (MMS). We also measured the estrogenic activity of the solution. Although the activity of FN was not detected in the present assay, it was found that the concentration of E₂C in the solution depended on the irradiation time, for example, 5 pM (40 min), 17 pM (80 min), and 18 pM (160 min). Therefore, in order to elucidate the active compounds, the solution irradiated for 160 min was fractionated by HPLC, and all fractions were again tested by the YMCE

assay. Two fractions were found to exhibit activity, which was evaluated in terms of E₂C concentration as 5 pM (19–21 min)^{a)} and 11 pM (21–23 min)^{a)}. The former active compound was identified as MMP, and the latter one was O,O-dimethyl S-[3-methyl-4-(methylthio) phenol]phosphorothioate (S-aryl fenthion). Furthermore, to characterize the activity, we measured the binding affinity of these 2 compounds to hER α by ELISA^{b)}. The affinity of MMP was found to be 4 $\times$ 10⁻⁵ times that of E₂C; S-aryl fenthion also showed significant affinity. ^{a)}Time indicates the HPLC retention time. ^{b)}Estrogen-R(α) Competitor Screening Kit of Wako Pure Chemical Industries, Ltd. (Osaka, Japan). Keywords : estrogenic potency, fenthion, photodegradation

MP152 Recurrent salmon dieoffs in urban streams: modeling effects on coho populations. J.A. Spromberg, N. Scholz, Northwest Fisheries Science Center, Seattle, WA. Recent studies evaluating stream habitat restoration projects in the Seattle, Washington area detected a high rate of pre-spawn mortality among ocean-bright coho salmon, (*Oncorhynchus kisutch*). Adult coho in several urban streams showed symptoms (disorientation, lethargy, loss of equilibrium, gaping, fin splaying) that led to death. This pre-spawn mortality (PSM) has been observed at rates from ~20% to 90% in the urban streams monitored. Weight of evidence suggests causative factors involve non-point source stormwater runoff from urban and residential areas. Models forecast the impacts of continued urban growth on established wild coho populations and metapopulations by using scenarios simulating changes in land use, runoff management or rain events. Model scenarios depicting a gradual increase of PSM from 0% to 75% over 20 years to an otherwise viable individual population resulted in 100% extinction in an average of 30 years (10 generations) and constant impacts of 75% resulted in extinction in an average of 14 years (5 generations). Individual populations were linked by migration to form metapopulations. For salmon, that migration takes the form of adult spawners straying to spawn in streams other than their natal stream. Metapopulation models predicted large reductions in the abundance of impacted population but not extinction as long as unimpacted source populations were available to provide stray migrants. Unimpacted source population abundance declined when surrounding impacted populations became migrant sinks. The proportion of the metapopulation experiencing PSM showed the strongest influence on metapopulation abundance. The absolute level of PSM, the stray rate and the spatial distribution of carrying capacity produced weak relationships in response as quantified by the metapopulation spawner abundance over time. The metapopulation models demonstrate the potential for rapid loss or depression of localized populations in urban streams from nonpoint and stormwater sources.

MP153 A More Robust Method for Determining Biological Impairment in Urbanized Watersheds. S.K. Calcagni, E. Conner, Department of Natural Science, Piedmont College, Demorest, GA. Determining biological impairment in watersheds undergoing urbanization frequently consists of rapid screening methods that require the collection of only a single sample. The organisms in this sample are identified and indices computed and compared to a standardized scale. However, such methods have an inherent weakness: they do not utilize sample replication and statistical analysis, causing many to question their scientific validity. We sought to eliminate this weakness with a modified methodology based upon the EPA Rapid Bioassessment Protocol (EPA RBP). We tested this methodology in a study that compared aquatic macroinvertebrate communities between two streams in northeast Georgia: Camp Creek (CC), a stream in a watershed undergoing urbanization, and the Middle Fork of the Broad River (MFBR), a reference stream in National Forest lands. Instead of collecting a single sample per site, three replicate samples, including aquatic macroinvertebrates, substrate, and standard water chemistry parameters, were collected according to the EPA RBP. Also, macroinvertebrates were keyed only to the family level rather than to genus or species. Mean values for water chemistry parameters, substrate composition, and the numbers of individuals in tolerant or intolerant orders or families were compared between the two streams using either unpaired Student's t-tests or Mann-Whitney U tests. Results showed that CC contained significantly more silt and clay, higher specific conductivity, and lower dissolved oxygen. CC also contained significantly more macroinvertebrates in the tolerant taxa (e.g., Diptera, Chironomidae) and significantly fewer individuals in the intolerant taxa (e.g., Ephemeroptera, Ephemerillidae). These data clearly supported the hypothesis that CC would exhibit community characteristics associated with disturbance. Notably, we also computed two biological indices commonly used for the subcoregion under study (Hilsenhoff Biotic Index and Hughes/Williams Index) and

these also indicated that CC was “impaired” relative to the MFBR, strongly suggesting that our modified methodology provides similar, if not equivalent, information regarding stream condition. Yet, our method eliminated the need to key organisms to genus or species, eliminated the use of indices, and allowed for quantitative, statistical analysis of the data, thereby enabling a more scientifically robust analysis.

MP154 Impacts of Stormwater Runoff on Coho Salmon in Restored Urban Streams. J.W. Davis, P. Arnold, Western Washington Fish and Wildlife Office, U.S. Fish & Wildlife Service, Lacey, WA; S. McCarthy, J. Incardona, B. Feist, N. Scholz, Northwest Fisheries Science Center, NOAA Fisheries, Seattle, WA; L. Reed, K. Lynch, Seattle Public Utilities, City of Seattle, Seattle, WA. Beginning in the late 1990s, several agencies in the greater Seattle, Washington area began conducting fall surveys for spawning salmon to evaluate the effectiveness of local urban stream restoration efforts. These surveys detected a surprisingly high rate of mortality among migratory coho females that were in good physical condition, but had not yet spawned. In addition, adult coho from several different urban streams showed a similar progression of symptoms (disorientation, lethargy, loss of equilibrium, gaping, fin splaying) that rapidly led to the death of the affected animals. In recent years, pre-spawn mortality (PSM) has been observed in many lowland urban streams, with overall rates ranging from ~ 25% to 90% of the fall runs. Continuous daily surveys of wild coho spawners in a forested reference stream in northwest Washington revealed < 1% PSM. Although the precise cause of PSM in urban streams is not yet known, conventional water quality parameters (i.e., temperature and dissolved oxygen) and disease do not appear to be causal. Rather, the weight of evidence suggests that adult coho, which enter small urban streams following fall storm events, are acutely sensitive to non-point source stormwater runoff containing pollutants that originate from highly developed landscapes. These findings have important implications for restoration and conservation efforts in urban and urbanizing watersheds, respectively.

MP155 Characterization of land use intensity and integration into large-scale diagnostic risk assessment; An application of the GIS-based WOE/WLR methodology. K. Kapo, G.A. Burton, Earth and Environmental Sciences, Wright State University, Dayton, OH. Land use, such as urban and suburban development, is a highly influential determinant of the types and severity of watershed stressors present over a landscape. Large-scale diagnostic assessments incorporating dynamic spatial land use patterns allow for the delineation of stressor-response associations dependent upon land use intensity within watersheds. This study quantitatively describes complex land use intensity in Ohio (USA) watersheds for various land use types using the cumulative size-frequency distribution and power-law scaling. GIS-based weights of evidence and weighted logistic regression (WOE/WLR) analysis is used to compare the spatial association of biological endpoint responses to a range of physical and chemical stressors at monitoring sites in varying degrees of land use intensity. Differences in both stressors present as well as aquatic community sensitivity to stressors are observed between established land use types based on the variance in land use pressures. Temporal land use trends are also quantitatively examined in relation to changes in spatial distribution and biotic condition within Ohio watersheds. The WOE/WLR method provides a quantitative synthesis of complex spatial patterns and a clear risk communication product of interactive GIS probability maps.

MP156 Changes in Benthic Macroinvertebrate Community Structure (1988 – 2005) in a Rapidly Urbanizing Western River, the Trinity River, Texas. J.L. Slye, D.R. Johnson, S.F. Atkinson, Institute of Applied Sciences, University of North Texas, Denton, TX. Benthic macroinvertebrate community composition studies have been conducted on the Texas Trinity River over the past 20 years. The Trinity River is created by four forks that converge in the Dallas-Fort Worth Metroplex (DFW). The Trinity River drains the most highly populated and industrialized watershed in Texas and is dominated by wastewater treatment plant (WWTP) and industrial effluents. This near-worst case condition presents an opportunity to examine the environmental effects of household and industrial effluents on a major river system. A benthic macroinvertebrate study, designed to develop a contemporary understanding of the river as it drains the Metroplex, was conducted in 1987 and 1988. Those results showed that many reaches of the Trinity River supported diverse benthic communities. However, benthic communities immediately downstream of wastewater treatment plants had the lowest biotic indices. Since 1988, the Metroplex has experienced increases in population (>30%) and urban land use, along with improvements

in wastewater treatment. A second study, initiated in 2005, paralleled the 1987-88 study, to evaluate changes in water quality and benthic community structure that might be influenced by the increased urbanization. Fifty taxa were reported from the 1988 data as compared to 112 taxa in 2005, with higher numbers of Oligochaeta and Chironomidae. The 2005 results were evaluated in detail to determine which land use, water chemistry, and habitat parameters could be contributing to differences in the populations of organisms found both spatially and temporally. The metroplex has experienced dramatic increases in residential and urban land uses, with corresponding decreases in agricultural and forested land uses. In-stream water chemistry, habitat, and geospatial data were used in multiple regression and multivariate analyses to predict benthic macroinvertebrate ecology. In-stream cover, river width, and surface water total organic carbon were the top three parameters used to predict benthic ecology.

MP157 Catch Basins as Sources of Mosquitoes and West Nile Virus: An Evaluation of Mosquito Larvae Abundance and the Efficacy of Control Strategies. M. Sternberg, C. Grue, J. Grassley, K. King, L. Conquest, University of Washington, Seattle, WA. During the summer of 2005, Washington was one of only two states within the contiguous U.S. with no human cases of West Nile Virus. In anticipation of its spread, Seattle officials promoted a city-wide research effort aimed at investigating environmental factors governing mosquito larvae abundance within catch basins (stormwater drainage basins) and the efficacy of three common larvicides. The three larvicides tested were Mosquito Dunks® and Bits® (AI = *Bacillus thuringiensis israelensis*), VectoLex® WSP (*Bacillus sphaericus*), and Altosid® Briquets (Methoprene). Catch basins were randomly selected within the city and were proportional to city sector and zone. Basins were monitored weekly for mosquito larvae along with other basin characteristics. Larvicide efficacy and fate were monitored in a smaller set of basins. Larval counts within the west and southwest sectors and the single family zone were statistically greater ($p < 0.05$) than other sectors and zones. Sediment texture, pH, and selected roadway contaminants did not differ between basins with high or low larval counts. All of the larvicides performed according to manufacturers' expectations. All treatments resulted in a rapid reduction in number of pupae (Bt and Bs) or hatching success of pupae (Methoprene), although the Bs treatment was the most effective. Larvicides were effective for at least 7 weeks post-application. The effectiveness of Methoprene was reduced during precipitation events. Concentrations of Bt and Bs exceeded background levels for at least 35 days. In most basins, Methoprene was not detected at concentrations above 0.2 ppb irrespective of time posttreatment. This information will be used by the city of Seattle in the development of long-term strategy for mosquito control. Research in 2007 will focus on the potential for the larvicides to enter surface waters following citywide application of Bs.

MP158 Environmental Factors Governing Amphibian Reproduction in Stormwater Detention Ponds. A.E. Yahnke, College of Forest Resources, University of Washington, Seattle, WA; C. Grue, Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, WA. Stormwater detention ponds are installed in developing landscapes to mitigate for the effects of increased impervious surfaces. They are designed to attenuate water flows and pollutants entering wetlands and streams from precipitation. However, even when not designed for ecological functions, stormwater ponds self-seed with wetland plants and wildlife often use them as habitat. Five native pond-breeding amphibian species in King County, Washington, use stormwater ponds for breeding. Species such as Northern red-legged frogs (*Rana aurora*) and Northwestern salamanders (*Ambystoma gracile*) lay egg masses on available wetland plants or over-hanging woody material, but large water-level fluctuations, a frequent phenomenon in stormwater ponds, can strand egg masses, often desiccating them. Additionally, the pollution abatement function of the ponds may expose amphibians in vulnerable life stages to a suite of pollutants (including pesticides, petroleum, and heavy metals) that are components of stormwater runoff. Stormwater pond selection as breeding sites may result from development-related wetland loss and degradation, or because water and/or air temperatures associated with stormwater ponds are more attractive to amphibians breeding during the cooler late winter-early spring. Stormwater pond management, including dredging to increase storage capacity and mowing pond edges for aesthetics and access, reduces available cover and food resources for amphibians, and is reflected in reduced amphibian abundance. However, amphibians will continue to lay eggs on available substrates such as fallen branches in ponds that were recently dredged. Our future research will focus on evaluating the

relative effects of contaminants on amphibian reproduction within stormwater ponds. Ultimately the role of stormwater ponds either as viable habitat or attractive sinks for amphibian populations needs to be evaluated in order to inform stormwater pond management and design.

MP159 Effects of Urbanization on Algal Communities across the U.S. A.H. Bell, B.C. Scudder, Wisconsin Water Science Center, US Geological Survey, Middleton, WI; J.F. Coles, New Hampshire Water Science Center, US Geological Survey, Pembroke, NH; K.D. Carpenter, Oregon Water Science Center, US Geological Survey, Portland, ND. The U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Program studied the effects of urbanization on riverine ecosystems, including algal assemblages at 262 sites in nine major metropolitan areas with varying physiographic settings across the US. An urban intensity gradient design was used to select 28-30 sites in each metropolitan area with land cover ranging from either primarily agriculture or forested land (low urban), depending on the metropolitan area, to highly developed (high urban). Study areas included Portland, OR; Salt Lake City, UT; Denver, CO; Dallas-Fort Worth, TX; Milwaukee-Green Bay, WI; Birmingham, AL; Atlanta, GA; Raleigh-Durham, NC; and Boston, MA. Algal data were sampled according to standard USGS protocols, along with habitat characteristics, field water-quality parameters, nutrients, pesticides, contaminants with semi-permeable membrane devices (SPMD), hydrology, and water temperature. Additionally, watershed and riparian land cover, road density, soils, topography, fragmentation statistics, and demographic datasets were compiled for each stream basin. Relations of environmental characteristics to algal, invertebrate, and fish assemblages were assessed using multivariate techniques; this paper describes the algal relations. The algal assemblages were moderately well correlated to urban indicator variables in some of the study areas, but in general, algal assemblages related more to non-urban characteristics. Preliminary analyses also show strong relations, in some study areas, of algal assemblages to specific environmental characteristics, especially water-quality concentrations such as nitrogen constituents and chloride, and land cover data such as impervious surface, urban, forest and agricultural land covers. These results will be valuable in determining the range in algal responses to urbanization in a variety of common environmental settings across the US.

MP160 A Preliminary GIS Analysis of Urban and Land Use Effects on Water Quality along the Central Amazon. K. Hernandez-Roeder, C.L. Howard, Environmental Science, University of Houston Clear Lake, Houston, TX. To determine the effect of land use on water quality along the central Amazon River, a GIS analysis was performed on data obtained from water samples collected in 2002 along the Rio Solimoes and compared with samples collected from the same areas in 2007. Conductivity, pH, apparent color, turbidity, and total dissolved solids were determined in the 2002 set; these parameters plus N and P were evaluated in the 2007 set. Maps were developed of water quality data using ArcGIS 9.1 using GPS coordinates of water samples plotted along with coordinates of urban centers of the central Amazon. Preliminary results indicate land use patterns influence water quality along the river's path. High conductivity results along with elevated turbidity readings were found in the upper Amazon with decreasing results toward the lower Amazon. Levels of dissolved solids were decreased in less populated areas of the central Amazon as well as in less disturbed river regions. These effects on water quality were more pronounced in 2007. Future studies include gathering water quality data along the Rio Negro, a river in the northern central Amazon region; to be used in conjunction with NASA satellite and shuttle data on land usage found between the two tributaries of the region to develop a model on long term effects of land usage on water quality of the Amazon region.

MP161 National Changes in Aquatic Habitat and Geomorphic Response to Urbanization, with Implications for Assessing Habitat Degradation. M.C. Pepler, F.A. Fitzpatrick, Wisconsin Water Science Center, U.S. Geological Survey, Middleton, WI. From 2000–2004, the U.S. Geological Survey conducted a study of urbanization effects on biological, chemical, hydrological, and physical characteristics of 262 streams in nine metropolitan areas of varying physiographic settings across the U.S. as part of the National Water-Quality Assessment Program. A rural to urban land-cover gradient approach was used. Landscape characteristics and measures of urbanization were examined at multiple spatial scales, including watershed, riparian buffer, and reach. Urban indicators included percent impervious surface, percent urban land, population density, proximity of urban land to the sampled reach, road density, and an index of urbanization. Habitat characteristics for each reach were measured at 11 transects during low flow and included

bankfull channel dimensions, percent of geomorphic channel units, wetted channel dimensions, channel-bottom substrate size, and bank conditions (substrate, percent and length of vegetative cover, angle, and percent erosion). Preliminary results from this study indicate that the main habitat alteration from urbanization, on the national level, was channel enlargement (channel widening or downcutting). However, the amount of channel enlargement depended on the climatic and physiographic setting of the watershed and its geomorphic history. Changes in substrate and geomorphic channel units associated with urbanization depended on local geomorphic and geologic setting and human alterations. Local natural features and numerous human alterations (on both rural and urban streams) decrease the potential responsiveness of stream habitat to urbanization and included bedrock controls or lack of alluvium, channelization, bank stabilization, grade control, and dams. Results from this study emphasize the importance of including both a wide range of geologic and topographic variables at multiple scales and a working knowledge of historical channel modifications, in determining physical responses of streams to land-cover disturbance by urbanization.

MP162 Effects of Urbanization on Stream Ecosystems in Western Lake Michigan Drainages, Wisconsin. B.C. Scudder, K.D. Richards, F.A. Fitzpatrick, J.J. Steuer, A.H. Bell, M.C. Pepler, J.S. Stewart, Wisconsin Water Science Center, U.S. Geological Survey, Middleton, WI; M.A. Harris, Illinois Water Science Center, U.S. Geological Survey, Urbana, IL. In 2003 and 2004, 30 streams near Milwaukee and Green Bay, Wisconsin were part of a national study by the U.S. Geological Survey to assess urbanization effects on physical, chemical, and biological characteristics along an agricultural to urban land-use gradient. A multi-metric urban intensity index was developed using GIS-based data to quantify the gradient of urbanization within these relatively homogeneous environmental settings. Thirty-five variables were used in the final urban intensity index and included road infrastructure, riparian buffer land cover, watershed land cover, and twenty-six 2000 Census socioeconomic variables that characterized the watershed settings and associated populations. Characteristics examined as part of this study included: habitat, hydrology, stream temperature, water chemistry, benthic algae, benthic invertebrates, and fish. Physical habitat measurements reflective of channel enlargement increased with urbanization but river engineering features in some of the watersheds may have confounded other potential habitat responses to urbanization. A number of hydrologic condition metrics, including flashiness metrics, duration of high and low flow, and daily stream temperature were positively correlated with urbanization. Spring sulfate, prometon, and diazinon concentrations were positively correlated to road density variables, percent impervious surface, and percent urban land-use. Spring and summer chloride concentrations were greater with increasing road infrastructure characteristics, urban land cover, and other landscape variables related to urbanization as a result of road salt deicer usage. Potential aquatic toxicity and organic contaminants, as measured from semi-permeable membrane devices, were higher with increasing road density, total impervious area, and urban land use. These findings would indicate that vehicles and related infrastructure were a major source of these chemicals. The quality of algae, invertebrate and fish assemblages showed negative responses to increasing percentages of urban land and associated characteristics of increasing impervious surface, streamflow flashiness, chloride, and decreases in percentage of watershed wetland area and streambank vegetative cover.

MP163 Regional assessment and management of adjacent urbanizing watersheds surrounding Bellingham, Washington USA. W.G. Landis, J.A. Ellis, L.A. Kaminski, C.M. Maginnis, Inst. Env. Tox, Western Washington University, Bellingham, WA. A series of watersheds for 7 creeks (Terrell, Silver, Squalicum, Spring, Baker and Cemetery) and Lake Whatcom are in the increasingly urban area within and surrounding Bellingham Washington. The creeks are spawning habitat for at least one species of anadromous salmonid, and small streams such as these used to account for half the salmon production in the Georgia Basin. Lake Whatcom serves as the reservoir for Bellingham and the adjacent part of Whatcom County. Lands within these watersheds come under the jurisdiction the City of Bellingham, Whatcom County, and the WA Department of Natural Resources. In the creek watersheds we have examined the relationship between land use and smolt production, in addition to a regional risk assessment. Lake Whatcom was the subject of a regional risk assessment incorporating both ecological and human health endpoints. There are features in common to each watershed. Non-point sources are important, but no type of contaminant dominates the system. The Lake Whatcom watershed is listed for phosphorus, but an elimination of phosphorus reduces

the total risk by only 20 percent. There is no clear pattern between different types of land use and smolt production in the streams, but the lack of apparent relationship may be due to the lack of appropriate data, or that the numerous blockages in the streams are limiting. In the risk assessment, non-point sources dominate; with no one factor being a key. In contrast, the TMDL process and the activities of planning departments make decisions on a stressor-by-stressor, case-by-case basis. This research demonstrates the disconnect between the reality of increasingly urban watersheds and the management structure for preserving valued ecological services.

MP164 Quantitative Tracer Studies To Characterize Hydrology Of An Urban Wetland. J. Johnson, C. Cobb, L. Sharpe, T. Byl, Environmental Engineering, Tennessee State University, Nashville, TN; J. Johnson, C. Cobb, T. Byl, Water Resources, USGS, Nashville, TN. Tracer studies are frequently done to characterize contaminant flow through heterogeneous hydrologic systems such as wetlands. Quantitative tracer studies can provide very useful information, such as time of travel, discharge, residence-time distribution, and Peclet values (which provides insight into advection and dispersion properties). The objective of this research was to evaluate Peclet values from tracer studies done in a wetland under different hydrologic conditions. The Residence-time Distribution (RTD) formula was used to calculate Peclet values. We divided the wetlands into 2 components for the tracer study. The length of the upper wetland was ~250 m and the lower wetland was ~500 m. The wetland is fed by a spring stream and storm runoff. Tracer studies were done under low/baseflow conditions and storm conditions. The Peclet values were greater under low/baseflow conditions when dispersion was greater. The transport of tracer during storm events or forced gradients was dominated by advective processes. The mean residence time under baseflow was 35 hours for the upper wetlands and 45 hours for the lower wetlands. The mean residence time during stormflow was 52 hours for the upper wetland and 59 hours for the lower wetlands. The findings show that despite the greater volume of water moving through the wetland during storm flow, it had a longer residence time due to water backing up. This has implications for the water chemistry and contaminant removal in the wetlands.

MP165 Effect of an Urban Wetland on Non-Point Source Pollution in Nashville, TN. C. Cobb, J. Johnson, L. Sharpe, T. Byl, Environmental Engineering, Tennessee State University, Nashville, TN; C. Cobb, J. Johnson, T. Byl, Water Resources, USGS, Nashville, TN. A major contributor to non-point source pollution (NPS) in urban streams is parking lot and road runoff during rain events. Wetlands have been shown to attenuate suspended sediments, bacteria and agricultural pollution in rural areas, but little work has been done with urban wetlands. The objective of this project was to determine if a natural wetland located down gradient of parking lots and city streets helped to mitigate the NPS runoff. The first phase of the project required walking through the wetlands, the parking lots and road during rain storms to observe where the water flowed and to establish sampling points. The second phase was to collect water at the sampling sites during base-flow and rainstorms that produced sufficient runoff after a minimum of 3 dry days. These samples were taken back to the lab for analysis. Additional water samples were collected during base- and storm-flow over the next 6 months. The samples were analyzed within 48 hours of collection for turbidity, specific conductance, pH, and volatile organic compounds (VOC). The most dramatic change in water quality was associated with the VOCs. The water coming off the parking lot and road had levels as high as 62 ug/L benzene, 132 ug/L toluene and 106 ug/L xylenes, as well as, 4 unidentified peaks. As the water moved through the wetland, the VOC concentration became undetectable. The wetlands also removed 90% of the turbidity and lowered nitrate concentration. Mid-way through this study, beavers modified the hydrology and forced a new flow path during high-water storm events. The new flowpath forced water to move through cattails and increased the residence time in the wetland. This hydrologic modification improved the efficacy of the wetland to remove NPS pollution. Two lessons were learned from this study. One, urban wetlands provide a valuable function for cleaning NPS pollution from urban runoff. Second, characterizing the hydrology of this wetland provided insight into designing constructed wetlands to mitigate water pollution in urban areas.

MP166 Concentrations of trace organic contaminants in urban stormwater runoff; contributions by land use category. K. Schiff, J. Peng, W. Lao, K. Maruya, So Cal Coastal Water Research Project, Costa Mesa, CA; J. Gan, University of California Riverside, Riverside, CA. Like most urban estuaries in the Southern California region, Upper Newport Bay (UNB) receives significant loading of anthropogenic contaminants via stormwater

runoff. Because TMDLs for persistent organic contaminants in the Newport Bay ecosystem are currently being developed, identification and quantification of contaminant sources in this embayment are key for effective regulatory action. To investigate the link between contaminant reservoirs associated with UNB sediments and stormwater inputs from its watershed, sites representing major land use categories were sampled during three storm events in 2006. Gas chromatography-mass spectrometry (GC-MS) was employed to determine stormwater particulate concentrations of total DDT, PCBs, chlordanes and PAH. For all four contaminant classes, levels were greater than, or equal to, the concentrations measured in UNB bedded sediments, indicating that stormwater inputs remain likely contributors to sediment contamination. Average suspended particulate concentrations of total DDT from agricultural sites (869 +/- 150 ng/g) and total PCB from construction sites (681 +/- 535 ng/g) were an order of magnitude greater than those representing the other land use categories. In contrast, total PAH from residential and industrial/commercial land uses were one to two orders of magnitude greater (1,550 +/- 462 and 26,100 +/- 35,200 ng/g, respectively) than either agriculture or construction land uses. Attempts to utilize chiral gas chromatography (CGC) and compound specific isotopic analysis (CSIA) were mildly successful, with possible discrimination among contaminant signatures from the major land use categories. It is likely that wet weather loadings are land use as well as contaminant class specific.

MP167 Water quality and limnological gradients in a chain of effluent-dominated urban lakes. B. Brooks, B. Fulton, T. Scott, A. Ramirez, T. Valenti, K. Chambliss, Baylor University, Waco, TX; M. Hooper, Texas Tech University, Lubbock, TX. In arid and semi-arid regions, urbanization can lead to an increased proportion of effluent-dominated or dependent systems, which pose numerous challenges to aquatic scientists. The Jim Bertram Lake System in Lubbock, Texas, USA is a series of effluent-dependent urban reservoirs, representing one of the largest reclaimed urban aquatic systems in the United States. Effluent that has first been land applied with circle pivot irrigation, percolated through soils and then reclaimed from groundwater flows through a series of five urban reservoirs. Historical studies indicate a decreasing gradient of nitrate levels through the cascading reservoirs, which suggests that this system may provide a treatment approach for future water reuse efforts. Select ambient water quality and limnological parameters were assessed in this system during summer 2006. Specifically, levels of select pharmaceuticals and other wastewater indicators, nutrient and chlorophyll a levels, alkaline phosphatase activity, nitrogen fixation potential, ambient toxicity to *Daphnia magna*, and physicochemical parameters were determined in each reservoir. Diel dissolved oxygen and temperature data were used to estimate ecosystem metabolism; metabolic rates were subsequently used to compute site specific P:R ratios. Our findings confirmed previous studies of decreasing nitrate through this system. Further, ambient *D. magna* chronic toxicity observed in the initial reservoirs was ameliorated at downstream sites. Carbamazepine, an antiepileptic pharmaceutical recently reported by our group in fish tissue from an effluent-dominated stream, was highly correlated ($R^2 = 0.98$) with nitrate, supporting other reports that carbamazepine may be a suitable wastewater tracer. Interestingly, autotrophic conditions were observed in reservoirs 1 and 2 ($P:R > 1$), while reservoirs 3–5 were increasingly heterotrophic ($P:R > 1$). A corresponding decrease in alkaline phosphatase activity and N:P ratios, and an increase in chlorophyll a values were observed through the cascading system. N_2 fixation was only observed in the last reservoir. Although the cascading system appears to improve select water quality parameters, shifting N:P ratios throughout the reservoir gradient provide conditions suitable for select harmful algal blooms, which have been increasingly observed in downstream impoundments.

MP168 Comparison of the response of the concentration of hydrophobic organic contaminants and P450RGS and Microtox® assay results in streams to urbanization and their relations to invertebrate community assemblages in six metropolitan areas of the U.S. W.L. Bryant, U.S. Geological Survey, Norcross, GA; D.M. Carlisle, U.S. Geological Survey, Reston, VA. Semi-permeable membrane devices (SPMDs) were deployed and invertebrate community assemblages assessed in streams along a gradient of urban land-use in and around Atlanta, Georgia; Raleigh, North Carolina; Denver, Colorado; Dallas, Texas; Milwaukee, Wisconsin; and Portland, Oregon. The goals of this study were: (1) to determine if the concentrations of hydrophobic organics and their potential toxicity to aquatic biota responded in some way along a gradient of urbanization within each metropolitan area; and (2) to compare these responses among the six metropolitan areas; and (3)

to determine if invertebrate community assemblages were related to the concentration of hydrophobic organics or bioassays results. Petite SPMDs (6") were deployed in 30 streams in each metropolitan area for 30-45 days during base flow conditions. Macroinvertebrate assemblages were assessed at each site approximately six weeks after SPMDs were retrieved from the streams. Of the 74 compounds detected and three assays utilized, 29 were strongly related to increases in urban intensity in at least one of the six metropolitan areas investigated. These 29 endpoints included: 16 PAHs, pentachloranisole, chlorpyrifos, chlordane, benfluralin, trifluralin, dacthal, HHCB, methyl-dibenzofuran, benzo(b)naphtho [2,3-d]furan and BDE 47. In addition, the number of compounds detected and results of the Fluorocan, Microtox[®], and P450RGS assays were strongly related to urban intensity. The number of endpoints related to urban intensity ranged from 6 in Portland to 21 in Raleigh. Petrogenic PAHs and dibenzofurans increased with increasing urban intensity in Atlanta, Raleigh, Milwaukee, and Denver while pyrogenic PAHs and P450RGS increased with increasing urban intensity in all six metropolitan areas. Overall, changes in invertebrate community assemblages were correlated with several of the endpoints measured in the SPMD extracts but differences in the relations between invertebrate assemblages and SPMD endpoints were observed across the six metropolitan areas. Invertebrate community assemblages were more strongly related to SPMD endpoints in metropolitan areas where urbanization is occurring over non-agricultural lands. Analytical chemistry and in-vitro assays of petite SPMDs extracts proved to be a powerful tool to assess response of hydrophobic organics in streams to urbanization.

MP169 Trace Element Concentrations in Livers of Polar Bears From Two Populations in Northern and Western Alaska. K. Kannan, Wadsworth Center and State University of New York at Albany, Albany, NY; T. Agusa, S. Tanabe, Center for Marine Environmental Studies (CMES), Ehime University, Matsuyama, Japan; T.J. Evans, United States Fish and Wildlife Service, Anchorage, AK. Concentrations of 20 trace elements (V, Cr, Mn, Co, Cu, Zn, Rb, Sr, Mo, Ag, Cd, In, Sn, Sb, Cs, Ba, Hg, Tl, Pb, and Bi) were measured in livers of polar bears (*Ursus maritimus*) collected from Northern and Western Alaska during 1993 to 2002, to examine differences in the profiles of trace metals between the Beaufort Sea (Northern Alaska) and the Chukchi Sea (Western Alaska) subpopulations in Alaska. Among the trace elements analyzed, concentrations of Cu (50-290 µg/g, dry wt) in polar bear livers were in the higher range of values that have been reported for marine mammals. Concentrations of Hg in polar bears varied widely, from 3.5 to 99 µg/g, dry wt, and the mean concentrations in polar bears were comparable to concentrations reported previously for several other species of marine mammals. Mean concentrations of Pb and Cd were 0.67 and 1.0 µg/g, dry wt, respectively; these concentrations were lower than levels reported elsewhere for polar bears from Greenland and Canada. Age- and gender-related variations in the concentrations of trace elements in our polar bears were minimal. Concentrations of Hg decreased slowly in samples collected during 1994-2002, whereas Cd and Pb concentrations were found to be stable or slowly increasing, in the livers of Alaskan polar bears. Concentrations of Ag, Bi, Ba, Cu, and Sn were significantly higher in the Chukchi Sea subpopulation than in the Beaufort Sea subpopulation. Concentrations of Hg were significantly higher in the Beaufort Sea subpopulation than in the Chukchi Sea subpopulation. Differences in the profiles and concentrations of Hg, Ag, Bi, Ba, Cu, and Sn suggest that the sources of exposure to these trace elements between Western and Northern Alaskan polar bears are different, in agreement with findings reported earlier for several organic contaminants.

MP170 Monitoring exposure of nestling bald eagles to lead in the Great Lakes Basin. J.P. Isanhardt, K.M. Heath, M.J. Hooper, Environmental Toxicology, Texas Tech University, Lubbock, TX; M.R. Wierda, W.W. Bowerman, Forestry and Natural Resources, Clemson University, Clemson, SC; J.G. Sikarskie, Veterinary Medicine, Michigan State University, East Lansing, MI; D.A. Best, US Fish and Wildlife Service, East Lansing, MI; T.G. Grubb, US Forest Service, Flagstaff, AZ; L. Grim, National Park Service, International Falls, MN. The bald eagle (*Haliaeetus leucocephalus*) was adversely affected historically by the use of lead (Pb) shot in waterfowl hunting. Eagles eating hunter-wounded waterfowl or those that used Pb pellets as grit in their gizzards, were exposed through ingestion of Pb shot. Further, ingestion of Pb from shattered Pb bullets in hunter-left gutpiles and carcasses, and lead from fishing tackle continue to poison avian species in the present. Pb toxicity cases in eagles have declined since lead shot was banned for waterfowl hunting. We wanted to explore if Pb exposure from post-Pb shot ban encounters with lead was evident in nestling bald eagles

from Michigan and Minnesota. We collected blood samples during normal eagle nestling banding activities throughout Michigan and at Voyageurs National Park, Minnesota during May and June 2006. Ninety-one blood samples were analyzed in triplicate for Pb using a graphite furnace atomic absorption spectrophotometer. Approximately 13% (9 of 70) of blood samples collected from Michigan sites and 9% (2 of 21) of blood samples collected from Voyageurs National Park contained levels of Pb above the MDL of 1 ng/mL. Concentrations in these 11 samples ranged from 12-176 ng/mL, with the majority of samples containing less than 100 ng/mL. All of the blood samples contained Pb levels that are considered to be below the subclinical effects threshold of 200 ng/mL for *Falconiformes*. Based on these findings, it appears that Pb exposure in nestling bald eagles from Michigan and Voyageurs National Park, Minnesota are generally at background levels with a small percentage (4%) rising toward sub-clinical effect levels. As Pb exposures as low as 100 ng/mL or lower can cause effects on nervous, renal, immune, reproductive, and hematopoietic systems in developing avian species, continued periodic monitoring of Pb exposure in Great Lakes bald eagles is warranted.

MP171 Comparative survival, physiological and behavioral effects of two brominated diphenyl ethers following simulated maternal transfer and dietary exposure in two species of turtles. A.M. Sides, K.M. Eisenreich, C.L. Rowe, University of Maryland Center for Environmental Sciences: Chesapeake Biological Laboratory, Solomons, MD. The common snapping turtle (*Chelydra serpentina*) and red-eared slider (*Trachemys scripta*) possess life history and ecological traits that make them well suited for studies of persistent, bioaccumulative compounds. Both species can accumulate persistent lipophilic compounds for long periods prior to reproduction, which may result in maternal transfer of high concentrations of contaminants to offspring. Brominated diphenyl ethers (BDEs) are a group of organic compounds employed widely in consumer products and industrial applications as flame retardants. BDEs are ubiquitous in marine and freshwater systems, soil, and biological tissues and are continuing to increase in the environment. Their potential to affect thyroid activity and neurological development suggests that some wildlife species may be at risk of reduced offspring viability due to maternal transfer of BDEs during embryogenesis. We examined the influences of simulated maternal transfer of BDEs and food-borne BDEs on hatching success, morphology, metabolism, growth and behavior of snapping turtles and red-eared sliders over the first year post-hatching. Eggs were topically exposed to three concentrations of BDE-47 and BDE-99 prior to the temperature sensitive period that determines sex. A subset of hatchlings was subsequently exposed to either BDE-47 or BDE-99 in their diet (nominally 5000 ng/g wet weight). Measurements of carapace length and width, plastron length, and wet mass were used to quantify growth differences between hatchlings from both exposure regimes and respiratory rates were measured to examine the potential metabolic anomalies. Hatching success did not differ significantly across treatments (sliders: $P = 0.073$; snapping turtles: $P = 0.333$) or between species regardless of treatment ($P = 0.462$). Deformities in red-eared slider embryos and hatchlings occurred in 22.4% of the individuals and in the snapping turtle embryos and hatchlings total deformities were found to occur in 32.0% of individuals with no significant differences across treatments. The red-eared sliders had greater respiration than the snapping turtles across all treatments during the over-wintering period, although respiration was not affected by treatment. Three behavioral assays are currently underway to identify potential effects on neurological development processes.

MP172 Organochlorine compounds and trace elements in common loon (*Gavia immer*) eggs from western Maine, 2001 - 2004. S.E. Mierzykowski, U.S. Fish and Wildlife Service, Old Town, ME. Between 2001 and 2004, ten non-viable eggs were recovered from common loon (*Gavia immer*) nests in western Maine and analyzed for organochlorine compounds and trace elements. Dioxin toxic equivalents (TCDD-TEQ) ranged from 11 to 388 pg/g, fresh wet weight. Dioxin and furan congeners comprised up to 34% of the TCDD-TEQ in four eggs and were below detection in six eggs. Dioxin-like PCB congeners formed the majority of the TCDD-TEQ (66 to 100%). Mean Total PCB concentration in loon eggs was 1.26 ug/g, while DDE ranged from 0.07 to 1.04 ug/g (mean 0.29 ug/g). Other organochlorines were below detection limits or detected at low concentrations (<10 ng/g). Mean concentrations of trace elements in loon eggs (ug/g, fww) were: copper 0.75, mercury 0.76, selenium 0.54, strontium 0.65, and zinc 9.58. Arsenic, cadmium, chromium, nickel, and lead were below detection or sporadically detected at low levels (<0.05 ug/g). TCDD-TEQ concentrations in two loon eggs were

above effect thresholds suggested for osprey and bald eagles. Total PCB, DDE, and most trace elements occurred at levels below effects thresholds and lower than concentrations reported in NH and NY loon studies conducted in the 1970s and 1980s. Mercury levels in Maine common loon eggs remain elevated compared to recent collections from other regions of the U.S.

MP173 Potential for spontaneous abortions in cattle from exposure to isocupressic acid in pine needle dust from stockpiles at a proposed biomass power project. C.A. Irvine, B.E. Sample, CH2M HILL, Sacramento, CA; D. Huxley, CH2M HILL, Denver, CO. A biomass power project in New Mexico was issued an air permit for construction, but there were concerns from a neighboring rancher about fugitive dust from the stockpile of ground pine and juniper causing late-term abortions in cattle. These concerns led to an appeal of the permit with the Environmental Improvement Board. The potential for risk to pregnant cows and their fetuses from chemicals found in pine and juniper needles was evaluated by literature review and exposure calculations in a unique application of wildlife risk assessment to aid the evaluation of appeal arguments. Isocupressic acid (ICA), a diterpene acid found in the needles, bark, and buds of several gymnosperms, is the primary phytochemical causing late-term abortions in cattle. ICA is known to occur at concentrations (0.08–1.35 % dry weight) in ponderosa pine, lodgepole pine, Jeffery pine, and juniper. Late-term abortions can be induced when pregnant cows eat the needles and bark from these plants during the last trimester. Doses associated with no abortion or the no observed adverse effects level (NOAEL) ranged from 2.7 to 5.4 kg needles/day. The distribution of lowest observed adverse effect levels (LOAELs) ranged from doses of 0.7 to 22 kg needles/day (geomean 3.7 kg/day). Overlap in the reported NOAEL and LOAEL doses was due to variability in animal tolerance, cow weight, days of gestation, ICA content of feed, and the specific exposure regime (duration, dosage, etc.) reported in the studies reviewed. In a conservative exposure estimate, a cow would have to consume 6% of its daily dietary matter as pine needle dust containing 0.5% ICA (0.7 kg pine needles for a median cow consuming 25 g/kg/day) in order to meet the most conservative LOAEL. This dose is equivalent to 1.21 g of pine needles/kg body weight/day or 45% of the daily incidental soil ingestion. Dust emission modeling over 50 acres around the site estimated that it would take 277 years of dust emissions from stockpiles to disperse the 24.5 kg/m² of pine needles needed to cover the top inch of soil with 45% ICA containing dust. Results of these exposure estimates indicated that there was no realistic risk of spontaneous abortions in pregnant cows from stockpile dust emissions containing ICA. Conclusions may be extrapolated to indicate no potential risk of spontaneous abortions in deer exposed to ICA containing dust while feeding in the vicinity of the plant.

MP174 Sublethal Responses of Avian Embryos Exposed to Polybrominated Diphenyl Ether Flame Retardants. B.A. Rattner, M.A. McKernan, Patuxent Wildlife Research Center, USGS, Beltsville, MD; M.A. McKernan, M. Ottinger, Department of Animal and Avian Sciences, University of Maryland, College Park, MD. Polybrominated diphenyl ethers (PBDEs) have been detected in bird eggs worldwide, and despite increasing concentrations over the past 25 years, toxicological thresholds have yet to be established. We previously reported embryonic survival, and pipping and hatching success in chicken (*Gallus gallus*), mallard (*Anas platyrhynchos*) and American kestrel (*Falco sparverius*) embryos receiving 0.01–20 µg PBDE/g egg. Survival, pipping and hatching success were decreased in kestrels, suggesting that they are more sensitive to PBDEs than chickens and mallards. Adverse effects were detected in kestrels at levels (≥ 1 µg/g egg) believed to approach environmentally relevant PBDE concentrations. Polychlorinated biphenyl congener 126 (PCB 126) was used as a positive control (1000 pg/g egg) in this study, and survival endpoints in chicken and kestrel were decreased at this dose. Some PBDE and PCB congeners are structurally similar to thyroid hormones and have been demonstrated to affect thyroid homeostasis in laboratory rodents. In the present study, thyroid glands collected from day old hatchling chickens, mallards, and kestrels and were analyzed for thyroxine (T₄) using a solid phase radioimmunoassay (DPC, Inc.) specifically validated for each of these species. Results indicated that thyroid gland T₄ stores (total gland content and T₄ /mg thyroid) in these species were relatively consistent and not significantly affected by PBDE exposure. In contrast, glandular T₄ stores were significantly lower ($P < 0.01$) in PCB 126 treated kestrels. Decreases in circulating T₄ levels in response to contaminants (e.g., PCBs, ammonium perchlorate) may lead to greater release of glandular T₄ to maintain a euthyroid state, which could decrease thyroidal T₄ stores. While PBDEs have been suggested to influence circulating T₄ in kestrel fledglings

(Ferne et al., 2005), it appears that glandular T₄ was not affected in chicken, mallard or kestrel hatchlings exposed in ovo. Histopathological changes in liver, kidney and immune organs, bone length, and potential skeletal deformities are currently being examined.

MP175 Estimating the Spatial Extent of Potential Secondary Exposure to Pesticides Using Allometric Equations. C.J. Salice, EFED, US EPA, OPP, Washington, DC. Secondary poisoning is an important consideration in estimating the spatial extent of potential pesticide exposure for terrestrial mammals and birds. Secondary poisoning to a bird or mammal could result if the animal consumed all or part of a prey species that has sufficient pesticide body burden. Presumably, the prey species would have obtained pesticide body burden through the consumption of food items that were directly sprayed with pesticides. The distance from the treated field that a potential prey species could move would then determine the distance from the treated field where poisoning through secondary exposure could occur. Since there are a number of potential prey species available to carnivorous or omnivorous birds and mammals, a method was developed that allows for a fairly rapid determination of spatial extent of potential toxicity as a result of secondary exposure. The approach relies on several known allometric relationships that relate body weight to food consumption rates and body weight to home range size. A key input for these allometric equations is the body weight of a given avian or mammalian receptor. Because it is difficult to know, with confidence, the extent to which a prey species might move off field after consuming pesticide treated food items, the home range of the potential prey species is used to generate the maximum distance that prey species might be expected to move in a day. The resulting output provides an upper-bound estimate of the distance from a treated field where secondary exposures to pesticides could occur.

MP176 Polycyclic Aromatic Hydrocarbons (PAHs) in Livers of California Sea Otters. K. Kannan, E. Perrotta, Wadsworth Center, New York State Department of Health and State University of New York at Albany, Albany, NY; N.J. Thomas, USGS-Biological Resources Division, Madison, WI. Concentrations of 16 polycyclic aromatic hydrocarbons (PAHs) were measured in livers of 80 adult female sea otters collected from the California coast during 1992–2002. Concentrations of PAHs in livers of sea otters were in the range of 588–17400 ng/g lipid wt (mean: 3880 ng/g, lipid weight). On a wet weight basis, concentrations ranged from 17 to 1430 ng/g (mean: 146 ng/g). Fluorene and phenanthrene were the predominant PAHs found in sea otter livers. No significant difference existed in the concentrations of total PAHs among the otters that died of infectious diseases, emaciation, and traumatic injuries. Nutritive conditions of sea otters did not influence the concentrations of PAHs in livers. No significant variation in PAH concentrations was found in samples collected during 1992–2002. Lack of association between infectious diseases, time, as well as between nutritive condition and concentrations of PAHs in the livers of sea otters indicates metabolism of PAHs in sea otters. Further studies should monitor PAH metabolites in livers of sea otters.

MP177 Chlorinated, Brominated and Perfluorinated Compounds and Trace Elements in Livers of Sea Otters from California, Washington, and Alaska (USA) and from Kamchatka (Russia). K. Kannan, Wadsworth Center and State University of New York at Albany, Albany, NY; H. Moon, National Fisheries Research & Development Institute (NFRDI), Busan, South Korea; T. Agusa, S. Tanabe, Center for Marine Environmental Studies (CMES), Ehime University, Matsuyama, Japan; N.J. Thomas, US Geological Survey-Biological Resources Division, National Wildlife Health Center, Madison, WI. Concentrations of organochlorine pesticides (DDTs, HCHs, chlordanes and HCB; the sum referred to as Σ OCPs), polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), perfluorinated compounds (PFCs; PFOS, PFOA, PFNA, PFDA) and 20 trace elements were determined in livers of 3 to 5-year old sea otters collected from the coastal waters of California, Washington, and Alaska (USA) and from Kamchatka (Russia). Concentrations of organochlorine pesticides, PCBs and PBDEs were elevated in sea otters collected from the California coast. Concentrations of Σ OCPs were 10-fold higher in sea otters collected from the California coast than those from other locations; PCB concentrations were 5-fold higher and PBDE concentrations were 2-fold higher in California sea otters than the otters from other locations. Concentrations of PAHs were higher in sea otters from Alaska than in the sea otters from other locations. Concentrations of several trace elements were elevated in samples collected from California and Alaska. Elevated concentrations Mn, Co, and Zn in sea otters from California and Alaska were indicative of oxidative stress-related injuries in these two

populations. It is probable that elevated exposure to one or more of the organic contaminants has contributed to oxidative stress-related injuries in these two populations. Concentrations of all of the target compounds including trace elements analyzed in sea otters from Kamchatka were lower than those found in the US coast.

MP178 Reproductive success of three passerine species as part of a site-specific risk assessment on the Tittabawassee River. T.B. Fredricks, M.J. Zwiernik, R.M. Seston, S.J. Coefield, C.N. Stieler, Zoology Department, Michigan State University, East Lansing, MI; M.S. Shotwell, D.P. Kay, Entrix, Inc., East Lansing, MI; S.C. Plautz, D.L. Tazelaar, Michigan State University, East Lansing, MI; J.P. Giesy, Biomedical Veterinary Sciences & Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Reproductive success of passerines nesting in the Tittabawassee and Chippewa River floodplains near Midland, Michigan, USA was examined due to the presence of polychlorinated dibenzofurans (PCDFs) and dibenzo-*p*-dioxins (PCDDs) in both the terrestrial and aquatic food webs. Mean concentrations of PCDF/PCDDs in soil and sediment were 10- to 20-fold greater downstream (target sites) of Midland compared to upstream (reference sites). Based on life history, site presence, and availability of on- and off-site historical data, tree swallow, eastern bluebird, and house wren were chosen as passerine receptor species of interest. Over 200 nest boxes were monitored within the floodplain both upstream (n=69) and downstream (n=133) of Midland during the 2005 and 2006 breeding seasons. Reproductive measurements were taken on all three species including egg mass, clutch size, hatching success, nestling growth rate, fledging success, and nest attentiveness. Comparisons of reproductive measurements were made for species between years (2005/2006), site type (reference/target), and adult age classes for eastern bluebird and tree swallow. Between-year effects were rare and likely due to weather conditions and/or prevalence of second year breeding adults (eastern bluebird and tree swallow) in 2005 at some sites. There were no statistically significant differences ($p>0.05$) in clutch size or egg mass between reference and target areas for any species when compared. There were no statistically significant differences in nestling growth rates or fledging success for house wren and tree swallows. However, for eastern bluebirds downstream sites had significantly ($p<0.05$) greater nestling 12- and 14-day masses ($p<0.05$) and better fledging success ($p=0.05$) compared to upstream sites. Increased fitness downstream for eastern bluebirds is difficult to explain and the difference is not due to a lack of power since statistical tests had adequate power ($\beta<0.2$) to distinguish a difference between areas for nestling masses and fledging success despite lower sample sizes at upstream sites.

MP179 An Integrated Chemical and Biological Study of Emerging Contaminants on the Upper Mississippi River. N. Jahns, H.L. Schoenfuss, Biological Sciences, St. Cloud State University, St. Cloud, MN; L.B. Barber, U. S. Geological Survey, Boulder, CO; K.E. Lee, U. S. Geological Survey, Mounds View, MN. The presence of emerging contaminants in many anthropogenically altered surface waters has raised wildlife and human health concerns. However, few studies have surveyed the presence of emerging contaminants and the effects on local fish populations on a large geographic scale. In this study, we collected concurrent water, sediment and fish samples (carp, redbreast, and smallmouth bass) from 43 sites on the Upper Mississippi River between the river's origin in Lake Itasca to the Iowa border. Water and sediment samples were analyzed for a variety of emerging contaminants including personal care products and alkylphenols. Fish were sampled for blood (vitellogenin analysis), reproductive organs and livers (histopathology). Plasma vitellogenin concentrations were elevated in male fish at some sites with generally higher concentrations in urbanized areas. Histological examination did not reveal intersex in any specimens. Vitellogenin induction was usually greater in smallmouth bass than carp and redbreast indicating a greater sensitivity of this species to vitellogenin induction. Vitellogenin induction correlated well with the detection of multiple emerging contaminants at specific collection sites. This study suggests that the Upper Mississippi River is experiencing local incidents of endocrine disruption prior to its course through the urban corridor of St. Cloud, Minneapolis and St. Paul and persistent endocrine disruption downstream of these cities. This study also indicated that large-scale geographic studies need to take into account land use patterns and stream characteristics to better assess the effects of anthropogenic inputs into the aquatic ecosystem.

MP180 Acute Toxicity of Common Agrochemicals in the Fairy Shrimp *Thamnocephalus platyurus*. J.M. Brausch, P.N. Smith, The Institute of Environmental and Human Health, Texas Tech University, Lubbock, TX.

Extensive pesticide usage in modern agriculture can impart considerable stressors among freshwater ecosystems throughout the United States. In the Southern High Plains (SHP) of Texas, cotton is the predominant agricultural crop accounting for over 60% of all cotton produced in the state and 20% of that produced in the United States. Acute toxicity of four commonly used agricultural pesticides (Methyl Parathion 4ec, Tempo® SC Ultra [active ingredient cyfluthrin], Roundup® Super Concentrate [glyphosate], and Karmex® DF [diuron]) was determined in three different strains of the fairy shrimp *Thamnocephalus platyurus*. Fairy shrimp from playas surrounded by native grasslands (n=8) were up to 500% more sensitive than fairy shrimp derived from playas in agriculture dominated watersheds (n=10) for Methyl Parathion 4ec, Tempo® SC Ultra, and Karmex® DF, possibly due to the development of resistance. However, differences in sensitivity were not observed with the post-emergent herbicide Roundup®, possibly due to the surfactant polyethoxylated tallowamine commonly used in Roundup® formulations. Laboratory cultured fairy shrimp generally had LC50 values intermediate to field-collected *T. platyurus*. These data suggest that fairy shrimp inhabiting playas in agriculturally-influenced regions have developed some degree of resistance to a variety of agrochemicals.

MP181 Development of Resistance in *Daphnia magna* to Two Aquatic Contaminants. J.M. Brausch, P.N. Smith, The Institute of Environmental and Human Health, Lubbock, TX. Populations inhabiting contaminated environments can adapt to stressors through the process of natural selection. Genetically based resistance has been demonstrated in microbes, plants, invertebrates, and vertebrates in response to many different stressors including metals, persistent organic pollutants, and pesticides. In this study, *Daphnia magna* were exposed to naphthalene or cyfluthrin for 12 generations to evaluate the development of resistance. Twenty-four hour old *D. magna* were exposed to concentrations that would kill a large percentage of *D. magna* for each chemical to select for the least sensitive individuals. Survivors were then moved to clean beakers and reproductive output was monitored to assess possible fitness trade-offs. Average LC50 values, survival, reproductive output, and time to first brood in both resistant and control *D. magna* were recorded for each generation. Cross-resistance was assessed among resistant and control *D. magna* by examining differences in sensitivity to chemicals with similar and dissimilar mechanisms of action. Evidence of resistance was observed after three generations, with naphthalene-exposed *D. magna* being 300% less sensitive to naphthalene and cyfluthrin-exposed 500% less sensitive to cyfluthrin, as compared to control individuals after 12 generations. There were no observable differences in survival, time to first brood, or total number of offspring produced between control and either of the F13 *D. magna* populations. Naphthalene-exposed *D. magna* exhibited cross resistance to pyrene and benz(a)anthracene (200% less sensitive than controls), and cyfluthrin-exposed *D. magna* were 200% less sensitive to DDT and 300% less sensitive to methyl parathion.

MP182 Variation Of Mercury And Organochlorine Contamination In Cottonmouths (*Agkistrodon piscivorus*) Along The Big Cypress Bayou Of East Texas. F. Bailey, T. Worrall, V. Cobb, Middle Tennessee State University, Murfreesboro, TN; T. Rainwater, T. Anderson, Texas Tech University, Lubbock, TX. Although investigations of reptile ecotoxicology have been on the rise recently, snakes remain an underrepresented taxon. This appears counterintuitive because snakes are often high-level consumers and tend to utilize limited spatial areas throughout their lifetime, thus making them potentially suitable indicators for contaminants capable of bioaccumulation. In this study, we analyzed mercury and organochlorine (OC) levels in tissues collected from snakes at three locations along the Big Cypress Bayou in northeast Texas. Mercury was observed in all samples analyzed (liver: mean = 457 ng/g, range = 52 - 2,276 ng/g, N = 34; tail tip: mean = 149 ng/g, range = 30 - 376 ng/g, N = 23). Both males and females exhibited a significant positive correlation between SVL and liver mercury levels, $r^2 = 0.588$; $r^2 = 0.368$ respectively. Mercury in tail tips was a strong indicator of liver mercury levels for both males and females, $r^2 = 0.870$; $r^2 = 0.756$. For total OCs, all snakes had detectable levels in fat bodies (mean = 108 ng/g, range = 5 - 899 ng/g, N = 30) and 82.9% had OCs in livers (mean = 30 ng/g, range = 0 - 243 ng/g, N = 35). The most common OC was DDT; found in 100% of fat bodies and 54% of livers. Other OC levels were highly variable in concentration and distribution.

MP183 Blood parameters, histopathology, porphyrins, and organic contaminants in surf scoters over-wintering on the south-coast of British Columbia, Canada. L. Wilson, J. Elliott, Canadian Wildlife

Service, Environment Canada, RR#1 Delta, British Columbia, Canada; M. Harris, Lorax Environmental, Bonshaw, Prince Edward Island, Canada; S. Trudeau, National Wildlife Research Centre, Environment Canada, Ottawa, Ontario, Canada. Most sea ducks species in North America show long-term unexplained declines in breeding populations. One of the most poorly understood species, surf scoters, winters in harbors along the west coast, after breeding in northern boreal forests. We investigated the condition and contamination of surf scoters during the winters of 1998-2001 at industrial and reference locations in the Georgia Basin of British Columbia in order to assess the potential for contaminants to impact their health and survival. Carcasses were examined and tissues collected for blood parameters, histopathology, EROD, porphyrins, and contaminant (OC, PCBs, PCDDs, PCDFs, PBDEs, nonylphenols, PAHs) analysis. Hepatic concentrations of OCs, PCBs and TEQs were low, although burdens did increase over winter at all sites. PBDEs were detected at several sites. Most common PBDEs were -99, -100, -153, -47, -154, which are also found in the commercial penta-BDE formulation. BDE-209 was detected but not a dominant congener. Bile PAH metabolites were typically non-detectable with notable exceptions. Nonylphenols and ethoxylates were detected in 11 of 16 samples, with concentrations ranging from 1-981 ng.g⁻¹ ww, arithmetic mean of 209 ng.g⁻¹ ww. The biological markers chosen to evaluate condition and contaminant exposure in this study provided insight into the physiological state of overwintering surf scoters and highlighted some concerns that warrant further investigation. Although organic contaminant concentrations were relatively low, elevated EROD activity indicated that the population in Howe Sound was responding to an Ah-receptor-mediated stressor ($p=0.001$, $n=40$), which was also significantly depressing hematocrit values ($p=0.002$, $n=40$) and possibly vitamin A status. In addition, the low proportion of lymphocytes in individuals across locations was associated with poor body condition (Pearson $r = 0.636$, $p=0.0005$, $n=32$) in early spring, a time just prior to northerly migrations to breeding grounds. The implication of these biological indicators of compromised health for the productivity and survival of affected individuals and particularly of the population in Howe Sound warrant further evaluation, in light of the dramatic decline in western populations of the species in recent decades

MP184 Impact of Single Pesticide Exposure on *Rana catesbeiana* Tadpoles in a Laboratory Environment. A. de Jong Westman, C. Bishop, K. Cheng, J. Elliott, University of British Columbia, Vancouver, British Columbia, Canada; A. de Jong Westman, C. Bishop, J. Elliott, Canadian Wildlife Service, Environment Canada, Delta, British Columbia, Canada; G. van Aggelen, Pacific Environmental Science Centre, North Vancouver, British Columbia, Canada. There is increasing concern worldwide regarding the rapid declines of amphibian populations, and though there have been many hypotheses postulated, no single cause has been identified. Pesticides may play a very important role in population declines of amphibians in the South Okanagan Valley, British Columbia. Researchers and regulators are beginning to recognize that amphibian responses to contaminant exposures are often inadequately predicted by tests on other aquatic organisms, such as fish or invertebrates. To determine acute toxicities of some of the pesticides currently in use in the South Okanagan Valley of British Columbia, toxicity tests were conducted on premetamorphic tadpoles of *Rana catesbeiana*, (American Bullfrog). LC50 tests were conducted using individual exposures with the pesticides, Guthion® (Azinphos-methyl), Diazinon and Thiodan® (Endosulfan). The pesticides used in the exposure regime were 50% active ingredient (A.I.) commercial formulas, determined by what is currently being sold by South Valley Sales (Oliver, BC) to orchardists in the South Okanagan valley. Mortalities and tadpole behavior were observed at 24 hour intervals, and thus a complete chart of LC50 values at each time interval was established. This particular experiment did not include any post-exposure observations, as the tadpoles were euthanized and tissue samples extracted at the end of the 96 hour time period, in preparation for genomics analysis. LC50 values were attained for all three chemicals, with significant mortality occurring in even the lowest concentrations of endosulfan.

MP185 Impact of Pesticide Exposure on *Spea intermontana* and *Pseudacris regilla* Embryo and Tadpole Survivorship and Development. A. de Jong Westman, C. Bishop, K. Cheng, J. Elliott, University of British Columbia, Vancouver, British Columbia, Canada; A. de Jong Westman, C. Bishop, J. Elliott, Canadian Wildlife Service, Environment Canada, Delta, British Columbia, Canada; G. van Aggelen, Pacific Environmental Science Centre, Environment Canada, North Vancouver, British Columbia,

Canada. There is increasing concern worldwide regarding the rapid declines of amphibian populations, and though there have been many hypotheses postulated, no single cause has been identified. Pesticides may play a very important role in population declines of amphibians in the South Okanagan Valley, British Columbia. Researchers and regulators are beginning to recognize that amphibian responses to contaminant exposures are often inadequately predicted by tests on other aquatic organisms, such as fish or invertebrates. To assess the impact of pesticides on amphibian populations in agricultural habitats, the Canadian Wildlife Service has studied the effects of these toxic chemicals on wildlife in the South Okanagan Valley over the last four years. To better understand the impact of single pesticides, a series of experiments were carried out on two lifestages of *Spea intermontana* and *Pseudacris regilla*. Egg masses of each species were collected from reference sites in the South Okanagan Valley, and transported to the Pacific Environmental Science Centre. Experiments included exposures to environmentally relevant concentrations of three current-use pesticides: Endosulfan, Diazinon and Azinphos-methyl, both alone and in combination. Both *S. intermontana* and *P. regilla* embryos were exposed throughout development to Gosner stage 25, whereupon the newly hatched tadpoles were euthanized and preserved for genomic analysis. An additional exposure regime involving Gosner stage 25 tadpoles for a subsequent eight days was carried out to determine differences in the susceptibility of lifestages. Overall, at such low concentrations, such as the environmental concentrations, very little effect was observed.

MP186 Functional analysis of cormorant (*Phalacrocorax carbo*) metallothionein 1 and 2 promoter/enhancer regions associated with element exposures. D. Nam, E. Kim, H. Iwata, S. Tanabe, Center for Marine Environmental Studies, Ehime University, Matsuyama, Japan. Induction of metallothionein (MT) is most likely a compensatory response for detoxification of metals through their binding to the induced MT proteins. In terms of sensitivity to metal stress, understanding the regulatory mechanism of MTs is necessary to assess the risk of metal pollution on the target species. In our previous study, we identified two distinct MTs (MT1/2) in great cormorant (*Phalacrocorax carbo*). To elucidate the regulatory mechanisms of cormorant MTs, we investigated ligand-dependent transactivation potencies of cormorant MT1 and MT2 promoter/enhancer regions using an in vitro reporter gene assay. About 1kb of MT1 and MT2 promoters were isolated and sequenced, where six and four MREs (metal responsive elements) were identified, respectively. Both MT1 and MT2 promoters were dose-dependently activated by Cd, Zn, Cu, and methyl Hg, whereas no transactivation was detected in response to Pb, Tl, Ag, inorganic Hg, Cr (VI), Cr (III), As (V), As (III), Ni, Co, Rb, and Bi. This suggests that the aforementioned four elements share a similar mechanism for the transactivation of MT1 and MT2, although there are differences in the distribution and number of MREs between the two promoters. The comparison of EC50 and LOEL for each element revealed that Cd was the most potent inducer of MT1 and MT2 promoters, followed by methyl Hg, Zn, and Cu. The transactivation potency by Cd, methyl Hg, Zn, or Cu exposure was more prominent for MT2 rather than MT1. The findings that both MT1 and MT2 promoters from cormorant were dose-dependently transactivated by Cu and Zn agree with the results of our previous study which showed a significant correlation between the expression levels of MT1 and MT2 mRNAs and these two metals in a wild population. Since LOELs of methyl Hg for both MT promoters were relatively higher than the levels in the liver of wild cormorants, methyl Hg concentration might not be high enough to induce MT mRNA expression in the wild population. Even though LOELs for Cd were much lower than the hepatic concentrations observed in the wild cormorants, no significant correlation of MT mRNAs with Cd was observed, which may be due to the masking effect of multiple element exposures, especially by Zn and/or Cu in the wild population. Detoxification potency of each cormorant MT isoform associated with element exposure is under investigation using an in vitro expression system.

MP187 The marine biotoxin domoic acid and its impacts on the California sea lion population: optimization of a population model by evaluating nine years of stranding records. A.C. Bejarano, F. VanDolah, L. Schwacke, NOAA/NOS, Charleston, SC; F. Gulland, The Marine Mammal Center, Sausalito, CA; M. Hunter, Pacific Marine Mammal Center, Laguna Beach, CA; J. Leger, SeaWorld, San Diego, CA. Since the mid 1990's hundreds of California sea lions (CSL; *Zalophus californianus*), in otherwise good nutritional condition, have recurrently stranded along the California

coast with visual signs of intoxication by the phycotoxin domoic acid (DA). Analyses of recent temporal and spatial CSL stranding patterns from suspected/confirmed DA cases, obtained from participants of the California Marine Mammal Stranding Network, showed that adult females comprised 47% to 82% of the total annual DA cases, and that they have stranded in larger numbers across all seasons and in larger proportions between Santa Barbara and San Mateo Counties, than any other sex/age-class. A factor responsible for these patterns maybe the increased abundance of the CSL population, especially of adult females, in the proximity of the Channel Islands during the breeding and pupping seasons. This information (location, frequency, duration of DA events) in conjunction with a bioenergetic model that estimates the lethal DA doses in individual CSLs, were further incorporated into a larger individual-based population model (IBM) to assess the potential long-term impacts of DA on the CSL population. The bioenergetic model, in which exposure was assumed to occur via ingestion of anchovies (*Engraulis mordax*) and sardines (*Sardinops sagax*), suggests that anchovies pose a greater risk of exposure to DA than sardines, and that a daily diet comprised of 20% anchovies would result in 4x the number of intoxicated females than a 20% sardine diet. The preliminary IBM model that incorporates the current population structure and growth rates, survivorship schedules and CSL sex/age-class behavioral differences, indicates a greater risk of DA intoxication for adult females, and shows sex/age-class specific effects consistent with the CSL stranding patterns. This study suggests that behavioral differences among CSLs life stages influence their probability of exposure to DA.

MP188 Effects of Sublethal Pesticide Exposure on Competitive Interactions in North American Pond-Breeding Anurans. C. Distel, M. Boone, Zoology, Miami University, Oxford, OH. The goal of this research is to determine whether pesticides can detrimentally affect amphibian communities by changing competitive interactions. In the face of rapid worldwide declines, understanding mechanisms to slow amphibian loss is crucial. Insecticides can affect tadpole survival and competition with the possibility of competitive exclusion where more than one species exists. We addressed the effects of sublethal levels of carbaryl, a short-lived insecticide, on competition among larval American toads (*Bufo americanus*) and Northern leopard frogs (*Rana pipiens*) using mesocosms. Carbaryl exacerbated the effects of interspecific competition on larval period as well as survival to, and mass at metamorphosis. The effect was stronger on toads than leopard frogs. These changes could lead to competitive exclusion over time, thereby promoting amphibian species loss.

MP189 Effects of the insecticide malathion on larval amphibians in the presence of cyanobacteria and overwintered green frog tadpoles. M.D. Boone, M. Mackey, Zoology, Miami University, Oxford, OH. Sublethal chemical contaminants can have direct negative effects on amphibians and also indirect effects on the aquatic food web by altering algal composition or competitive interactions. Chemical contaminants may alter communities in such ways that favor some species over others through changing food resources, and reduce local biodiversity. In this study, we examined the single and interactive effects of the insecticide malathion, the cyanobacteria *Anabaena* spp., and overwintered green frog competitors on metamorphosis of gray treefrog (*Hyla versicolor*) tadpoles by rearing animals from hatching through metamorphosis in 1000 L mesocosms. We hypothesize that presence of malathion will favor the growth of cyanobacteria, which will negatively impact gray treefrogs and positively affect overwintered green frogs, which are associated with human habitation. We are finding that the insecticide sets the stage for the biotic interactions that occurs in the community and influenced the gray treefrog population by altering food resources, algal composition, and competitive strength of the larger overwintered green frog competitors. This study will help us evaluate why some species increase in abundance in contaminated environments, while other species disappear, by examining the indirect consequences of sublethal contaminant exposure.

MP190 Amphibians and global fractionation of PCBs. R. Angell, K. Drouillard, D. Haffner, GLIER, University of Windsor, Windsor, Ontario, Canada. Many species worldwide are in decline, resulting in a similarly negative trend in biodiversity. Over the course of the last 20 years, such a worldwide decline has been observed in amphibian species. If chemical pollution were determined to be a contributing factor in this decline, amphibians may be in a unique position to be bio-indicators of environmental health in a given system due to the unique changes in diet (herbivore to insectivore) and habitat (aquatic to terrestrial/aquatic) they experience throughout their life cycle, as well as the relatively short time frames during

which these developments occur. Thus, the development of a life-cycle model for pollutants such as PCBs with relation to amphibians would be useful in testing the role of man made chemicals in amphibian decline and determining the functionality of frogs as bio-indicator species. The term life cycle can be used to refer to both the processing and fate of a chemical, in this case PCBs, or the stages of an organism, in this case referring to several amphibian species. It is hypothesized that there is a latitudinal gradient of PCBs and amphibians are useful as indicators of this gradient, which is the result of global fractionation. Previous tests of this hypothesis conducted in Northern Europe using adult frogs have been inconclusive (Wania & Su 2004; Meijer et al 2002). Additional support for the theory of global fractionation in amphibians could be useful in determining changes in contaminant activity in wildlife with changing temperature patterns due to global warming. Thus, to test this hypothesis we conducted a survey across a latitudinal range in Ontario, Canada. Five indigenous young of year (newly metamorphosed) amphibian species were collected at five sites and were analyzed for PCB and lipid concentrations. References: Leney, Jocelyn L., et al. 2006. Does Metamorphosis Increase the Susceptibility of Frogs to Highly Hydrophobic Contaminants? *Environ. Sci. Technol.* 40: 1491-1496 Meijer, S.N., et al. 2002. Influence of Environmental Variables on the Spatial Distribution of PCBs in Norwegian and U.K. Soils: Implications for Global Cycling. *Environ. Sci. Technol.* 36: 2146-2153 Wania, Frank & Yushan Su 2004. Quantifying the Global Fractionation of Polychlorinated Biphenyls. *Ambio*. 33(3): 161-168

MP191 Organohalogen contaminant concentrations in bottlenose dolphins from Mississippi Sound. A. Guichard, J. Kucklick, National Institute of Standards and Technology, Charleston, SC; A. Guichard, O.F. Donard, Laboratoire de Chimie Analytique BioInorganique et Environnement-UMR 5034, Pau, France; L. Schwacke, National Oceanic and Atmospheric Administration (NOAA), Cooperative Center for Marine Animal Health, Hollings Marine Laboratory, Charleston, SC; T. Rowles, NOAA, National Marine Fisheries Service (NMFS), Marine Mammal Health and Stranding Response Program, Silver Spring, MD; C.S. Barry, NOAA, NMFS Southeast Fisheries Science Center, Pascagoula, MS; P.E. Rosel, NOAA, NMFS Southeast Fisheries Science Center, Lafayette, LA. Bottlenose dolphins are common coastal dolphins that have been shown to reflect local or regional trends in environmental conditions. The National Institute of Standards and Technology has been collaborating with the National Oceanic and Atmospheric Administration to provide data on persistent organohalogen pollutants (POPs) in many different bottlenose dolphin groups inhabiting in shore or near shore areas of the U.S. East Coast and Gulf of Mexico. The present study provides new information on POPs in dolphins sampled by remote dart biopsy from the Mississippi Sound area. Samples (n = 58 and n = 30, males and females, respectively) were collected between July 2005 and October 2005. Blubber biopsy samples were analyzed for polychlorinated biphenyls, organochlorine pesticides and brominated flame retardants by gas chromatography-mass spectrometry. For all samples, PCBs were the predominant compounds measured with ΣPCBs ranging for males geometric mean: 19,965 ng/g w.w stdev: 10,994 ng/g w.w, Σ chlorinated pesticide concentrations geometric mean: 1,993 ng/g w.w stdev: 1,712 ng/g w.w, ΣPBDE concentrations were found to be lower than PCBs geometric mean: 1,088 ng/g w.w stdev: 1,993 ng/g w.w. Most POPs varied significantly with location, with dolphins sampled near Biloxi, MS, having generally higher concentrations. This study confirms previous work showing that POP concentrations in bottlenose dolphin groups in close proximity (tens of km) to each other can vary significantly probably reflecting local habitat contamination.

MP192 Evaluating the Impacts of Persistent Environmental Contaminants on the Reproductive Success of Great Blue Herons. S.D. Baker, M.S. Sepúlveda, Purdue University, West Lafayette, IN. Great Blue Herons (*Ardea herodias*) (GBHs) have been identified as one of the most highly contaminated species of piscivorous birds. Many contaminants are known to be endocrine disruptors, affect behavior, and cause various other physiological changes that can decrease reproductive success. Contaminant exposure in GBHs from Indiana was quantified to determine if levels were high enough to impair reproduction. In 2005 and 2006, 35 GBH eggs were collected from six colonies in northwestern, north-central, and south-central Indiana and analyzed for contaminant exposure, metabolites, and stable isotope profiles. Between 30 and 101 nests were monitored in seven GBH colonies weekly over a three-month period to count hatchlings and fledglings.

Mean levels of polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and organochlorine pesticides (OCPs) in GBH eggs were 3101, 7.20, and 2869 ppb, respectively. Analyses performed on fish revealed those collected from the Grand Calumet River had significantly higher concentrations of PCBs, PAHs, and OCPs than fish from the Wabash River. Reproductive success, calculated as the average number of chicks fledged per active nest, ranged from 1 to 2.66, with an average 1.52 chicks. Fledging success, calculated as the average number of chicks fledged per successful nest, ranged from 1.65 to 2.83, with a mean of 1.92 chicks. Mean stable isotope values were -15.37 and 15.56 for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$, respectively. Results for $\delta^{13}\text{C}$ indicate that GBHs from all regions were feeding from the same habitat type during the time before eggs were laid. The location and type of habitat is uncertain. Eggs from central Indiana had significantly enriched $\delta^{15}\text{N}$ values compared to the north and south. Results of fatty acid profiling indicate higher nutritional quality of eggs from northern and southern regions. Stable isotope and fatty acid data from the central region could indicate nutritional stress (Hobson et al. 1993). Biomagnification factors, calculated to determine if contaminants in eggs were from local sources, were inconclusive. Use of stable isotope and fatty acid profiling was effective in determining that feeding grounds of GBHs from all study regions are of similar type, but birds from the north and south have access to sites with higher quality prey. Results of this study indicate that factors other than environmental contamination may be impacting GBHs from Indiana.

MP193 Life Stage Related Elimination Rates of DDT in the Green Frog, *Rana clamitans*. K.E. McCormack, Department of Biological Sciences, University of Windsor, Windsor, Ontario, Canada; K.G. Drouillard, G. Haffner, Great Lakes Institute for Environmental Research, University of Windsor, Windsor, Ontario, Canada. Amphibians have been in decline worldwide since the 1970s. One hypothesis that has been gaining support as a possible cause for the declines is exposure to chemicals. Amphibians are commonly exposed to chemicals; however the possibility of a causal relationship between chemical exposure and amphibian declines has been largely ignored. As each amphibian life stage responds differently to the same chemical concentration, it is necessary to develop dynamic models for each life stage in order to understand the overall effects a chemical will have on a species. With a wide spread distribution, the green frog, *Rana clamitans*, is an ideal species for this purpose. In this study, DDT was used as a test chemical to examine chemical elimination in green frogs before, during, and after metamorphosis. Changes in chemical activity were related to potential changes in physiological and behavioral stress using a range of biomarkers. This study provides evidence that simple dose-response models need to be modified for organisms with complex life cycles.

MP194 Lead Shot Poisoning in Swans: Sources of Pellets Within Whatcom County, WA and Sumas Prairie, B.C. M. Smith, J. Grassley, C. Grue, University of Washington, Seattle, WA; M. Davison, J. Bohannon, Washington Department of Fish & Wildlife, Mill Creek, WA; C. Schexnider, US Fish & Wildlife Service, Lacey, WA; L. Wilson, Canadian Wildlife Service, Delta, British Columbia, Canada; M. Jordan, Trumpeter Swan Society, Everett, WA. Between 1999 and 2007, swan populations in northwest Washington and on the Sumas Prairie, British Columbia have lost at least 1,800 members to lead poisoning caused by the ingestion of spent lead shot. In 2001, an international effort was initiated to locate the source(s) of the lead. Participants include the Washington Department of Fish and Wildlife, U. S. Fish and Wildlife Service, Canadian Wildlife Service, Trumpeter Swan Society and the University of Washington (Washington Cooperative Fish and Wildlife Research Unit). A total of 251 trumpeter swans (*Cygnus buccinator*) were outfitted with radio transmitters. A blood sample was collected at capture and analyzed for lead content. Sick and dead swans were collected throughout the winter, and carcasses examined to determine cause of death and to identify gizzard contents. Results suggest that swans arrive on the wintering grounds with low blood lead levels, but subsequently are exposed to lethal amounts of shot. The locations of collared swans were used to identify forage areas and roost sites, and data for swans that subsequently died from lead poisoning were used to identify and prioritize areas for soil/sediment samples. Analyses of soil/sediment samples collected in 2005-06 suggest that Judson Lake is a primary source of lead shot for the swans. In 2006-07, swans were hazed from the lake in an effort to verify it as a primary source of lead shot. Results of the hazing effort, lead related swan mortality numbers in 2006-07, and possible confounding weather events will be presented.

MP195 Can *Mythimna unipuncta* be a useful bioindicator of soil and pasture quality in volcanic environments? A. Rodrigues, L. Cunha, J. Medeiros, P. Garcia, A. Amaral, CIRN, DB, University of the Azores, Ponta Delgada, Portugal. Whether grass and *Mythimna unipuncta* chronically exposed to volcanic emissions and intensive agriculture exploitation demonstrate different levels of trace metals is unknown. To investigate this issue, soil, grass and *M. unipuncta*, which is considered a plague in the Azores, from two pastures in São Miguel Island (Azores), one without fertilizers and permanently exposed to volcanic emissions (Furnas), and the other heavily fertilized but not exposed to volcanic emissions (Arribanas), were analyzed for seven selected trace elements (Cd, Cu, Mg, Mn, Pb, Rb, Zn) by using High Resolution Inductively Coupled Plasma Mass Spectrometry. Soils from Arribanas showed the highest levels of Cd, Mg, and Pb, but on the other hand concentrations of Cu, Mn, Rb and Zn were higher in soils from Furnas. Grass from Arribanas showed a concentration of Cd ten times higher than the grass from Furnas. Also, Mg and Zn in the grass from Arribanas showed higher concentrations. Grass as well as caterpillars and soil from Furnas revealed higher concentrations of Co, Mn and Rb, which can probably be due to volcanic activity. The high concentrations of Cd, Mg, Pb and Zn in soil, grass and caterpillar samples from Arribanas could be due to the intensive use of fertilizers, which are rich in some of these elements. Data obtained showed a high sensitivity of *M. unipuncta* for the selected elements, which makes this species a useful bioindicator of soil and pasture quality.

MP196 Crocodilians as sentinels of current use pesticide contamination in Costa Rica. P.B. Grant, P.S. Ross, Institute of Ocean Science (Fisheries and Oceans Canada), Sidney, British Columbia, Canada; M. Woudneh, AXYS Analytical Services Ltd., Sidney, British Columbia, Canada. Caiman (Caiman crocodilus) are fish-eating crocodilians that inhabit freshwater and estuarine habitat in tropical regions of the Americas. In Costa Rica, the two crocodilian species present are under considerable pressure from human activities including hunting, habitat destruction, and agricultural impacts. Banana plantations represent 12% of Costa Rica's agricultural lands, but they account for 35% of the country's pesticide use. In order to assess exposure of caiman to pesticides, we obtained whole blood (30cc) samples from 14 live-captured adult males and females. Blood samples were obtained from the ventral caudal vein using 18 g needles and a Vacutainer system. We analyzed the blood samples for 79 legacy and current-use pesticides using newly developed ultra-trace high resolution mass spectrometry (HRMS). Results suggest that high trophic level caiman are exposed to varying pesticide concentrations, reflecting degree of local use and physico-chemical properties of the pesticides. Pesticides, together with other anthropogenic pressures, may imperil the continued viability of crocodilians in the tropics.

MP197 Microsatellite Genetic Diversity of Gopher Tortoises on a Military Reservation. N. Villotti, C.W. Theodorakis, Environmental Sciences, Southern Illinois University Edwardsville, Edwardsville, IL; B. Cooper, C.W. Theodorakis, Department of Biological Sciences, Southern Illinois University, Edwardsville, IL. Populations of threatened and endangered species occur in scattered metapopulations, separated by fragmented habitat patches, and characterized by source-sink and extinction-recolonization events. Many threatened and endangered species of the Southwest US dwell on large land tracts owned by the Department of Defense. The Department of Defense requires an efficient way to provide conservation efforts while minimally impacting mission essential training capabilities. The aim of this research is to analyze genetic diversity and gene flow in four populations of Gopher Tortoise (*Gopherus polyphemus*) on two military bases, assessing the impact of land use and pollution exposure. Microsatellites were used to determine genetic diversity and gene flow within and between populations. Genomic DNA was extracted from 120 blood samples. Fluorescently labeled microsatellite markers were amplified using PCR at eight loci, and then analyzed on an automated sequencer. Microsatellite genetic diversity was determined both between and within populations. It was found that within population genetic diversity and genetic distance among populations was related to land use and level of military activity.

MP198 Retrospective analysis of productivity and contaminant blood levels in nestling bald eagles from the Delaware Bay. C. Stern, US Fish & Wildlife Service, Pleasantville, NJ. The New Jersey bald eagle (*Haliaeetus leucocephalus*) population has rebounded from near extirpation in the early 1970's to 59 monitored nesting pairs in 2006. Annually, some nesting pairs experience reproductive failures resulting in productivity below the minimum 1.0 fledgling per active breeding nest site needed to maintain the population.

Environmental contaminants such as PCBs, DDT, and mercury have been implicated as affecting reproductive success, impairing behavior, and impacting metabolic functions. Between 1993 and 1996, blood was collected from 35, 6 to 8 week-old, eaglets from around Delaware Bay in New Jersey and Delaware. Blood samples were analyzed for congener-specific and total PCBs, congener-specific polychlorinated dibenzo-*p*-dioxins and dibenzofurans, pesticides, and heavy metals. The DDT metabolite, *p,p'*-DDE, was the predominant organochlorine pesticide present and was detected in all but one sample, with a geometric mean concentration of 12.28 ng/g, and maximum concentration of 141 ng/g. Several eaglets had total PCB blood levels (maximum 395 ng/g) comparable to those in the Great Lakes subpopulation which had demonstrated poor reproductive success. Blood contaminant concentrations were compared to published Great Lakes contaminant-productivity regressions and Delaware Bay-specific contaminant-productivity regressions were developed. Results from these regression comparisons will be discussed.

MP199 Assessing Risk for the Mallard and Belted Kingfisher on the North Fork Holston River, VA and TN. E. Curtis, A. Shortelle, C. Butcher, M. Bystedt, L. Venne, N. Ruberti, MACTEC Engineering and Consulting, Inc, Kennesaw, GA. The North Fork Holston River (NFHR), located in southwestern Virginia and northeastern Tennessee, is part of the Upper Tennessee River Basin. A former chlorine plant (site) operated on the NFHR from 1950 to 1972 and contributed mercury (Hg) to the river. Numerous studies have been conducted on the NFHR downstream of the site to monitor biota Hg and methylmercury (MeHg) concentrations, as well as the health of the river system as it recovers. Potential risks to the mallard (*Anas platyrhynchos*) and belted kingfisher (*Ceryle alcyon*) residing and foraging in the NFHR habitats were assessed. The NOAEL-based Hazard Index (HI) for the mallard was below the threshold value of 1, indicating that mallard ducks are unlikely to be adversely affected in the NFHR. The kingfisher exposure evaluation was supported by the collection of fish (lengths ranging from 0 to 178 mm), crayfish, and sediment. NOAEL- and LOAEL-based HIs for the kingfisher ranged from 22 to 29 and 2.3 to 3.1, respectively, downstream of the site, indicating potential risk due predominately to exposure to MeHg concentrations in fish. In addition to these risk assessments, the Natural Resource Damage Assessment (NRDA) Trustees supported by MACTEC scientists conducted injury assessments on the NFHR for the mallard and kingfisher, which indicated that Hg does not pose a risk to the reproductive success of the mallard or the kingfisher. The NRDA kingfisher findings substantiated the overestimation of risk calculated for the kingfisher. The Hg and MeHg toxicity reference values (TRVs) used for quantification of the kingfisher risk were generated from a mallard reproductive study due to the lack of available avian piscivore data. The mallard feeds primarily on plants and insects, whereas the kingfisher feeds primarily on fish and crayfish, suggesting differential forms and bioavailability of Hg in dietary sources, as well as metabolic differences. Based on these assessments, the mallard TRVs are an overestimation of risk for piscivorous avian receptors.

MP201 The Analysis and Characterization of Environmental Estrogens in the Galveston Bay Watershed and their Cytotoxic Effects on Fish Liver and Reproductive Cell Lines. K.R. Tatum-gibbs, Chemistry, Texas Southern University, Houston, TX. In recent times, the presence of endocrine disrupting compounds (EDCs) in the environment has become increasingly important to scientific researchers. Among the various compounds considered as emerging environmental pollutants, natural and synthetic steroids, pesticides, and industrially produced by-products all warrant particular concern; both because of the volume of these substances used, and because of their potential to act as endocrine disruptors. Of the various groups of substances with reported endocrine-disrupting properties, female sex hormones and synthetic steroids are considered to be the most potent types of estrogenic compounds (Alda et al., 2003). Unfortunately, it has not been until recent investigations that these compounds have received any attention from the scientific community, most likely because they are found present in the environment at very low concentrations. Now, researchers are beginning to realize that the widespread use of oral contraceptives and animal growth stimulators formulated with these potent estrogenic chemicals are yielding potentially dangerous consequences with their presence in waste water and aquatic environments (Ying et al., 2002). Furthermore, these compounds are capable of inducing adverse responses in various organisms at extremely low concentrations (Snyder, 1999). Thus, the introduction of these potentially toxic compounds in the environment will not only affect water quality, but could also affect the health of wildlife and humans existing in that

environment. This study seeks to identify and quantify EDCs in aquatic environments. The study and experimental design will aim to understand many aspects of aquatic environments with respect to estrogen contamination, as well as, other EDCs; and focus on how these compounds affect aquatic organisms. Water samples will be collected and analyzed using LC-DAD-MS from tributaries that lead into the Galveston Bay Watershed (Lake Houston, Trinity River, San Jacinto River and the Houston Ship Channel). Results obtained from this study will show the extent to which aquatic environments are affected by EDCs and show the possible toxicity of these contaminants to the environment and aquatic organisms. Identification of these compounds is important to understand their health impact and how to deal with them once they have entered the environment.

MP202 Effects of organophosphate pesticides on brain and plasma cholinesterase activity in quail as a function of exposure route. J.W. Heffernan, B. Blakley, M. Wickstrom, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; P. Mineau, Environment Canada, Ottawa, Ontario, Canada; T. Wolf, Agriculture and Agri-Food Canada, Saskatoon, Saskatchewan, Canada. Evaluation of pesticide risk to wild birds usually considers only the oral route of exposure. However, studies comparing similar pesticide toxicity tests under laboratory and field conditions have found greater risks to birds under field conditions than under lab conditions. This may be due in part to contributions to toxicity from exposure routes other than oral. Dermal exposure has been shown to be an important factor in explaining patterns of bird kills with anticholinesterase pesticides in North America. The overall objective of this research is to test the hypotheses that the dermal route of exposure contributes to the toxicity of organophosphate (OP) pesticides to birds under simulated field conditions, and that the relative contribution of dermal exposure to total toxicity can be explained by the physicochemical properties of the OP pesticide. Pilot study exposures with Lorsban® 4E (chlorpyrifos, 480 g/L) spray on a simulated cereal crop field to compare the dermal only, dermal plus dietary and dermal plus direct spray exposure routes in northern bobwhite (*Colinus virginianus*) at various spray application rates have been completed. Response to the pesticide exposures was measured using brain and plasma cholinesterase activity assays. Brain and pooled plasma cholinesterase activity in negative control birds was 13.88+/-0.50 µmol/min/g wet mass (n=15) and 17.08+/-0.14 µmol/min/mL (n=20), respectively. Brain and plasma cholinesterase activity in a positive control bird sacrificed 24 hours after receiving an oral dose at 8 mg a.i./kg was 8.22 µmol/min/g wet mass and 4.52 µmol/min/mL, respectively (n=1). In the pilot study, bobwhite were exposed via the dermal only, dermal plus dietary and dermal plus direct spray exposure routes at 1152 g a.i./ha, and sacrificed at 12 or 48 hours post-exposure (each n=6). No significant differences in brain cholinesterase activity between exposed birds and negative controls were found at this rate regardless of exposure route. Results of plasma cholinesterase activity assays are pending. A second pilot study trial exposing bobwhite to Lorsban® 4E via the dermal only, dermal plus dietary and dermal plus direct spray routes at 2880 g a.i./ha was recently completed. Birds were sacrificed at 24 or 72 hours post-exposure. Results of brain and plasma cholinesterase activity assays are pending.

MP203 PCDF and PCDD accumulation rates for three passerine species as part of a site-specific risk assessment on the Tittabawassee River. T.B. Fredricks, M.J. Zwiernik, S.J. Coefield, R.M. Seston, C.N. Stieler, Zoology, Michigan State University, East Lansing, MI; S.C. Plautz, D.L. Tazelaar, Michigan State University, East Lansing, MI; M.S. Shotwell, D.P. Kay, Entrix, Inc., East Lansing, MI; J.P. Giesy, Biomedical Veterinary Sciences & Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Dietary accumulation of both polychlorinated dibenzofurans (PCDFs) and dibenzo-*p*-dioxins (PCDDs) in passerine birds nesting in the Tittabawassee and Chippewa River floodplains near Midland, Michigan, USA was examined in both the aquatic and terrestrial food webs. Mean concentrations of PCDF/PCDDs in soil and sediment were 10- to 20-fold greater downstream (target sites) of Midland compared to upstream (reference sites). Based on life history, site presence, and availability of on- and off-site historical data, tree swallow, eastern bluebird, and house wren were chosen as passerine species of interest. Over 200 nest boxes were monitored upstream (n=69) and downstream (n=133) of Midland located in the floodplain of the rivers during the 2005 and 2006 breeding seasons. Soil, sediment, and local insect samples were collected from selected grids at both upstream and downstream sites that corresponded with specific nest box loop locations for contaminant analyses. Seventeen 2,3,7,8 (PCDF/PCDD) congeners were

measured in all samples and converted to TEQs using avian WHO TEF values. Concentrations of TEQs in eastern bluebird, house wren, and tree swallow eggs, nestlings and dietary items along with soil and sediment were used to estimate site-specific bioaccumulation and trophic transfer pathways. Avian TEQs downstream of Midland for house wren, tree swallow, and eastern bluebird eggs ranged from 1.2×10^{-2} – 2.3×10^3 ($n=16$), 1.5×10^{-1} – 4.5×10^2 ($n=14$), and 3.1×10^{-1} – 1.0×10^3 ($n=10$) ng/kg wet weight (ww) while nestling concentrations of TEQs for house wren and eastern bluebird ranged from 7.1×10^{-1} – 1.2×10^3 ($n=18$) and 4.8×10^{-1} – 9.6×10^2 ($n=13$) ng/kg ww, respectively. Avian TEQ concentrations for soil were approximately 8-times greater compared to sediment which explains the greater concentrations in both house wren and eastern bluebirds which forage primarily in the terrestrial food web.

MP204 Ecological Screening Levels for Total Petroleum Hydrocarbons in Soil. J. Conder, ENVIRON International Corporation, Irvine, CA; M. Sorensen, ENVIRON International Corporation, Atlanta, GA. Petroleum hydrocarbons are ubiquitous soil constituents at many sites for which an ecological risk assessment is required. Quantification of the thousands of individual hydrocarbons in environmental media is not analytically feasible for full-scale site characterization. Instead, constituents are analyzed via Total Petroleum Hydrocarbon (TPH) methods that quantify “TPH” concentrations according to the number of carbons in each molecule (e.g., USEPA Method 8015B). There are no ecological screening levels (ESLs) with which to interpret the risk potential of TPH-impacted soils. Using exposure and effects modeling, we estimated ESLs for exposure to a small mammal (Botta's pocket gopher, *Thomomys bottae*) and an herbivorous bird (California quail, *Callipepla californica*). A mammalian toxicity reference value was calculated using an approach based on hydrocarbon constituents of diesel fuel. An avian toxicity reference value was derived from avian toxicity testing with number 2 fuel oil. Uptake into wildlife foods (plants) was assumed to be similar to benzo(a)pyrene. Assuming an area use factors of 1 for both species, the ESLs for Botta's pocket gopher and California quail were estimated to be 3,400 and 130,000 mg/kg, respectively. These values likely to be very conservative for most sites due to the lower bioavailability and toxicity of highly weathered petroleum compounds compared to the laboratory studies upon which they are based, which utilize fresh material that is composed of smaller, more reactive compounds. Although these ESLs should not be used as cleanup criteria, they provide a much more realistic screening approach alternative to using the only other widely-available screening level for petroleum in soil, an ESL for gasoline (20 mg/kg), published by USEPA Region 4.

MP205 Toxicity of Oil Sands Process-Affected Water (OSPW) and Substrates to Wood Frog (*Rana sylvatica*). N. Gupta, M. Wickstrom, Toxicology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. The Athabasca oil sands in northern Alberta represent one of the largest known oil deposits in the world. The process used to extract oil from these deposits results in the production of large volumes of process-affected water (OSPW), which must be incorporated into wetlands as a component of the reclaimed landscapes. These wetlands need to provide suitable habitats for aquatic and semi-aquatic organisms such as amphibians. Wood frogs (*Rana sylvatica*) are an abundant native species that might be expected to inhabit these reclaimed wetlands. The objective of this study is to determine potential detrimental effects of OSPW and sediments on the growth and development of wood frogs. In summer 2006, wood frog eggs collected from uncontaminated wetlands were exposed to OSPW from six different impacted wetlands and aged tap water (control) under laboratory conditions. Endpoints evaluated included percent hatchability and tadpole survival. Hatchability was reduced in eggs exposed to water from one of the OSPW sites compared with the other process-affected ponds and the control water. Tadpole survival was significantly affected by exposure to water from all six impacted sites. By Gosner stage 26-27 (development of hind limb bud) mortality was 100% in four of the six OSPW groups. In summer 2007, newly hatched wood frog tadpoles (Gosner stage 18-21) were exposed to water from six different wetlands containing OSPW and process-affected sediments from four additional wetlands as well as a tap water control. Preliminary results show less than 10% survivability of tadpoles in all OSPW sites relative to controls at Gosner 26-27. Results of sediment exposure and tadpole whole body triglycerides and thyroid hormone analyses are pending.

MP206 Subchronic Toxicity of 2,4,6-Trinitrotoluene; 2,4-Dinitrotoluene, and 2,6-Dinitrotoluene in Developing Tadpoles (*Rana catesbeiana*). N.E. Paden, A. Gentles, E.E. Smith, R.J. Kendall, Environmental

Toxicology, The Institute of Environmental and Human Health, Texas Tech University, Lubbock, TX. Amphibian growth and development can be altered by explosive's residues that are present in the environment. Environmental data for 2,4,6-trinitrotoluene (TNT); 2,4-dinitrotoluene (2,4-DNT) and 2,6-DNT indicate that these compounds are present in water and other ecological compartments. The bullfrog (*Rana catesbeiana*) represents one native species with a wide distribution and a high potential for exposure to these residues. Based on the bullfrog's life history and current data gap on subchronic developmental toxicity an evaluation was carried out using bullfrog tadpoles. Bullfrog tadpoles (8 days old) were exposed to TNT (0, 0.125, 0.25, 0.5, 1, 2, and 4 mg/L); 2,4-DNT (0, 0.125, 0.25, 0.5, 1, 2 and 4 mg/L) and 2,6-DNT (0, 0.25, 0.5, 1, 2, 4 and 8 mg/L) for 90 days. The endpoints that were analyzed included: survival, weight gain, snout vent length (SVL) and gross morphological deformities. The results indicate that the three compounds tested had significant toxicological effects at the highest concentration tested. These effects included changes in gross morphological characteristics, mild abdominal and optic edema, dorsal flexure of the tail, incomplete coiling, and deformed head. In addition, the survival rate of the tadpoles exposed to TNT at 4mg/L was significantly lower than the control group. The data indicate that explosive's residues at the highest concentrations will affect amphibian development and growth. Further research is needed to determine the specific mechanism of toxicity in amphibians.

MP207 PCDF and PCDD concentrations in great horned owls (*Bubo virginianus*) inhabiting the Tittabawassee River floodplain in central Michigan. S.J. Coefield, M.J. Zwiernik, T.B. Fredricks, R.M. Seston, D.L. Tazelaar, M.W. Nadeau, J.P. Giesy, Zoology, Michigan State University, East Lansing, MI; D.P. Kay, M.S. Shotwell, ENTRIX, Inc., East Lansing, MI; J.P. Giesy, Veterinary Biomedical Sciences & Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. The great horned owl (*Bubo virginianus*) is a long-lived top predator that maintains its territory year-round. Because of its potential for accumulating contaminants, the great horned owl (GHO) has been chosen as an indicator species to determine the impacts of polychlorinated dibenzofuran (PCDF) and polychlorinated dibenzo-p-dioxin (PCDD) on terrestrial wildlife species along the Tittabawassee River in central Michigan USA. The Tittabawassee River contains elevated levels of PCDFs and PCDDs in sediments, floodplain soils, and fish downstream of Midland, MI. From 2005 through 2006, plasma was collected from 31 nestlings and 14 adult resident GHOs. The plasma was analyzed for PCDF and PCDD concentrations as part of an on-going wildlife study conducted in support of an ecological risk assessment of the Tittabawassee River.

MP208 The great horned owl site-specific dietary exposure to PCDF/Ds in the Tittabawassee River floodplain in central Michigan. M.W. Nadeau, S.J. Coefield, M.J. Zwiernik, T.B. Fredricks, R.M. Seston, D.L. Tazelaar, S.C. Plautz, J.P. Giesy, Zoology, Michigan State University, East Lansing, MI; D.P. Kay, M.S. Shotwell, ENTRIX, Inc., East Lansing, MI; J.P. Giesy, Veterinary Biomedical Sciences & Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Great horned owls (*Bubo virginianus*) in the Tittabawassee River floodplain in the vicinity of Midland, Michigan, USA, are exposed to the elevated levels of polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-p-dioxins (PCDDs) found in the floodplain soils. The site-specific dietary exposure of great horned owl (GHO) was determined by analyzing prey remains found in the nest and egested pellets collected from the base of nest and roosting trees. In addition, small mammals, rabbits, muskrats, and passerine birds from the floodplain above and below Midland were collected and analyzed for PCDF/DD concentrations. The average daily intake (ADI) of PCDD/DD was predicted by use of a weighted average dietary concentration expressed as 2,3,7,8-tetrachlorodibenzo-p-dioxin equivalents (TEQ). In 2005 the GHO ADI of PCDF/DDs downstream of Midland was 1.1×10^1 ng TEQs/kg/day. Monitoring the GHO dietary composition over multiple years allows determination shifts in prey base that may impact the GHO exposure to contaminants.

MP209 Productivity of American Robins (*Turdus migratorius*) in the Tittabawassee River floodplain. D.L. Tazelaar, M.J. Zwiernik, R.M. Seston, S.C. Plautz, T.B. Fredricks, S.J. Coefield, J.P. Giesy, Zoology Department, Center for Integrative Toxicology, National Food Safety and Toxicology Center, Michigan State University, East Lansing, MI; D.P. Kay, S.A. Roark, M.S. Shotwell, Entrix, Inc., East Lansing, MI; J.P. Giesy, Department of Veterinary Biomedical Sciences and Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Measures of reproductive success and population sustainability are important assessment endpoints in

evaluations of ecological risk. During spring 2007, productivity data for the American robin were collected from 17 nests at reference sites and 24 nests at target sites within the Tittabawassee River floodplain downstream of the city of Midland, MI, USA. Previous studies have indicated that target sites were exposed to concentrations of polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-p-dioxins (PCDDs) that were greater than in nearby reference areas. Estimates of dietary exposure for the American robin, based on analysis of PCDF and PCDD congeners in dietary items and soil normalized to 2,3,7,8 dibenzo-p-dioxin equivalents (TEQ) by use of WHO avian TEFs, suggested that the median daily dose was two orders of magnitude greater at target sites than reference sites, with 90th percentile estimates of the daily dietary dose downstream of Midland up to 600 ng TEQ/kg BW/d. Reproductive success and population sustainability of the American robin was assessed by measuring clutch size, hatch success, and nest success. Clutch sizes ranged from 1 to 4 eggs at both reference and target sites, and hatch success ranged from 0 to 100% at both reference and target sites. Nest success data for all nests will be available for presentation. Rates of early nest success were, on average, one or more nestlings fledged at four of 14 nests at reference sites and two of 16 nests at target sites. The American robin productivity assessment presented will also include additional data collected during summer 2007.

MP210 The Effects of Maternal Contaminants on the Developing Snapping Turtle Hatchling, *Chelydra serpentina serpentina*. J.L. Schnars, Wildlife & Fisheries Science, Pennsylvania State University, Erie, PA. Previous research has revealed high levels of organochlorinated contaminants in snapping turtle tissues. Maternal transfer results in these contaminants being exposed and stored in the developing eggs. This study examines the levels of PCB contaminants at the embryo and hatchling stages, as well as the influence of temperature. Eggs were collected directly from females and injected with low (1 ppm) and high (10 ppm) concentrations of PCB solutions. Clutches were incubated using a split-plot design with low and high temperature treatments. Hatchlings were euthanized and analyzed for PCB concentrations. Total [PCB] was higher in hatchlings when compared to their eggs, and congener profiles revealed increases and decreases in specific congeners. Specific congeners significantly decreased at high temperature levels. There was a significant interaction in PCB and temperature treatment ($p=0.01$). Such results have critical implications in the use of eggs as a site bioindicator and the role of climate change on nest incubation.

MP211 An examination of the hypotheses for the mechanism of tributyltin-induced imposex. R.M. Sternberg, A.K. Hotchkiss, M.P. Gooding, G.A. LeBlanc, Environmental and Molecular Toxicology, North Carolina State University, Raleigh, NC. This research used the imposex-prone eastern mud snail *Ilyanassa obsoleta* as a model to examine hypotheses for the mechanism by which tributyltin (TBT) induces imposex, the development of male phenotypic characteristics by female neogastropods. One of the hypothesized mechanisms for TBT-induced imposex is that TBT elevates free testosterone which then initiates the physiological processes necessary for females to develop this pseudohermaphroditic condition. One study tested whether TBT elevates free testosterone by inhibiting acyl coenzyme A:testosterone acyltransferase (ATAT), an enzyme that converts free testosterone to a testosterone-fatty acid ester. Results showed that TBT competitively inhibits ATAT activity in microsomes prepared from *I. obsoleta* at concentrations measured in field-collected neogastropods from TBT-contaminated areas suggesting that TBT elevates free testosterone in neogastropods by inhibiting their major regulatory process for maintaining free testosterone homeostasis. Using a weight-of-evidence approach, another study addressed the assumption that testosterone is a functional hormone in reproductive recrudescence, i.e., the annual development of the reproductive tract, of neogastropods. Collectively, the lack of sex-specific differences in testosterone levels through reproductive development and the apparent absence of an androgen receptor tipped the weight of evidence against a role for this hormone in the regulation of molluscan recrudescence. A final study examined an alternative hypothesis for the mechanism of TBT-induced imposex: TBT causes females to develop male sex characteristics by disrupting retinoid signaling. Results implied that RXR-mediated signaling may stimulate sex-specific recrudescence during critical temporal windows and that TBT may induce imposex by initiating retinoid signaling prematurely in females enabling the development of the male sex phenotype. Overall, this research provided mechanistic support for how TBT elevates testosterone in neogastropods but cast doubt upon the validity of hypothesis that the TBT-induced increase in testosterone initiates a biochemical signaling pathway resulting in imposex.

Therefore, the observed effect of TBT on neogastropods must be due to some other mechanism of toxicity. Disruption of retinoid signaling is viewed as a mechanism worthy of additional investigation.

MP212 Species sensitivity to dioxin-like compounds can be predicted from AHR genotype using non-lethal sampling methods. J.A. Head, S.W. Kennedy, National Wildlife Research Centre, Environment Canada, Ottawa, Ontario, Canada; J.M. O'Brien, S.W. Kennedy, Department of Biology, Centre for Advanced Research in Environmental Genomics, University of Ottawa, Ottawa, Ontario, Canada; M.E. Hahn, Department of Biology, Woods Hole Oceanographic Institution, Woods Hole, MA. The aryl hydrocarbon receptor (AHR) is a ligand-activated nuclear transcription factor that is implicated in the toxic response to dioxins, polychlorinated biphenyls (PCBs), and dibenzofurans (collectively referred to as dioxin-like compounds). We have recently demonstrated that species differences in sensitivity to the toxic effects of dioxin-like compounds can be predicted from the identity of two key amino acids in the ligand binding domain (LBD) of the avian AHR. Here we expand upon our previous work with liver samples by describing methods for determining AHR genotype that are consistent with working with threatened populations of birds. We have demonstrated that the sequence of the AHR LBD can be obtained using non-lethal (RNA isolated from blood) and non-invasive (DNA isolated from various sources) sampling techniques. These developments have allowed us to make dioxin sensitivity predictions for species of birds that are currently listed as endangered in Canada, including the ivory gull (*Pagophila eburnea*), and the piping plover (*Charadrius melodus circumcinctus*).

TP1 Debromination of Decabrominated Diphenyl Ether by Resin-bound Iron Nanoparticles. A. Li, C. Tai, Z. Zhao, Y. Wang, Q. Zhang, G. Jiang, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, China; A. Li, School of Public Health, Univ. Illinois Chicago, Chicago, IL; Z. Zhao, J. Hu, Department of Chemistry, Shandong University, Jinan, China. The kinetics and pathways of reductively degradation of decabromobiphenyl ether (BDE209) was investigated using nano-scale zerovalent iron (n-Fe0) which was immobilized on a cation exchange resin using an innovative method. The debromination of BDE209 was rapid at ambient conditions without the catalysis of noble metals. The reaction was stepwise, and less brominated congeners were produced with increasing reaction time. The pseudo first order rate constant was about $0.28 \pm 0.04/h$. The dechlorination of decachlorobiphenyl (PCB209) was also investigated similarly, but the reaction rates were much slower than debromination of BDE209. Identification of the reaction products was highly challenging and assisted by regression equations between experimental and reference gas chromatographic relative retention times, confirmation by high resolution mass spectrometry, and quantitative structure retention relationships. Partial reaction pathways are proposed. For randomly selected PBDE and PCB congeners, the net charges of individual atoms were calculated using the quantum chemical computation (AM1 method) to explain the difference in dehalogenation pathways between BDE209 and PCB209.

TP2 The Chemistry and Stereochemistry of a less common Brominated Flame Retardant: 1,2-Dibromo-4-(1,2-dibromoethyl)cyclohexane. G. Arsenault, M. Alan, R. Nicole, B. Yeo, Research Division, Wellington Laboratories, Guelph, Ontario, Canada; A. Lough, Chemistry Department, University of Toronto, Toronto, Ontario, Canada; M. Robert, Chemistry Department, University of Guelph, Guelph, Ontario, Canada; K. Pleskach, G. Tomy, Department Fisheries & Oceans, Winnipeg, Ontario, Canada; S. Tittlemier, Food Research Division, Health Canada, Ottawa, Ontario, Canada. 1,2-Dibromo-4-(1,2-dibromoethyl)cyclohexane, also known as tetrabromoethylcyclohexane (TBECH), is a commercial brominated flame retardant (BFR) which is apparently used as an additive in some polystyrene and polyurethane products. There have been no reports published regarding the identity of the stereoisomers present in the commercial mixture. The objective of this work was to determine which stereoisomers are present in the technical mixture, SAYTEK-BCL-462. ¹H-NMR spectroscopy and an x-ray structure determination have determined that the technical mixture consists largely of two (of the four possible) diastereomers, *rac*-(1*R*,2*R*)-1,2-dibromo-(4*S*)-4-(1*S*)-1,2-dibromoethylcyclohexane and *rac*-(1*R*,2*R*)-1,2-dibromo-(4*S*)-4-(1*R*)-1,2-dibromoethylcyclohexane, in a mole ratio of approximately 1:1.

TP3 Development of a method to efficiently extract polybrominated diphenyl ethers (PBDEs) from consumer products. B.L. Dorie, I. Hua, Civil Engineering, Purdue University, West Lafayette, IN; T.P. Seager, The Sustainability Institute, Rochester Institute of Technology, Rochester, NY. Brominated Flame Retardants (BFRs) are a class of compounds that enhance the fire resistance in plastic consumer products (i.e. television sets, electronics and automobiles) in order to meet flammability regulations. Polybrominated diphenyl ethers (PBDEs), a sub-group of BFRs, have been hailed as a persistent organic pollutant (POP) under the guidelines set forth by the United States Environmental Protection Agency (U.S. EPA). Studies have shown that PBDEs are prevalent, accumulate in the environment and also have adverse human health effects. In response, the past few years have seen a rise in the U.S. and the European Union of legislation banning commercial mixtures of PBDEs – in particular penta and octa-BDE, as well as more recently deca-BDE. One area of concern is that emissions from consumer products can act as a source of PBDEs to the atmosphere. To establish the emission rates, a reliable method to accurately and precisely extract PBDEs from finished consumer products is required. Extraction efficiency of PBDEs out of the plastic products depends largely upon transport processes. It is necessary to find an optimal combination of particle size distribution, temperature and solvent type in order to formulate a reliable method. Accelerated Solvent Extraction (ASE) is a relatively new procedure that uses high temperatures and pressure to extract compounds from different solid matrices. When used in tandem with Cryogenic Mechanical Milling (CMM) to homogenize the sample and equally distribute particle size, extraction efficiency can be optimized. Samples are then analyzed on a GC-ECD in comparison to a set of polymer standards with a known (spiked) PBDE concentration to measure extraction efficiency. In this study, we describe the optimization of PBDE extraction from various types

of polymers used in consumer products, including High Impact Polystyrene (HIPS).

TP4 Changes in gene expression and assessment of DNA methylation in primary human hepatocytes exposed to the environmental contaminants Hexabromocyclododecane and 17-β Estradiol. S.O. Aniaigu, T.D. Williams, K.J. Chipman, School of Biosciences, The University of Birmingham, Birmingham, United Kingdom. Alteration of the expression of genes involved in the regulation of cell cycle and apoptosis as well as DNA methylation are major epigenetic mechanisms associated with the effects of non-genotoxic carcinogens. One of the most frequent and consistent observations in cancer cells is the presence of global DNA hypomethylation in association with site-specific hypermethylation of critical tumour suppressor genes. There is concern over the possible carcinogenic potentials of environmental pollutants such as hexabromocyclododecane (HBCD) and 17-β estradiol (E2). HBCD is a non-genotoxic brominated flame retardant which has been shown to induce liver tumours in rats and to induce cytochrome P450s in a manner similar to the non-genotoxic rodent carcinogen, phenobarbital. Similar concerns exist regarding the presence of E2 in the environment as this chemical has been reported to be carcinogenic in various mammalian species. Hence we evaluated the effects of both HBCD and E2 on critical gene expression and DNA methylation in conjunction with a model DNA methylation inhibitor, 5-aza-2'-deoxycytidine (5AdC) in cultured primary human hepatocytes. Exposure of hepatocytes to E2 (100ng/L) and HBCD (30 and 300ng/L respectively) for 72h showed no evidence of significant changes in their global DNA methylation status. On the other hand and as anticipated, 5AdC (5μM) produced statistically significant ($P < 0.005$) global hypomethylation in these primary cells. On analysis of gene specific methylation, all the tested compounds showed absence of methylation in the promoter regions of two key tumour suppressor genes (p16 INK4a; RB1) and two classical oncogenes (c-myc; H-ras) using a methylation sensitive PCR technique (MSP). Furthermore, the gene expression data (real-time PCR) showed that both HBCD concentrations did not alter the expression of the following genes: p16, RB1, c-myc, H-ras, ERα and THRα. On the other hand, E2 elicited a three-fold up-regulation of ERα and approximately a two-fold up-regulation of both RB1 and THR genes. Analysis of further genes previously associated with the action of non-genotoxic carcinogens is underway.

TP5 Genotoxicity and Thyroid System Effects in BDE-99 Exposed Common Carp (*Cyprinus carpio*). R.T. Benedict, C.L. Mitchelmore, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, Solomons, MD; S.B. Brown, National Water Research Institute, Environment Canada, PO Box 5050, Burlington, Ontario, Canada. Juvenile carp (*Cyprinus carpio*) were fed 670 ± 40 ng day⁻¹ fish⁻¹ of BDE-99 (2,2',4,4',5-pentabromodiphenyl ether) in amended food for 62 days followed by a 5 day depuration. The debromination product, BDE-47 (2,2',4,4'-tetrabromodiphenyl ether) bioaccumulated in liver and intestines of carp exposed to BDE-99 with minimal or no accumulation of BDE-99. BDE-47 is commonly detected at higher concentrations than BDE-99 in wild carp tissues as well as being the dominant congener in other laboratory studies of this nature. In vivo exposure to BDE-99 significantly ($p < 0.05$) increased the amount of DNA damage (single-strand breaks) in hepatocytes following 62 days of exposure as measured by the comet assay. After 5 days of depuration, hepatocytes did not exhibit any DNA damage, which suggested an effective repair capacity. Further, BDE-99 exposure had a statistically significant ($p < 0.05$) effect on the plasma thyronine: thyroxine (T3:T4) ratio. Deiodination analysis of liver and intestinal microsome preparations from this in vivo study demonstrated little biological effect of BDE-99 exposure on deiodinase enzyme activity in these juvenile carp. Changes in deiodinase enzyme activity do not appear to be responsible for the altered thyroid hormone levels. To our knowledge this is the first literature report for carp intestinal deiodinase enzyme activity and the first to assess the impacts of BDEs to this enzyme system. Implications of the present study include the potential for increased toxicity due to DNA damage and altered thyroid hormone levels following BDE-99 exposure.

TP6 Human Intake Fraction of Brominated Flame-Retardants Using a Multiscale Multimedia Model. S. Shaked, Applied Physics, University of Michigan, Ann Arbor, MI; O. Jolliet, C. Wannaz, School of Public Health, University of Michigan, Ann Arbor, MI; S. Humbert, Institute of Transportation Studies, University of California Berkeley, Berkeley, CA; S. Schwarzer, GRID-Europe, United Nations Environmental Program, Geneva, Switzerland; M. Margni, G. Soucy, CIRAIG, Ecole Polytechnique,

Montreal, Quebec, Canada; J. Dettling, G. Soucy, Great Lakes Commission, Ann Arbor, MI. To study the local and long-range multi-media exposure to polybrominated diphenyl ethers (PBDEs) and tetrabromobisphenol A (TBBPA), we examine the influence of spatialization using a multiscale multi-continental multimedia model. This model consists of a GIS-based environmental fate and exposure module that estimates the pollutant transport, deposition and population intake at local (Laurentian Great Lakes area) and global scales. By incorporating jet streams into a multi-continental model, we provide a better estimate of long-range transport and of subsequent inter-media transfers. Local exposure is studied in further detail within the Laurentian Great Lakes area. Our previous one-box model for PBDEs showed that the total oral intake fraction decreases from 10^{-2} to 10^{-4} as the log(Kow) of the various PBDEs increases from 7 to 8.7. We compare these intake fractions to those calculated with the spatial model and estimate spatial intake fractions, defined as the intake in one region resulting from an emission in a separate region. For a given PBDE congener, these can vary by more than an order of magnitude depending on substance residence time, population density and density of food production in the considered area. Finally, we determine the magnitude of exposure from inhalation, drinking water and food production in different regions and compare them with typical indoor exposures described in the literature. The present approach can also be very useful for source apportionment and to help focus further measurement efforts on the most critical issues.

TP7 Environmental Fate of Brominated Flame Retardants in Great Lakes Sediments and Aquatic Organisms. D. Lim, C. Lastoskie, Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI. Brominated flame retardants (BFRs) impart flammability resistance to plastic and foam components utilized in a large number of household products and consumer goods. In recent years, it has been recognized that BFRs pose a worldwide pollution problem due to their persistence, long-range transport capability, and predisposition to bioaccumulate. BFRs such as polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyls (PBBs) share structural similarities to polychlorinated biphenyls (PCBs) and are suspected endocrine disruptors. Results are reported for a Level IV fugacity-based dynamic bioaccumulation model of the fate of hexabrominated biphenyl discharges into the Saginaw Bay region of Lake Huron. PBBs were manufactured at the Pine River facility of the Michigan Chemical Corporation as the active ingredient in the FireMaster flame retardant compound until 1977. Their production was halted following a 1973 food chain contamination episode in which FireMaster was introduced into cattle feed at farms in southeast Michigan. A non-equilibrium multimedia environmental model is presented that predicts transient concentration profiles of hexabromobiphenyl in Great Lakes waters and sediment during the period from 1975 to 2000. PBB concentrations in the environmental compartments were used as inputs into a food web model for Great Lakes aquabiota. Predicted bioconcentration factors from the trophic model were compared with PBB concentrations measured in lake trout during the period from 1980 to 2000. Good agreement was obtained between the model results and field measurements. Hexabromobiphenyl was most persistent in the sediment compartment. From a sensitivity analysis, the predicted hexabromobiphenyl concentrations in lake trout were found to be most sensitive to uncertainty in the input parameter for the sediment half-life, particularly for concentration projections beyond 1990. The gut absorption efficiency parameter significantly affects the food web model results for the time interval prior to 1990. Using the unsteady-state environmental fate and food web models, emission rates of 2,2',4,4'-tetrabromodiphenyl ether (BDE-47) into the Great Lakes were estimated by comparing fugacity model predictions with BDE-47 concentrations measured in lake trout. The results indicate a sharp rise in the BDE-47 emission rate into all the Great Lakes over the last twenty years.

TP8 Does BFR 47 affect in vitro steroidogenesis in fish gonadal tissue? L. Peters, K. Pleskach, V.P. Palace, G.T. Tomy, Department of Fisheries and Oceans, Winnipeg, Manitoba, Canada; L. Peters, V.P. Palace, G.T. Tomy, University of Manitoba, Winnipeg, Manitoba, Canada. Polybrominated diphenyl ether (PBDE) flame-retardants are lipophilic persistent organic compounds used in manufacturing of plastics, electronic equipment, polyurethane foam and textile materials. PBDEs have become an increasingly important environmental problem due to their ability to bioaccumulate and biomagnify. Since the late 1970's, substantial increases of these compounds have been measured in wildlife and human adipose tissue. Recent studies have

focused on the potential endocrine disrupting properties of PBDEs, which include effects on thyroid hormones and gonadal tissue steroidogenesis. Previous in vitro studies that have explored the influence of PBDEs on reproductive hormone production, cell proliferation and apoptosis have focused strictly on mammalian models. Recent work has suggested that fecundity and gonadal steroidogenesis may also be affected in fish exposed to PBDEs. As the predominant congener found in fish, the potential effects of BDE 47 on in vitro ovarian steroidogenesis were examined in two species of fish.

TP9 Can biotransformation of higher BDEs (e.g., BDE 209) cause the bioaccumulation of lower BDEs (e.g., BDE 47, 99, 100) in fish over the long term? S.P. Bhavsar, N. Gandhi, University of Toronto, Toronto, Ontario, Canada; S.P. Bhavsar, S.B. Gewurtz, Ontario Ministry of the Environment, Toronto, Ontario, Canada; S.B. Gewurtz, Brock University, St. Catharines, Ontario, Canada; H. Stapleton, Duke University, Durham, NC; G.T. Tomy, Department of Fisheries and Oceans, Winnipeg, Manitoba, Canada. It is well accepted that many lower brominated diphenyl ethers (BDEs) are more toxic than higher BDEs. In order to understand the impact of debromination of higher BDEs on bioaccumulation of more toxic lower BDEs, we investigate the extent and rate of BDE 209 debromination in fish. We used our previously calibrated multi-chemical, dynamic fugacity-based fish model that was applied to experimental data of Tomy et al. (2004). The calibrated model estimated approximate gut absorption efficiencies (GAE) and half-lives (HL) of 13 PBDE congeners in juvenile lake trout by reproducing observed concentrations for high and low doses applied in uptake and depuration phases for total 168 days. In this study, we first apply the model to the experimental data of Stapleton et al. (2004, 2006) to estimate possible ranges of GAE and HL. We then conduct a modelling analysis to examine the extent to which higher BDEs such as BDE 209 biotransform into lower BDEs. The modelling results suggest that juvenile fish may debrominate BDE 209 into nona, octa, hepta and hexa BDEs within 5-6 months. However, none of the major penta (e.g., BDE 99, 100) and tetra (e.g., BDE 47) BDEs were biogenerated in this time period. Further modelling study on the influence of the debromination process on fish levels of both higher and lower BDEs over the long term is underway.

TP10 Determination of polybrominated diphenyl ethers (PBDEs) in dust by SFE-GC-MS/MS and SFE-GC-NCI/MS. F. Calvosa, A.F. Lagalante, Chemistry, Villanova University, Villanova, PA; M. Cantwell, U.S. E.P.A., Narragansett, RI. Polybrominated diphenyl ether (PBDE) flame retardants in NIST SRM 2585 (Organics in Household Dust) were extracted using supercritical fluid extraction (SFE) with 1,1,1,2-tetrafluoroethane (R-134a). Following SFE, a SPE cleanup on silica was used to remove polar compounds. GC-MS analysis was used to quantify PBDE congeners of interest. Two different ionization sources were used to quantify PBDE levels; 1) electron ionization (EI) with MS/MS quantification using a stable isotope internal standard ($^{13}\text{C}_{12}$ -BDE-99) and negative chemical ionization (NCI) with external standard MS quantification using m/z 79 and 81. The accuracy and efficiency of both the extraction and ionization method were determined by comparing the concentration of the PBDE congeners to the NIST certified values. GC-NCI/MS demonstrated a greater sensitivity over GC-EI/MS/MS and analysis of the SFE extract demonstrated an exhaustive recovery of all the PBDE congeners analyzed.

TP11 Sorption Properties of Cholesterol-lowering (Statin) Pharmaceuticals to Biosolids in Wastewater Treatment Systems. K.J. Ottmar, M. Fuller, J. Smith, Civil Engineering, University of Virginia, Charlottesville, VA. This current research examined the sorption mechanisms of the two most common cholesterol-lowering drugs, atorvastatin (brand name Lipitor) and simvastatin (brand name Zocor or Vytorin). Both of these drugs are highly prescribed, accounting for over 100 million prescriptions per year. Their limited hepatic metabolism results in approximately 80% of the metabolically active compound entering the wastewater treatment systems. Prior research with various organic compounds has shown that the mechanism of sorption to the biosolids follows linear Freundlich parameters; meaning that partition, as opposed to adsorption, is the key mechanism. These initial experiments were conducted with both radioactive and non-radioactive atorvastatin and simvastatin in a batch equilibrium process over 24 hours. Initial results for aqueous statin concentrations in the 1.0 - 10 ppb range also show a linear relationship with a significant portion of the statin mass associating with the biosolids phase. As such, the contributions of sorption to fate and transport evaluations warrant further evaluation.

TP12 A multiresidue analytical method to measure synthetic fragrances and organic UV filters and their occurrence in the environment. Y. Kameda, H. Yamashita, M. Ozaki, Public Works Research Institute, Tsukuba, Japan. A multiresidue analytical method to measure 16 synthetic fragrances and 9 organic UV filters was developed. We investigated their concentrations in surface waters, sediments, wastewater treatment influent and effluent. The concentrations in sediment core samples in Tokyo Bay were also measured. These results revealed that surface waters and sediments were contaminated by many synthetic fragrances and organic UV filters, especially organic UV filters in Japan. This is the first report for some organic UV filters concentrations in the environment.

TP13 Occurrence of synthetic fragrances and organic UV filters in surface waters, sediments, and core sediments in Japan. Y. Kameda, H. Yamashita, M. Ozaki, Public Works Research Institute, Tsukuba, Japan. We investigated 16 synthetic fragrances and 9 organic UV filters in 43 sites on four large river systems in Kanto region which is situated in a densely populated area. We also measured their concentrations in sediment core samples in Tokyo bay. Many fragrance materials and organic UV filters were detected in many sites. We revealed their partitionings between suspended particulate matters and waters. Some synthetic fragrances and organic UV filters in sediments in 1977 were higher than those in 1990's. This results showed that they might be persistent in the environment.

TP14 Loading estimation of synthetic fragrances and organic UV filters to wastewater treatment plants and their removal during wastewater treatment in Japan. Y. Kameda, H. Yamashita, M. Ozaki, Public Works Research Institute, Tsukuba, Japan. We investigated 16 synthetic fragrances and 9 organic UV filters in wastewater treatment influent, effluent, and returned sludge at many wastewater treatment plants in Japan. Their concentrations profile in influent was different from that in Europe and USA. Loadings of fragrances and organic UV filters to wastewater treatment plants were estimated. Their removal during plants were also evaluated.

TP15 Short course-Advanced mass spectrometric analysis for endocrine disruptors and pharmaceuticals in the environment. D. Barcelo, IIQAB-CSIC, Barcelona, Spain. Abstract (200 words maximum): In this course you will learn about the various mass spectrometric methods used for the determination of endocrine disrupting compounds (EDCs) and pharmaceuticals in environmental samples. Among the EDCs we have selected five groups of compounds that are of priority within European Union and US research activities: alkylphenols, polybrominated diphenyl ethers, phthalates and steroid sex hormones. Target pharmaceuticals included in this short course will be antibiotics, beta-blockers, anti-inflammatory drugs, lipid regulators and psychiatric drugs. In the past, GC-MS has been the technique most commonly employed for the environmental analysis of EDCs and selected pharmaceuticals like anti-inflammatory drugs. However, due to the poor volatility and/or polarity of some compounds, derivatisations step aimed to produce more volatile products is required to improve the sensitivity of subsequent GC analysis. Thus, the advantages of better sensitivity are sometimes largely offset by loss of sample during the additional manipulation. Furthermore, each derivatisation step is generally focused on one group of target analytes, producing volatile derivatives of the expected compounds, and thus discriminating related compounds and metabolites, which are simultaneously present but differ in structure. This is the reason why, for some groups of EDCs and pharmaceuticals, GC-MS and GC-MS-MS methodology has been recently substituted with LC-MS and mainly with LC-MS-MS. LC-MS-MS has gained in popularity, due to the sensitivity, ruggedness and ease of use given by API interfaces, such as electrospray (ESI) and atmospheric pressure chemical ionization (APCI), respectively. Combined with a new generation of MS equipment (single triple quadrupole, linear on-trap and time of flight), LC-MS and LC-MS-MS have become often routine methods for several classes of EDCs, and pharmaceuticals such as alkylphenolic compounds, synthetic and natural steroids, bisphenolic compounds, brominated flame retardants like HBCD, antibiotics, beta-blockers, anti-inflammatory drugs, lipid regulators and psychiatric drugs. The latest developments on the use of LC-Q-TOF-MS and other hybrid instruments for multi-residue analysis of pharmaceuticals will also be reported.

TP16 Determination of Veterinary Antibiotics in Water and Soils Originating from Animal Feeding Operations by Liquid Chromatography/Tandem Mass Spectrometry. W. Song, H. Li, Crop and Soil Science, Michigan State University, East Lansing, MI; M. Huang, Food and Drug

Analysis, Covance Laboratories Inc., Madison, WI. Veterinary antibiotics have been commonly administered to treat animal diseases, and routinely added as feed supplements at subtherapeutic level to stimulate animal growth and improve the efficiency of feed utilization. These practices can lead to the widespread distribution of veterinary pharmaceuticals in soil and water. Developing simple and robust analytical methods to identify and quantify antibiotics in soil and water media is needed to evaluate their environmental fate and exposure to the surrounding biota. In this study, a single-cartridge solid phase extraction (SPE) was established to simultaneously extract multiple classes of veterinary antibiotics including monensin, tylosin, carbadox, and amprolium from surface water. The associated soil samples were extracted using methanol/ammonium acetate mixture, and cleaned up and concentrated using SPE procedure. The prepared samples were assayed using liquid chromatography coupled to a tandem mass spectrometry. The obtained recoveries for these analytes were > 70% in surface water and > 50% in soil samples. The limits of quantitation ranged from 0.6 to 20 ng/L for surface water samples, and 4 to 90 ng/kg for soil samples. The developed method was also used to determine the antibiotics in surface runoff and soils sampled from a livestock production facility.

TP17 The vitellogenin induction by some veterinary pharmaceuticals on *Oryzias latipes*. P. Kim, K. Kim, J. Lee, Dept. Occupational and Environmental Health, Yongin University, Yongin, Kyonggi-Do, South Korea; K. Choi, Dept. Environmental Health, Seoul National University, Seoul, Seoul, South Korea. This study was designed to determine endocrine disruption of some veterinary medicines on several measures of endocrine function in adult *Oryzias latipes* relative to 17 β -estradiol (E2). Vitellogenin (Vtg) produced in male fish has been used for a biomarker to study endocrine disruptors. However, the characteristics of Vtg produced in male fish have not been studied well. In this study, investigated the localization of Vtg in the whole body of male fish with chlortetracycline, sulfathiazole, amoxicillin, enrofloxacin, carbadox, trimethoprim. Vtg was qualified and quantified through Western blot and ELISA. As a result, male fish exposed to chlortetracycline respectively appeared 0.24, 0.12, 7.61 and 40.02 per mill of 0.1, 1, 10 and 100 ppm respectively, that was value elevated compared with control male fish. Amoxicillin made Vtg elevation from 100 ppm in male fish. Sulfathiazole 5 ppm, carbadox 5 ppm, enrofloxacin 10 ppm were the starting dose of Vtg induction in male fish. This study suggested potential endocrine disruption of some veterinary pharmaceuticals in aquatic ecosystem.

TP18 Preliminary ecotoxicological risk assessment of benzylparaben using Japanese medaka and medaka cDNA microarray. M. Watanabe, Y. Hirata, H. Yamamoto, University of Tokushima, Tokushima, Japan; N. Tatarazako, National Institute for Environmental Studies, Tsukuba, Japan; Y. Kagami, M. Uchida, H. Nakamura, Ecogenomics Inc., Kurume, Japan. Benzylparaben is frequently used as an antimicrobial preservative in the cosmetic and pharmaceutical industries. Since its structure resembles alkylphenols and since it revealed weak estrogenic activity in vivo (rodents) and in vitro (yeast reporter gene assay) studies, widespread use of this chemical has raised concerns about the potential human and wildlife health risks when exposed in the environment. Up to this date, many studies have been reported concerning human health risks and potential toxicity based on an assumption of benzylparaben exposure through oral intake. However, availability of reports as for the persistence of benzylparaben and its bioactive metabolites in the environment and its toxicological effect(s) on aquatic organisms is very scarce. Therefore, one objective in this preliminary study was to measure persistence and estimated observable concentrations of benzylparaben in some aquatic environments and sewage treatment plant effluents. In addition, another objective was to assess potential risks and effects caused by benzylparaben (14-day exposure at 4, 20, 100, and 500ppb) using 2~4-week-old Japanese medaka (*Oryzias latipes*), vitellogenin assay, and medaka cDNA microarray gene expression analysis. Briefly, the results showed that benzylparaben's environmental persistence was very low (>99.8% was removed by sewage treatment process and 71% by chlorination process), 96-hour-LC₅₀ was observed at 730ppb (2-week-old medaka), and serum vitellogenin protein induction (4-week-old male medaka) was observed at 500ppb of benzylparaben (environmentally relevant concentration is 0.5~5ppb). These suggested almost no direct toxicological effect caused by this chemical. In contrast, the gene expression analysis by medaka cDNA microarray revealed up-regulation of the genes such as choriogenins, vitellogenins, globins, annexins, p53, and cytochrome P450 family members. Interestingly, transcription of some of these genes was indeed induced by

benzylparaben even at its environmentally relevant concentration (4ppb). Thus, our discussion is focused upon potential ecotoxicological risks of benzylparaben with paying prior attentions to its very weak environmental persistence and yet observable transcriptomic endpoints shown in the medaka liver at environmentally relevant concentration.

TP19 Use of Water Quality Indicators to Detect Septic System Input on Grand Lake, Oklahoma. K. Burgess, J. Bidwell, Zoology, Oklahoma State University, Stillwater, OK; D. Townsend, Grand River Dam Authority, Vinita, OK. Grand Lake is an 18,616 ha reservoir located in north-eastern Oklahoma. A large number of both seasonal and permanent dwellings exist around the shoreline, with some of these areas still serviced by septic systems. The present study is investigating the potential influence of septic effluent on Grand Lake water quality. We are using GIS to map factors such as housing density and age and soil type as potential indicators of septic system failure. Water quality parameters have been evaluated in close proximity to developed areas and include nitrate, nitrite, ammonia, phosphate, total phosphorous, dissolved oxygen, pH, temperature, conductivity, N15 isotope signature, and total/fecal coliform. Results from the first field season indicate two developed coves on the upper (inflow) end of Grand Lake have significantly greater levels of nutrients than another developed sites served by a municipal wastewater treatment plant, although this difference may indicate a longitudinal gradient associated with incoming river flow. Polar Organic Integrative Samplers (POCIS) are also being used to determine the presence of caffeine, β -estradiol, cholesterol, and a suite of other wastewater indicators. These passive samplers were placed in two developed coves containing septic systems, an undeveloped control cove, two pelagic sites, and a site near the discharge of a municipal wastewater treatment plant (WWTP).

TP20 The effects of fluoxetine on nitrogen excretion and the immune system in a marine teleost. D. McDonald, Marine Biology and Fisheries, RSMAS, University of Miami, Miami, FL. The most commonly prescribed antidepressants, including fluoxetine, inhibit the reuptake of serotonin (5-HT; 5-hydroxytryptamine) by 5-HT transporters in neurons, human platelets and gastrointestinal tract. This inhibition results in an increase in local 5-HT concentrations and so the action of fluoxetine is analogous to the physiological actions of 5-HT itself. After consumption, the metabolites of fluoxetine as well as 10-15% of the unchanged parent drug are excreted from the body and enter sewage treatment facilities but are not degraded. Consequently, these compounds have reached measurable quantities in surface waters and the impact of pharmaceutical exposure on marine life needs to be thoroughly examined. The gulf toadfish, *Opsanus beta*, is a benthic, marine teleost fish abundant along the Florida coastline and within the Gulf of Mexico. Many 5-HT sensitive physiological processes have been identified in toadfish and are potentially susceptible to environmental fluoxetine contamination. To test this potential, fish were treated with fluoxetine by intravenous injection or intraperitoneally using slow-release coconut oil implants. These fish were compared to a third subset of fish that were exposed to fluoxetine in the water (nominal concentrations of 0, 0.01 and 10 $\mu\text{g/l}$) for 15 days. Circulating 5-HT and cortisol, an important stress hormone in teleost fish, were monitored in these groups of fish as well as acute and chronic changes in nitrogen excretion, a process that is regulated by 5-HT in toadfish. The immune system is also regulated by 5-HT and thus, potential immunosuppressive effects of fluoxetine were determined by differential leukocyte counts made on whole blood smears.

TP21 Determination of anthropogenic contamination indicators in freshwater using solid-phase extraction and gas chromatography/mass spectrometry. K.L. Fallert, J.B. Belden, Department of Environmental Studies, Baylor University, Waco, TX. As populations continue to expand, freshwater supplies are continuously strained; not only by high demand, but by increased contaminants in the aquatic environment. Urban effluent contamination has been documented from known discharges in numerous streams across the United States and Europe. Two of the primary sources of potential pollution in streams and reservoirs are failing or ineffective onsite wastewater treatment systems (OWTS) and municipal wastewater treatment plants (WWTP). Screening for common pharmaceuticals and personal care products (PPCPs) would indicate contamination from anthropogenic sources much more rapidly and utilizing fewer resources than traditional source tracking. In addition to PPCPs, runoff from agricultural lands is of continued concern, especially in regards to herbicides. We have developed a GC/MS analysis technique for the simultaneous determination of several PPCP and herbicide analytes utilizing a solid-phase extraction technique. This method has been applied

as a portion of a phased, comprehensive investigation to determine if Lake Whitney, a large reservoir in central Texas, could be utilized as a regional water supply reservoir for the region. Additionally, the method has also been applied to analyze soil column effluent. Columns containing various soil types had septic pass through imitating differing leach field conditions to determine the effects of soil type. Both applications illustrate the utility of the method for the determination of indicators of anthropogenic contamination and the versatility this method allows.

TP22 Assessment of Urban Aquatic Environments that Receive Complex Anthropogenic Mixtures. D.H. Wilkison, D.J. Armstrong, Water Resource Discipline, U.S. Geological Survey, Lee's Summit, MO. From 1998 through 2007, over 750 surface-water or bed-sediment samples in the Blue River Basin – a largely urban basin in metropolitan Kansas City – were analyzed for more than 100 anthropogenic compounds. Non-point source runoff, hydrologic alterations, and numerous waste-water discharge points have resulted in the routine detection of complex anthropogenic mixtures of compounds in water- and bottom-sediment samples at basin stream sites. More than 75 percent of samples analyzed had detections of the antimicrobial compound triclosan, the insect repellent DEET, metabolites of detergent surfactants, caffeine, and the nicotine metabolite cotinine. More than one-half of stream samples had detections of the pharmaceutical compounds acetaminophen, sulfamethoxazole, trimethoprim, and carbamazepine. Concentrations of individual anthropogenic compounds (except for nutrients) in water samples typically were less than 1 microgram per liter but mixture concentrations were 30 to 50 times greater. Anthropogenic-derived total nitrogen concentrations were frequently greater than 10 milligrams per liter in stream samples and anthropogenic-derived total phosphorous concentrations were routinely greater than 1 milligram per liter. Temporal and spatial variations of organic wastewater compounds, pharmaceuticals, and nutrient loads were observed, primarily related to a site's proximity to point-source discharges and stream flow dynamics. Bioassessments, conducted yearly between 2002 and 2007, indicated substantial declines in macroinvertebrate communities along an urbanization gradient. Declines in aquatic community health were correlated with increased concentrations of anthropogenic compounds at stream sites but not with increased stream habitat assessment scores. Stream habitat assessment scores were not robust measures of environmental stressors in the urban basin. Consequently, toxicity testing is planned for 2007 and 2008 at 10 sites in the basin and 1 outside control site to better characterize how complex mixtures of anthropogenic compounds effect in-stream biota. Test species will include producers, consumers, and decomposers and will examine both acute and chronic toxicity of water and sediments.

TP23 Bioaccumulation of methyl triclosan in tilapia in a wastewater treatment plant. G.C. Nallani, Biological Sciences, Univ. of North Texas, Denton, TX. In 2003, the Denton, Texas municipal wastewater treatment plant (DWWTWP) introduced tilapia (*Oreochromis mossambicus*) into the clarifiers and sand filters to control excessive algae growth. This tilapia population has been able to survive and thrive. Previous studies showed that antimicrobials triclosan (TCS) and triclocarban (TCC) and the metabolite methyl triclosan (MTCS) were present in the plant effluent at parts per trillion (ppt) concentrations. We examined tilapia muscle extracts for these compounds to assess their potential for bioaccumulation. TCS and MTCS were analyzed by isotope dilution GC/MS and TCC by isotope dilution LC/MS/MS. Only MTCS significantly bioaccumulated in the tilapia with tissue concentrations approximately three orders of magnitude above effluent concentrations.

TP24 Triclosan and endocrine disruption: Evidence for alterations in thyroid hormone homeostasis. K.B. Paul, Curriculum in Toxicology, UNC Chapel Hill, Chapel Hill, NC; J.M. Hedge, K.M. Crofton, Neurotoxicology Division, US EPA, RTP, NC; M.J. DeVito, Experimental Toxicology Division, US EPA, RTP, NC. Triclosan (5-chloro-2-(2,4-dichlorophenoxy)phenol) is a chlorinated phenolic antibacterial compound found as an active ingredient in many personal care and household products. Unequivocal evidence of triclosan contamination of rivers and wastewater treatment plant effluents highlights an exposure potential for both humans and wildlife. Triclosan has been measured in human breast milk and urine samples, fish exposed to effluent, and algae. The structural similarity of triclosan to thyroid hormones and recent in vitro studies demonstrating activation of the human pregnane X receptor (PXR) and inhibition of sulfotransferases indicate possible adverse effects on thyroid homeostasis. The current research tested the hypothesis that

triclosan decreases circulating concentrations of thyroxine, and that this occurs via activation of pregnane X receptors, constitutive androstane receptors (CAR), and/or up-regulation of hepatic catabolism of hormones. The hypothesis was tested using a 4-day oral triclosan exposure (0–1000 mg/kg/day) in weanling female Long-Evans rats. Serum and liver tissue were harvested for measurement of serum total thyroxine (T₄), hepatic ethoxresorufin-O-deethylase (EROD) and pentoxyresorufin-O-deethylase (PROD), and qRT-PCR for a number of CAR and PXR responsive genes. Dose-dependent decreases in total T₄ were observed. The benchmark dose (BMD) and lower bound on the BMD (BMDL) for the effects on T₄ were 69.7 and 35.6 mg/kg/day, respectively. Triclosan treatment induced PROD activity up to 5-fold at 300 mg/kg/day. There was no biologically relevant change in EROD activity. The data demonstrate that triclosan is an endocrine disruptor and alters thyroid hormone homeostasis in rats. This abstract does not necessarily reflect the policy of the US EPA.

TP26 Sediment Toxicity Identification and Evaluation (TIE) Phases I, II and III Guidance Document. K.T. Ho, R.M. Burgess, M.C. Pelletier, M.G. Cantwell, J.R. Serbst, S.A. Ryba, Atlantic Ecology Division, U.S. Environmental Protection Agency, Narragansett, RI; D.R. Mount, T.J. Norberg-King, R.J. Hockett, Midcontinent Ecology Division, U.S. Environmental Protection Agency, Duluth, MN; M.M. Perron, School of Public Health, Harvard, Boston, MA. Contaminated sediments from a number of freshwater and marine sites have demonstrated toxicity to a variety of test species, as well as adverse ecological effects such as population declines and changes in community structure. However, simply knowing a sediment is toxic has limited use. The identification of pollutants responsible for the toxicity of contaminated sediments has broad application including linking sediment toxicity to specific dischargers, designing cost-effective remediation programs, identifying environmentally protective options for dredged material disposal, and focusing ecological risk assessments. For all of these reasons the U.S. Environmental Protection Agency has released a Sediment Toxicity Identification and Evaluation Guidance (TIE) Document. This document provides guidance for both interstitial water and whole sediment TIEs and combines our current understanding of TIE methods for both marine and freshwater sediments. This presentation will summarize methods covered in the document including Phase I TIE (Characterization) methods for interstitial waters and whole sediments with guidance on when to use whole sediment or interstitial water methods, removal of interstitial waters for testing, and test volume considerations. The interstitial water TIE manipulations presented include the following: graduated pH, aeration, filtration, C18 reverse-phase extraction, EDTA addition, cation exchange, and solid phase extraction. Whole sediment methods presented will include general procedures and considerations for whole sediment testing and the following manipulations: *Ulva lactuca*, zeolite, cation and anion exchange, acid volatile sulfide, Ambersorb, powdered coconut charcoal, and base metal substitution. Existing guidance for Phase II (Identification) and III (Confirmation) methods which have been tailored for chemical classes normally found in sediments will also be presented.

TP27 Overview of Sediment Quality Conditions in the St. Louis River Area of Concern, MN/WI. J.L. Crane, Environmental Analysis & Outcomes Division, Minnesota Pollution Control Agency, St. Paul, MN. The St. Louis River Area of Concern (AOC) has special significance due to its geographic boundary shared by Minnesota and Wisconsin, proximity to Lake Superior, and economic, social, and recreational importance to the area. Contaminated sediments contribute to several use impairments in the lower St. Louis River, including fish consumption advisories, restrictions on dredging, and habitat impairments to bottom-feeding organisms. Sediment quality data collected by state, federal, tribal, academic, and private groups during 1990 - 2005 have been assembled into a GIS-based sediment quality database for the St. Louis River AOC. A number of ecosystem health indicators have been evaluated from the database, including sediment chemistry, sediment toxicity, benthic invertebrate community structure, tissue chemistry, physical parameters, and sediment quality targets. Taken together, these indicators provide a weight-of-evidence approach for assessing the effects of contaminated sediments on the beneficial uses of this aquatic ecosystem. In tandem with the database, a set of GIS maps have been developed to plot features of these sediment quality data on maps in relation to GIS watershed data (e.g., contamination sources). This presentation will provide an overview of sediment quality conditions in the St. Louis River AOC and will identify regions of the AOC that present low, medium, and high risks to benthic invertebrates living in the sediments.

These organisms are vital to the integrity of aquatic and nearshore ecosystems, and they provide an important part of the lower food chain for economically important species like sport fish and waterfowl. This project was funded by the Wisconsin Coastal Management Program and NOAA, Office of Ocean and Coastal Resource Management under the Coastal Zone Management Act, Grant #NA05NOS4191067.

TP28 Reproductive, physiological and histological consequences of exposure to sediment extracts from the South Branch of the Potomac River on Japanese medaka (*Oryzias latipes*). S.R. Davis, C.M. Foran, Biology, West Virginia University, Morgantown, WV; S.R. Davis, P.M. Mazik, West Virginia Cooperative Fish and Wildlife Unit, Department of Forestry, West Virginia University, Morgantown, WV. Recently an intersex condition, defined as the presence of oocytes in the testes of male gonochoristic fish, has been observed in smallmouth bass in the South Branch of the Potomac River, West Virginia, indicating exposure to exogenous estrogens. Endocrine disrupting chemicals (EDC's) are generally hydrophobic and would tend to be found within the sediment of aquatic environments. Few studies have attempted to show the effects of exposure to EDC's on fish using sediment chemical extracts. We have developed a mass sediment extraction technique to determine the effects of extracted chemicals from three sites (Springfield, Petersburg, and Franklin) on reproductive performance of adult mating pairs of Japanese medaka (*Oryzias latipes*) for 14 days. Sediments were divided, sonicated separately with two solvents (hexane and ethyl acetate:acetone (50:50)), and filtered three times. After solvent exchange with acetone, pairs were subjected to extracts at the ratio of 10g of extracted sediment in 1L of water. Hatching success significantly decreased due to exposure to Franklin (hexane and ethyl acetate:acetone) and Petersburg sediment extract (ethyl acetate:acetone). Vitellogenin quantification using whole livers and histological analysis of a subset of exposed fish will lend further insight into the investigation of endocrine disruption in the South Branch of the Potomac River.

TP29 Selecting an Effective Risk-Based Remedial Alternative for Contaminated Sediments in Seaplane Lagoon at the Former Alameda Naval Air Station. N.L. Bonnevie, ARCADIS BBL, Portland, ME; J. Holder, ARCADIS BBL, Carpinteria, CA; H. Thurston, Battelle, Duxbury, MA; A. Bullard, Battelle, Newtown, PA; P. White, CH2MHill, Boston, MA; D. Michael, Neptune & Co., Los Alamos, NM; M. Parker, BRAC PMO West, U.S. Navy, San Diego, CA. As part of the Base Realignment and Closure Act (BRAC) the Navy is evaluating historical sediment contamination at numerous sites around the country to identify and address potential risks to human health and the environment. One of these areas, Seaplane Lagoon, is a man-made lagoon located at the former Alameda Naval Air Station (NAS) in Alameda, CA. From the 1940s to 1975, industrial wastewater and stormwater generated at the former NAS were discharged into the Lagoon from a series of storm drains, resulting in elevated levels of metals and organic chemicals. A variety of ecological receptors were found to be potentially exposed at the site including benthic and aquatic species as well as piscivorous birds. Human health exposures were determined to be limited; however, the potential for consumption of fish and shellfish does exist. Based on the results of numerous site-specific investigations, it was determined that sediments in areas of the Lagoon posed a potential threat to human health and the environment. In determining an appropriate remedial action plan, the Navy needed to consider the proposed redevelopment of the site as a commercial marina as well as the potential impacts on ecological and human receptors. This presentation describes the evaluation process and the final risk-based remedy selected.

TP30 Differentiating Multiple Sources of PCB Aroclors Using Additional Formulation Information on a River Sediment Characterization Project. R.J. Vitale, Environmental Standards, Inc., Valley Forge, PA; B.E. Stearns, K.F. Young, Severn Trent Laboratories, Burlington, VT. For a river sediment characterization project adjacent to an industrial site that had been used for the manufacture of electrical cable during World War II, it was determined that residuals from multiple operator manufacturing processes on the industrial site were not well characterized by an assessment of either Aroclors or congeners. The characterization of polychlorinated biphenyls (PCBs) is generally performed based on Aroclor patterns or based on individual congeners. For this project, a method of analysis that provided for the characterization of polychlorinated naphthalenes (PCNs) and polychlorinated terphenyls (PCTs) was developed and validated. The method provided additional Aroclor formulation information that was used as a discriminator for the sources of the PCBs. Of particular interest in this

investigation was the inclusion of PCTs and PCNs for operator-specific source characterization.

TP31 The Important of Sediment as a Depository of Endocrine Disrupting Chemicals and its Influence on Estrogenic Activity. C.N. Duong, B. Lee, S. Kim, Environmental Science and Engineering, Gwangju Institute of Science and Technology, Gwangju, South Korea. Sediment is an important component of natural environment. It consists of many different particles to adsorb organic chemicals including endocrine disrupting chemicals (EDCs). The effects of EDCs-contained sediment in the Youngsan River and the Hwangryong River, South Korea were investigated for 2006 - 2007. Samples were collected from 6 sampling sites for both chemical analysis and bioassay during dry and rainy seasons. Pore water in sediment was extracted and estrogenic chemicals in sediment were eluted using liquid-liquid extraction followed by gas chromatography-mass spectrometry analysis. The effects of whole sediment on Japanese medaka were examined by the concentration of vitellogenin (Vtg) with ELISA bioassay. In addition, effects of nanosize particles in sediment on the concentration and estrogenic activities of EDCs were measured. Target chemicals in this study were: nonylphenol, octylphenol, bisphenol A, estrone, 17 β -estradiol, 17 α -ethynylestradiol and genistein. According to the preliminary results of chemical analysis, most of them could be found at ng/L level in the sediment samples. In the bioassay test, adult males of Japanese medaka were exposed to the sediment for 7 days and the livers were removed from their body for Vtg measurement. Both positive and negative controls were used for the test. Bioassay results showed significantly increased Vtg concentration of male fish after 7 days sediment exposure. Keywords: endocrine disrupting chemicals; sediment; gas chromatography-mass spectrometry, sediment, Japanese medaka

TP32 Bayesian Modeling of Polychlorinated Biphenyl (PCB) Dechlorination in Sediment for Remediation Decision Support. A.S. Hughes, M. Small, Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA; A.S. Hughes, J. VanBriesen, M. Small, Civil and Environmental Engineering, Carnegie Mellon University, Pittsburgh, PA; J. VanBriesen, Biomedical Engineering, Carnegie Mellon University, Pittsburgh, PA. Natural anaerobic dechlorination of PCBs is carried out by largely unidentified populations of microorganisms, whose growth is believed to be tied to the use of PCBs as electron acceptors. These microorganisms control the rate, extent and route of dechlorination. The route taken from a higher-chlorinated to a lesser-chlorinated PCB molecule, or congener, is called a pathway. Eight groups of dechlorination pathways, called single processes, have been classified. They neither include all dechlorination pathways known to occur, nor consider all 209 PCB molecules. It is believed that a different microbe, or possibly consortia of microbes, is responsible for each process. Microbial specificity is thought to be governed by the nature of the microbial populations, the physical and chemical characteristics of the site, and the structure and concentration of PCBs. Current dechlorination models incorporate neither this specificity nor the biogeochemical parameters that affect it. Inclusion of these parameters in a Bayesian belief network (BBN) can significantly improve the accuracy of anaerobic PCB dechlorination predictions. This model will combine prior knowledge with empirical evidence and incorporate uncertainty to provide decision makers with insight into the relationships among PCB congener distributions, sediment geochemistry, and populations of microorganisms in a sediment system. The preliminary development of a BBN demonstrated that the pathways contained within dechlorination processes are inadequate for congener-specific dechlorination modeling. Thus, data mining methods are used to identify additional pathways to include in dechlorination processes. These new pathways are included in the BBN, in addition to a joint posterior distribution based on the observed distribution of congeners at specific sites and the likelihood function for this observed distribution and site measurements. Through state-of-the-science prediction of natural PCB dechlorination, this model may offer an alternative remediation option where there was none before. In cases where MNA or cap-and-treat technologies are chosen over dredging, use of the model will have resulted in a reduction in costs, and human health and environmental risks.

TP33 Polybrominated Biphenyls in Sediment and Floodplain Soils of the Saginaw and the Shiawassee Rivers and Saginaw Bay, Michigan, USA. S. Yun, K. Kurunthachalam, Environmental Health Science, SUNY at Albany, Albany, NY; S. Yun, R. Addink, K. Kurunthachalam, New York State Department of Health, Wadsworth Center, Albany, NY; J.M. McCabe, A. Ostaszewski, T.M. Deborah, T.B. Allan, Michigan Department of Environmental Quality, Waste and Hazardous Materials Division, Lansing,

MI. Concentrations of polybrominated biphenyls (Σ PBBs; BB-101,-118, and -153) were determined in more than 120 floodplain soils, surface sediments, and sediment cores collected from Saginaw Bay, the Saginaw River, and the Shiawassee River, Michigan, USA, in 2004. In addition, sediment samples collected in 2002 from the Pine River and the Tittabawassee River were analyzed for PBBs. BB-153 was the predominant congener accounting for 95% of Σ PBB concentrations in sediments and floodplain soils. BB-153 was found in sediments from the Pine, the Tittabawassee, and the Saginaw Rivers, but not in the Shiawassee River. The highest concentration of BB-153 (13.5 ng/g, dry weight) was found in floodplain soils collected downstream of the Pine River. The concentration of BB-153 decreased by 100- to 300-fold from the Pine River to upstream of the Saginaw River. High concentration of BB-153 (4.68 ng/g) was also found in sediment collected at the mouth of the Saginaw River. In Saginaw Bay, the surface sediment concentrations of BB-153 were lower than those of the subsurface sediments. BB-153 was not detected in floodplain soils collected from the shoreline of Saginaw Bay. Even after ban of the production of PBBs, 30 years ago, BB-153 continues to be found in sediments from the Pine, the Tittabawassee and the Saginaw Rivers and in Saginaw Bay.

TP34 Dioxin-Like Toxicity in the Saginaw Bay Watershed: Polychlorinated -dibenzo-p-dioxins, -dibenzofurans, and -biphenyls in sediments and floodplain soils from the Saginaw and Shiawassee Rivers, Michigan, USA. S. Yun, K. Kurunthalam, Environmental Health Science, SUNY at Albany, Albany, NY; S. Yun, K. Kurunthalam, New York State Department of Health, Wadsworth Center, Albany, NY; O. Arthur, M.M. John, T.M. Deborah, T.B. Allan, Michigan Department of Environmental Quality, Waste and Hazardous Materials Division, Lansing, MI. Sediment and floodplain soils in the Saginaw River Watershed, Michigan, USA, have been demonstrated to be contaminated with a variety of organic compounds including polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). In this study, concentrations of PCBs including non-ortho coplanar congeners, PCDDs and PCDFs were measured in more than 120 sediment and floodplain soils collected from the Shiawassee River, Saginaw River, and Saginaw Bay to determine the sources and magnitude of contamination and to elucidate the contribution from individual contaminant group to overall 2,3,7,8-tetrachlorodibenzo-p-dioxin equivalents (TEQs). Sediment and soil extracts were also analyzed for the total dioxin-like activity using H4IIE-luc cell bioassay. Elevated concentrations of PCBs (>1000 ng/g, dry weight) were found in surface sediment and floodplain soils collected in the Shiawassee River near Chase Lake, Middle Ground Island on the Saginaw River, and in subsurface sediments from Saginaw Bay. Concentrations of PCDDs and PCDFs in sediment and floodplain soils from the Saginaw River and Saginaw Bay were 2-3 orders of magnitude higher than the samples from the Shiawassee River. The highest PCDD/F concentration (55200 pg/g, dry weight in a subsurface layer) was found in sediment collected at the mouth of the Saginaw River. Concentrations of PCDFs were greater than the concentrations of PCDDs in sediment from the Saginaw River. 2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, and 2,3,4,7,8-PeCDF were the major PCDF congeners found in sediments from the Saginaw River. Elevated concentrations of PCDFs coupled with the predominance of lower chlorinated PCDF congeners in sediments from the Saginaw River were similar to those found in samples from the Tittabawassee River, a tributary to the Saginaw River. These results suggest the existence of a major source of PCDFs within this watershed. A few localized areas of high PCDD/F and PCB concentrations with unique congener compositions in the Saginaw River indicated the presence of other minor sources, such as wastewater treatment plants (WWTPs). PCDFs were the major contributors to TEQs in sediment and soils from the Saginaw River and Saginaw Bay.

TP35 The Significance of Non-aqueous Phases in Assessing the Toxicity of Contaminated Sediments. D.R. Mount, L.J. Heinis, T.L. Highland, R. Hockett, D.J. Hoff, C.T. Jenson, T.J. Norberg-King, ORD/NHEERL/MED, USEPA, Duluth, MN. Although oils, tars, and other non-aqueous liquids are common sources of contamination in aquatic sediments, the toxicity of such contamination has generally been attributed to component chemicals, particularly PAHs. While PAHs can be toxic to aquatic organisms, it is not entirely clear that they are the only source of toxicity from contamination by non-aqueous phases. In laboratory experiments, reference sediments were spiked with either purified triolein or mineral oil, and tested for toxicity. Toxicity to both *Hyalella azteca* and *Chironomus dilutus* was observed, even though these two model oils are not thought to have components with

sufficient solubility to cause toxicity, a supposition supported by non-toxicity of the water accommodated fraction (WAF) of mineral oil. When "oil" content was quantified gravimetrically via solvent extraction, the toxicity of several PAH-contaminated field sediments corresponded with the exposure response curves for model oils. When these field sediments were treated with coconut charcoal, toxicity to *Hyalella* and *Chironomus* was not reduced despite the fact that PAH concentrations in interstitial water and in tissues of exposed oligochaetes were reduced. This further indicates that the presence of oil was influencing toxicity beyond the effect of PAHs alone. Results of these studies suggest that greater attention should be given to the quantification and assessment of effects from non-aqueous phases in field sediments. This abstract does not necessarily reflect EPA policy.

TP36 Interferences of humic Acid in Adsorption of Contaminants on Two Types of Sorbents for Reactive Capping of Sediments. B. Sharma, K.H. Gardner, Civil Engineering, University of New Hampshire, Durham, NH. Contaminated sediments can be treated using in-situ treatment methods that aim to either degrade or sequester contaminants, reducing their bioavailability. The main purpose of this research was to develop and evaluate a reactive capping mat that can be used for in-situ remediation of contaminated sediments. This study investigated the interferences caused by humic acid on the adsorption of co-planar and non-co-planar polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) on two types of sorbents being evaluated for use in a mat: activated carbon and organoclays. Several kinetic and isotherm studies have been conducted using several formulations of activated carbons and organoclays as sorbents to treat individual PCB congeners and PAHs. The results showed that preloading of sorbents with humic acid, and simultaneous adsorption of humic acid and contaminant, significantly reduced the adsorption capacity for all selected PCB congeners and PAHs. Experiments conducted without preloading of sorbent surfaces demonstrated that desorption upon subsequent spiking with humic acid (simulating long-term exposure to porewater that contains high humic acid concentrations) was not pronounced and varied with co-planarity of PCBs and number of rings of PAHs. Also, humic acids were found to interfere to a much greater extent with adsorption to activated carbon than with organoclay formulations evaluated in this work. A structural analysis using Scanning Electron Microscopy for activated carbon and X-Ray Diffractometry for organoclay were conducted to observe differences caused by humic acid on the surfaces of the sorbents. BET surface area analysis has also been conducted to confirm the effect of humic acid on porosity of activated carbon. Current experimental work is focusing on the effects of fulvic acid (FA) and natural organic matter isolated from sediment porewater to understand the influence of different fractions of dissolve organic carbon that will be present in real site conditions. The results of this work indicate that organic acids, which are quite concentrated in sediment porewater, have a significant impact on the efficacy of reactive cap components and are an essential factor in the design and ultimate performance of this type of in-situ sediment management approach.

TP37 Dioxin like activity of sediments from the Danube River using three different cell lines and chemical analysis. S. Keiter, S. Grund, T. Braunbeck, H. Hollert, Aquatic Ecology and Toxicology, University of Heidelberg, Heidelberg, Germany; B. van Bavel, M. Engwall, H. Olsman, Man-Technology-Environment Research Centre (MTM), University of Örebro, Örebro, Sweden; U. Kammann, Institute for Fishery Ecology, Federal Research Centre for Fisheries, Hamburg, Germany; M. Klempt, Department of Fish Quality, Federal Research Centre for Nutrition and Food, Hamburg, Germany; W. Manz, Federal Institute of Hydrology, Koblenz, Germany. This investigation is a consequence of a distinct fish decline in the upper Danube River since the beginning of the 1990s. In contrast to the decline of fish population, former studies have repeatedly documented that the water quality along the Danube River is clearly improved. However, the conclusion of a first investigation in 2002 – using in vitro-biotest systems – was that a high ecotoxicological hazard potential is associated with local sediments. In comparison to the highly polluted rivers Rhine and Neckar in Germany, the present study documented that sediment samples from the upper Danube River showed very high AhR-mediated activity in the used biotests (GPC.2D, DR-CALUX and EROD assay). The combination of fractionation techniques and different in-vitro tests revealed that the main induction could not be explained by priority pollutants, even though the concentrations of priority PAHs were very high. In conclusion, this investigation shows that the high induction rates are mainly mediated by non-priority PAHs. Due to the effects

of PAHs towards fish and the well known connection between dioxin-like activity and carcinogenicity the link between contamination and the fish decline cannot be ruled out. Hence, there is an urgent need to broaden the toxicological and environmental knowledge regarding to non-priority compounds, as a basis for risk assessment.

TP38 Modeling the Impact of Flocculation on the Fate of PCBs in an Urban Estuary. C.A. Chang, J.E. Baker, University of Maryland, Chesapeake Biological Laboratory, Solomons, MD. Flocculated particles (flocs) have several important physical characteristics such as higher porosity and specific surface area (m^2/g) that may affect the partitioning and fate of polychlorinated biphenyls (PCBs). However, most PCBs transport models do not include flocculation and assume a uniform specific surface area, porosity, fraction of organic carbon (f_{OC}), and sorption-desorption rate over a wide spectrum of heterogeneous particles. In this study, a heterogeneous floc-based contaminant model that simulates the fate of PCBs among sediment, suspended flocs, and surrounding water has been developed. The first part of model simulates the coagulation of both organic carbon and inorganic solids ranging in diameter from 2 to 1000 μm , simultaneously calculating temporally varying f_{OC} , bulk density, and settling velocity. Further, fractal geometry has been applied to estimate the porosity and specific surface area for each size of particles. The second part of model simultaneously predicts transport of PCBs by erosion, sedimentation, coagulation, and kinetically-limited partitioning in a wide spectrum of heterogeneous flocs. The model was calibrated using the Shear Turbulence Resuspension Mesocosms (STORM) tank experiments that mimic resuspension and settling of contaminated Hudson River sediment with realistic bottom shear stress. With coagulation and kinetically-limited partitioning, the model results showed a good agreement with measured particulate and dissolved PCB concentrations throughout the entire simulation period. The contaminant residence time without coagulation was five times less than with coagulation run during the settling period. The gross PCB 52 partitioning coefficients that were estimated from the kinetically varied and uniform f_{OC} and porosity size distribution runs were 1.8 ± 2.50 and 1.5 ± 1.34 ($\text{m}^3/\text{g-OC}$) respectively during the erosion period.

TP39 Assessment of PAH Bioavailability and Toxicity In Freshwater Aquatic Sediments: Is *Hyalella azteca* Growth a Meaningful Risk Endpoint? J.P. Kreitinger, H.A. Jones, N.A. Azzolina, ENSR, Ithaca, NY; D. Farrar, T.S. Bridges, US Army Engineer Research and Development Center, Vicksburg, MS; F.G. Doherty, AquaTox Research, Syracuse, NY; S.B. Hawthorne, Energy and Environmental Research Center, University of North Dakota, Grand Forks, ND. The assessment of risk associated with contaminants present in freshwater sediments is routinely evaluated by conducting laboratory toxicity tests using the amphipod *Hyalella azteca*. However, the growth of *H. azteca* during 28-day chronic tests when exposed to 131 sediment samples collected from 8 industrial sites did not demonstrate a dose-response relationship to the bioavailable concentration of freely dissolved polycyclic aromatic hydrocarbons (PAHs) measured in sediment porewater. A significant dose-response between amphipod growth and sediment porewater PAH concentration was not apparent despite total PAHs (sum of 16) in bulk sediment ranging from <1 to 1732 mg/kg and the predicted internal body residue based on the freely dissolved concentration of 34 PAHs ranging from <0.1 to 62 $\mu\text{mol}/\text{g}$ lipid. In contrast, a strong dose-response relationship was observed between amphipod survival and the dissolved concentration of 34 PAHs in sediment porewater with an estimated critical body residue (CBR_{50}) equal to 34 $\mu\text{mol}/\text{g}$ lipid. An analysis of variance demonstrated that approximately 26% of the variability in amphipod growth was associated with test date, laboratory and site where samples were collected and approximately 44% of the variability in growth was associated with characteristics related to the nutritional quality of the sediment organic matter. The sediment characteristics associated with reduced amphipod growth included the sediment soot carbon content ($p < 0.0001$), while the characteristics associated with increased amphipod growth included sediment ammonia-N and the number of dead organisms observed per beaker ($p < 0.0001$). Other sediment characteristics, including total organic carbon and sand content were not associated with amphipod growth ($p > 0.05$) and sediment clay content was only weakly associated with reduced amphipod growth ($p = 0.026$). These data indicate that interpretation of amphipod growth may be confounded by the nutritional quality of sediments and is not a reliable measure for assessing the bioavailability and risk of PAHs present in aquatic sediments.

TP40 Assessment of *Corbicula fluminea* as a Potential Freshwater Bioaccumulative Test Species. J. Steevens, J. Clarke, G. Ray, US Army

Engineer Research and Development Center, Vicksburg, MS; M. Siipola, T. Sherman, D. Ebner, R. Abney, W. Briner, J. Britton, Portland District, U.S. Army Corps of Engineers, Portland, OR. The freshwater Asiatic Clam, *Corbicula fluminea*, native to China, Korea, and southeastern Russia, is found in abundance throughout the Pacific Northwest and North America. Though the clam can be found in almost any habitat, they prefer flat areas with sand or clay. They are primarily considered filter-feeders; however, they routinely bury in the sediment for extended periods and filter interstitial sediment water (pore water) or pedal-feed. Current analytical techniques often require more than 1 gram of tissue for determining bioaccumulated contaminant concentrations. Therefore, the larger tissue mass obtained from *C. fluminea* make it a better bioaccumulation test organism than the freshwater oligochaete, *Lumbriculus variegatus*. *C. fluminea* promises to fill the need for a trophic niche freshwater test organism or an indicator species for bioaccumulation studies and is proposed as a freshwater bioaccumulation species for the assessment of dredging and clean-up projects. In August and September 2005, 32 nearshore locations were sampled for *C. fluminea* along the Columbia River from Vista Park near Skamokawa, Washington (RM 32) to Warrendale, Oregon (RM 147). Four additional samples were collected in the lower Willamette River. Tissue samples were analyzed for the following bioaccumulative constituents: semivolatile compounds (including PAH), chlorinated pesticides, PCB Aroclors and all 209 congeners), polybrominated diphenyl ethers (PBDE; fire retardants), organotin, and metals (Hg, Pb, Zn, Cd). All clam tissue had detectable levels of some bioaccumulative contaminants. Statistical relationships among sampling stations were elucidated using exploratory multivariate techniques. Relative abundances of major constituents were superimposed on regional maps of the sampling stations. A mid-reach point source for PCBs was identified as well as localized areas of DDTs, PBDEs, and PAHs.

TP41 Potential Errors in EMAP PAH Assumptions. D.J. Lauren, G. Long, URS, Fort Washington, PA; W. Bosworth, URS, Gilford, NH. During the course of a risk assessment at an MPG site, two major problems with the USEPA (2003) guidance for deriving sediment benchmarks for PAHs were encountered. The EPA EMAP now recommends evaluating 34 PAHs including 16 alkylated PAHs. When fewer PAHs have been analysed, EPA recommends multiplying the concentrations by factors ranging from 11.5 when only 16 PAHs were measured to 4.14 when 23 PAHs were measured. However, it has previously been shown that alkylated PAHs at MGP sites and other pyrogenic sources are low relative to petrogenic PAHs and at our stations where the PAH profile indicated an un-weathered source, the ratio between the 23 PAHs we measured and the EMAP list was 1.08. Therefore, the recommended multiplication factor is not universally applicable and must be evaluated on a site-specific basis. The second problem we encountered concerns the presence of wood breakdown products and their influence on the EMAP list. The site we investigated is co-contaminated with wood chips. The EMAP list includes parent phenanthrene to C4-phenanthrene, but retene, a breakdown product of abietic acid found in wood products, is a C4-phenanthrene. At one of our reference stations that was low in PAHs but contaminated with wood chips, the ratios C4-phenanthrene, as well as of C3-, C2-, C1- and parent phenanthrene, were highly elevated above those found in the un-weathered source material described above. In this case the ratio between the 23 measured PAHs and the EMAP list was 30.5. More PAH contaminated stations that were co-contaminated with wood chips also had high ratios relative to the un-weathered source material. This suggests that 1) the EMAP list and recommended multiplication factors do not apply to MGP sites and 2) the role of wood by-products should be evaluated prior to making risk management decisions.

TP42 Heavy Metals in Archived Sediment and Oyster Collected from Savannah Coastline, USA. K.S. Sajwan, S.K. Kurunthachalam, P. Sivapatham, J.P. Richardson, Department of Natural Sciences and Mathematics, Savannah State University, Savannah, GA; B.G. Loganathan, Department of Chemistry, Murray State University, Murray, KY. Sediment and oyster collected from selected marsh/estuarine ecosystem in Savannah GA USA, were analyzed for elements such as Al, As, B, Cd, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Si, and Zn. Sediments were extracted by ammonium acetate (NH₄OAc), Mehlich-3 (M-3), and water procedures while acid digestion procedure adopted for oyster tissue. Concentrations of elements in sediments were higher in M-3 followed by NH₄OAc and water extraction procedure. Calcium and Mg was greater in sediments by any of extractions, while other elements differ depending upon extraction procedures. No significant spatial variation (P<0.05) of any

of elements analyzed except Mn in NH₄OAc/water extraction procedure and Fe and Al by water extraction procedure. Contamination of Al, B, Cd, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Si, and Zn in oyster tissue ranged 399-1460, 231-254, <1.5-2.9, <1.5-8.0, 67-121, 232-1357, 17-54, <1.5-2.5, <1.5-4.0, 241-381 and 978-2428 ug/g dry weight (dw), respectively. Much elevated concentrations of elements such as P, Ca, Mg, K and S were noticed in oyster tissue. Concentration range of Hg and As in sediment was 1.2-1.9 and 11-55 ug/g dw, respectively. Concentration range of Hg and As in oyster tissue was 130-908 and 200-912 ng/g dw, respectively. Except As and Hg, other elements are several orders of magnitude greater in oyster tissue. There is no significant (P<0.05) contamination variation in target analytes in between nine selected sites. Concentrations of heavy metals in sediment and oyster were comparable, lower or higher with those to other countries and other locations in USA. Greater biota-sediment accumulation factor (BSAF) was noticed for P and Zn. Concentrations of Hg and P in oyster tissue were higher than threshold limit for human consumption. Overall, the baseline data can be used for regular ecological monitoring, considering the domestic and industrial growth around this important marsh/estuarine ecosystem.

TP43 Nitrate Removal in Coastal Retention Pond Sediments of High Sulfate and Sulfide Concentration. C. Aelion, U. Warttinger, Environmental Health Sciences, University of South Carolina, Columbia, SC. Constructed retention ponds and natural impounded lagoons on coastal golf courses collect run-off and serve as nutrient sinks for storm and irrigation water run-off before it drains into the adjacent marshes and estuaries. Constructed ponds are generally lower in sulfate (SO₄²⁻) and sulfide (H₂S) concentrations than lagoons. This study examined the relative abilities of sediment from a golf course constructed pond (Pond 109) and a natural lagoon (Blue Heron Pond (BH)) to remove nitrate (NO₃⁻) via denitrification (DNF) at differing SO₄²⁻ and H₂S concentrations. Microcosms were incubated with added NO₃⁻ (300 µg gdw⁻¹), and SO₄²⁻ (500 or 1000 µg gdw⁻¹) or H₂S (100 or 1000 µg gdw⁻¹). The acetylene block technique was used to measure DNF. SO₄²⁻, H₂S as acid volatile sulfides (AVS), nitrous oxide (N₂O), NO₃-N + NO₂-N, and ammonium (NH₄-N) were measured over time using spectrophotometry (SO₄²⁻, H₂S), flow injection analysis (inorganic N) and gas chromatography (N₂O). SO₄²⁻ added to both pond sediments at 500 and 1000 µg gdw⁻¹ did not impact DNF rates, but H₂S addition decreased DNF. Background and added SO₄²⁻ (500 µg gdw⁻¹) were reduced more quickly in the constructed ponds vs. lagoons (one week vs. 3 weeks, respectively), and AVS initially were produced more quickly. No SO₄²⁻ was reduced or AVS produced in abiotic controls. In both ponds more NH₄-N was produced when H₂S was added than with no H₂S addition. Microcosm results suggest that in constructed ponds DNF was not inhibited by high SO₄²⁻ concentrations. H₂S addition or production of H₂S from SO₄²⁻ reduction may result in a decrease in DNF or an increase in alternative NO₃⁻ utilization processes such as dissimilatory nitrate reduction to ammonium.

TP44 Long Term Environmental Monitoring Program McMurdo Station Antarctica: Soils. T.L. Wade, S.T. Sweet, G. Denoux, Geochemical and Environmental Research Group, Texas A&M University, College Station, TX; A. Klein, Department of Geography, Texas A&M University, College Station, TX; M.C. Kennicutt, Office of the Vice President for Research, Texas A&M University, College Station, TX. The Antarctic Treaty (including Annexes) and US Statutes establish the framework for monitoring activities of scientific research stations. The monitoring program at McMurdo Station is based on years of international and US planning activities and is consistent with international obligations. The objective of this project at McMurdo Station is to assess the impacts, if any, of human activities to the local environment. To accomplish this goal for the terrestrial environment, several hundred terrestrial soil samples were collected annually and analyzed for total petroleum hydrocarbons (TPH) and trace metals. Due to the large amounts of petroleum products transported to and used at McMurdo Station they represent the largest potential source of contamination. Over 50% of the TPH concentrations from the random sampling program are below background concentrations (30 ppm). The few relatively high TPH concentrations are at or below any known levels of biological response. There are few biological receptors that would be affected by petroleum hydrocarbons in the terrestrial setting due to the small number of indigenous plants or animals. Trace metal contamination at terrestrial sites is primarily limited to areas where metallic materials have been discarded such as land-fills. In general, trace metals are present at background levels with few exceptions and far below any levels of concern. Based on historical data and our studies, TPH and trace element

contamination is localized around input sources (e.g. fuel storage facilities, refueling stations, vehicle storage areas, heavy shop areas and historical dumps) and does not show signs of an increasing "footprint" over time.

TP45 An in situ study using caged *nucella lapillus* and *Crassostrea gigas* to monitor TBT induced bio-effects in Irish coastal waters. M. Giltrap, E. McGovern, B. McHugh, Chemistry, Marine Institute, Galway, Ireland; M. Giltrap, A. Macken, M. Davoren, Radiation and Environmental Science Centre (RESC), Dublin Institute of Technology, Dublin, Ireland; B. Foley, School of Chemical & Pharmaceutical Sciences, Dublin Institute of Technology, Dublin, Ireland. Tributyltin (TBT) is recognised as an effective antifouling agent for use in marine paints for shipping and on aquaculture fish cages and in other marine applications. It has however been found to be toxic to many species of gastropods and can affect these species at concentrations as low as 2ng/L. TBT has been linked to shell thickening and reduced meat yields in oysters and perhaps more significantly to the onset of imposex, i.e. the imposition of male sexual organs on female gastropods, with this index being internationally recognised as a bio-indicator of TBT pollution. Species of the gastropod, *Nucella lapillus* showing no imposex and juvenile pacific oysters *Crassostrea gigas* were transplanted in cages at test sites around the Irish coast. Mussels (*Mytilus edulis*) were provided as a food source for the gastropods. The degree of imposex in the gastropod as measured by the vas deferens sequence index (VSDI) and the extent of shell thickening in the oysters was investigated at t=0 and t=18 weeks. The concentrations of TBT in tissue representative samples of each of the test species were also measured at t=0 and t=18 weeks. Sediment samples were also taken from each site and analysed for organotin speciation in the <2mm and <63µm fraction at t=0 and t=18 weeks. It is anticipated that in the absence of resident gastropod populations the application of such cost effective caging techniques may assist in provision of environmental quality information at potential hotspot locations. Results of analysis will be presented.

TP46 The importance of the benthos in sediment quality investigations - A case study. P.M. Chapman, C. McPherson, A.M. de Bruyn, Golder Associates, North Vancouver, British Columbia, Canada; L. Cooper, Lone Star Steel, Lone Star, TX. Sediment quality in a Texas reservoir subject to point and non-point sources of contaminants was assessed using the Sediment Quality Triad weight of evidence (WOE) approach. Fifteen stations were sampled plus a reference station which, unfortunately, comprised a different habitat type than the other 15 stations. Accordingly, standard comparisons between reference and exposed stations were inappropriate. Interpretation of potential relationships between benthic community structure and sediment-associated contaminants was also confounded by differences in habitat-related characteristics (e.g., water depth and total organic carbon [TOC]) within the reservoir. Multivariate analyses of the benthic community identified two station groupings separated primarily by habitat-related differences rather than contaminant-related toxicity. Laboratory toxicity tests and chemical analyses, including measures of bioavailability, did not differ consistently between the two community-based station groupings, indicating that toxicity resulting from chemical contamination was not a major factor in observed community structure in the reservoir, although subtle alterations to the benthos due to chemical contamination could not be ruled out in the absence of an appropriate reference comparison. Appropriately giving highest weight to resident benthic community structure, followed by the results of laboratory toxicity tests, then chemical analyses, provided a realistic and useful assessment of chemical pollution even in the absence of a suitable reference comparison, and emphasizes the importance of appropriate data analyses during WOE assessments. The alternative approach of relying on only sediment toxicity and chemistry data would have provided misleading information.

TP47 Wetlands Risk Assessment- Lessons Learned in Hydric Soils. D.J. Lauren, T. Morrison, URS Corp, Fort Washington, PA. It is critical to understand the native ecology and geochemistry before attempting to evaluate ecological risk in wetlands. URS was asked to re-evaluate the potential risk to benthic invertebrates that was indicated by bioassays conducted at a site along the Raritan River, NJ. The site is a freshwater wetland that is maintained by a combination of rainfall and impermeable clays, not streams. The native wetlands in this area had been covered with metals-laden dredge spoils during the 1940's and 1950's. We found high concentrations of dissolved metals in pore water due to low pH. The low pH is probably the result of the oxidation of pyrites present in these clays that is brought about by oxygen transported by Phragmites root systems. Despite high pore water metals concentrations and toxicity to benthic invertebrates in bioassays, the wetlands are presently

covered with dense stands of Phragmites. Evaluation of risk assessments at other nearby sites show that low pH and elevated metals concentrations are regional, not site-specific, sub-surface conditions. Little soil exists above the Phragmites root mass and this prevents a complete exposure pathway for aquatic invertebrates to the pore water. The substrate is better described as hydric soil than sediment and organisms typically used for sediment bioassays are not found at the site and are not well suited for evaluating risk in this habitat. Review of risk assessments conducted at a similar site in the same dredge spoil contaminated region showed no chronic sublethal toxicity to earthworms, but these organisms may not be appropriate for hydric soils either. Of the organisms that are available for bioassays in hydric soils, collembolids are the most appropriate. Review of the literature for collembolids exposed to aged naturally metal contaminated soils supported the regional and literature-based earthworm toxicity benchmarks, not the benthic invertebrate benchmarks. Understanding the geochemistry, potential exposure pathways, and ecological receptors enabled us to better evaluate potential ecological risks in wetlands soils.

TP48 Effects of Testing Conditions on Control Survival of *H. azteca* in Water-only Tests. R.S. Grippo, L.L. Harding, J.L. Farris, Department of Biological Sciences, Arkansas State University, Jonesboro, AR; R.S. Grippo, J.L. Farris, Graduate Program in Environmental Sciences, Arkansas State University, Jonesboro, AR; M.S. Hobbs, Department of Natural Sciences, Williams Baptist College, Walnut Ridge, AR. Use of *Hyalolella azteca* in short-term water-only tests has increased because of its utility in determining contaminant toxicity to organisms without the interference of sediment components and organic matter. Water-only tests with *H. azteca* can also be useful for determining if ambient toxicity resides in sediments or overlying water samples. However, multiple methods are currently being used for *H. azteca* water-only tests. This study addresses challenges to performing 96-h acute water-only toxicity tests using *H. azteca* and examines methods for generating reliable toxicity data with *H. azteca*. Feeding regimes (fed versus not fed), dilution water type (dechlorinated tap water versus reconstituted moderately hard water (MH), and substrate type (leached maple leaf discs, sterile gauze discs, glass beads, Nitex discs, and no substrate) were tested for their effect on control *H. azteca* survival. We found that feeding the test organisms did not produce significantly different survival compared to not feeding over the course of the 96-h exposure. The use of dechlorinated municipal tap water did significantly reduce mortality of *H. azteca* compared to MH. Substrate types tested also significantly affected survival. Maple leaf discs and sterile gauze discs were the most successful substrates with Nitex being the least successful and having the most variance among replicates. Our results suggest that testing methodology can influence the interpretation of 96-h toxicity tests for *H. azteca* by influencing control survival and thus comparisons with survival in ambient test water. Therefore, test methods should consider both the type of substrate and type of dilution water being used.

TP49 Development of a method for conducting whole-sediment toxicity tests with juvenile freshwater mussels. N.E. Kemble, C.G. Ingersoll, J.L. Kunz, N. Wang, USGS, Columbia, MO. Methods have been established for conducting whole-sediment toxicity tests with a variety of freshwater organisms including amphipods, midge, mayflies, and oligochaetes. However, few studies have evaluated the bioavailability of contaminants in whole-sediment samples to freshwater mussels. Sediment is an important source of potential contaminants to juvenile mussels given that juvenile mussels inhabit sediment after transformation of glochidia from the gill of a fish. Our objective was to develop a method for conducting 28-d whole-sediment exposures with juvenile mussels (fatmucket, *Lampsilis siliquoidea*; rainbow, *Villosa iris*; and Neosho mucket, *L. rafinesqueana*) in control sediments. The approach was adapted from the ASTM standard E2455-06 for conducting water-only toxicity tests with early life stages of freshwater mussels. Two- to four-month-old juveniles were obtained from laboratory cultures. Tests were conducted at 20 C in well water (hardness 280 mg/L as CaCO₃) or reconstituted ASTM hard water (hardness 170 mg/L as CaCO₃). Ten organisms were exposed in each of four replicate test chambers and were fed instant algae twice daily. Mussels were exposed to up to three control sediments (Florissant, West Bearskin, or Tucker Prairie). Sediments were sieved with a #60 sieve (250 µm-opening) before the start of the whole-sediment toxicity tests to facilitate isolation of mussels from sediment at the end of the exposures. Test endpoints measured were survival (foot or shell movement) and growth (shell length). At 28 d, survival was greater than 90% for all species in the control

sediments. Growth data for all of these studies is on-going at this time. Results of this study indicate that whole-sediment toxicity tests can be successfully completed with juvenile mussels in control sediment, additional studies are needed evaluating the responses of juvenile mussels in contaminated sediment compared to more common whole-sediment test organisms (i.e., amphipods, midge, mayflies, and oligochaetes).

TP50 Influence of temperature on the toxicity and toxicokinetics of pyrethroid insecticides in *Chironomus tentans* larvae. A.D. Harwood, M.J. Lydy, Zoology and Fisheries and Illinois Aquaculture Center, Southern Illinois University, Carbondale, IL. Changes in temperature can have substantial effects on biological processes, and these effects vary between insecticide classes. While decreased temperature causes increased toxicity of pyrethroid insecticides and decreased toxicity of organophosphate insecticides in aquatic species, the mechanism for this change is not completely understood. Changes in temperature can directly influence the toxicokinetic parameters of uptake, biotransformation, and elimination, and in general these processes typically increase with temperature. The objectives of this study were to examine the effect of temperature (13 and 23 degrees Celsius) on toxicokinetic parameters in *Chironomus tentans* larvae in both water and sediment exposures for the pyrethroid insecticides, permethrin and lambda-cyhalothrin, and compare these changes to those in an organophosphate insecticide, chlorpyrifos. Toxicity of the pyrethroid insecticides increased with decreasing temperature and the reverse trend occurred for chlorpyrifos, and these changes were described using toxicokinetic measurements. The increased toxicity noted for permethrin and lambda-cyhalothrin was likely due to a decrease in biotransformation of the parent compounds at the lower temperature, whereas chlorpyrifos biotransformation decreased with a 10 degree Celsius drop in temperature, lowering oxon concentration, and decreasing toxicity. This research can be used to help explain Toxicity Identification Evaluation results for pyrethroid insecticides.

TP51 Effects of Binary Mixtures of Type I and Type II Pyrethroid Insecticides to the Aquatic Amphipod, *Hyalella azteca*. A. Trimble, M. Lydy, Southern Illinois University Carbondale, Carbondale, IL; J. Belden, Baylor University, Waco, TX. Pyrethroid insecticides can be divided into two major categories (Type I and Type II), both of which have the same mode of action, yet often substantially different physical and toxicological properties. Pyrethroids have been detected in mixtures of both Type I and Type II in stream sediment samples. The majority of the current research and legislation is based upon the assumption that mixtures of these chemicals interact additively. The structural differences between Type I and Type II pyrethroids could, however, lead to deviations from additivity. The objective of this research was to examine the toxic effects of binary mixtures of Type I and Type II pyrethroid insecticides in order to determine if these compounds interact additively. Three possible mixture combinations were tested: Type I – Type I; Type II – Type II; or Type I – Type II. For each mixture, 10-d sediment toxicity tests, each consisting of two single-compound components and a binary mixture component, were conducted using *Hyalella azteca* as the test organism. Toxicity curves for each concentration-summed mixture were compared to predicted curves that were generated using both concentration addition and independent action models. Model Deviation Ratios (MDRs) were calculated to determine which model best predicted the mixture toxicity and, hence, if the compounds could be considered as acting additively or non-additively. Preliminary results have indicated that most of the mixtures interact additively, with some of them showing the potential for non-additivity to varying degrees.

TP52 Identification of the sources of sediment-associated toxicity in the Illinois River using a sediment toxicity identification evaluation (TIE). W.T. Mehler, M.J. Lydy, Fisheries, Southern Illinois University, Carbondale, IL. The difficulty of assessing risk to benthic ecosystems of complex mixtures in sediment is often attributed to understanding the bioavailable fraction of each contaminant. These issues have led to the development of the toxicity identification evaluation (TIE) approach. In 1992, pore water TIE testing on Illinois River sediments indicated that ammonia was the primary contaminant among toxic sites. The current study will provide data that will be used in combination with previous work to better characterize the sources and spatial trends of toxicity in Illinois River sediments. This study will use a whole-sediment TIE that will complement and strengthen previous pore-water TIE studies, by using sediments, which provide closer to in situ like conditions than that of extracted pore water.

TP53 Sediment quality within the impounded reaches of Cape Fear River locks and dams. T. Augspurger, S.E. Ward, US Fish and Wildlife Service, Raleigh, NC; C.G. Ingersoll, N.E. Kemble, J.L. Kunz, Columbia Environmental Research Center, US Geological Survey, Columbia, MO. In November 2006, we evaluated contamination and toxicity of sediments and pore waters from impoundments created by three locks and dams on the Cape Fear River (North Carolina, USA). Whole-sediment concentrations of elemental contaminants and polycyclic aromatic hydrocarbons were typically less than those associated with adverse effects to sensitive aquatic organisms. Whole sediments had no significant effect on survival or growth in 28-d toxicity tests with *Hyallela azteca* or in 10-d tests with *Chironomus dilutus*. Copper, lead, and zinc in sediment elutriates and pore waters frequently exceeded water quality standards and indicated that re-suspension of Cape Fear River sediments could temporarily impair surface water quality. In 2-d sediment elutriate tests with *Ceriodaphnia dubia*, statistically-significant reductions in survival occurred in four of nine exposures. Pairwise correlation analyses indicated several whole-sediment and elutriate water chemistry variables were significantly and negatively correlated with *C. dubia* survival. Of the correlated variables, elutriate manganese had among the strongest correlation ($r^2 = 0.79$, $p = 0.0006$) and the most plausible biological association with reduced *C. dubia* survival because some elutriate manganese concentrations exceeded known lethal concentrations for *C. dubia*. We conclude that contamination of surface sediments behind Cape Fear River locks and dams is unlikely to be a concern unless they are disturbed. Mobilization of sediments may result in short-term water column exposures of aquatic organisms based on the elutriate toxicity test and chemistry results. Sediment re-suspension and contaminant release in the elutriate tests may be near a worst case simulation of actual conditions following sediment disturbing activities. When specific sediment disturbing activities are proposed for the river (e.g., dredging, dam alterations, etc.), data on modeled or measured sediment re-suspension and chemical concentrations in near-sediment surface waters should be considered with the chemistry and toxicity testing results reported here in a sediment risk assessment and management plan.

TP54 Sediment Assessment in the St. Louis River Area of Concern, Superior, Wisconsin. A. Muneer, USEPA, Chicago, IL; J. Killian, Wisconsin DNR, Madison, WI. The St. Louis River, the largest U.S. tributary to Lake Superior, drains 3,634 square miles, entering the southwestern corner of the lake between Duluth, Minnesota and Superior, Wisconsin. Historic and ongoing land use and water-related activities in the middle and lower portions of the estuary have contributed a variety of nutrients and chemicals to the St. Louis River. In 1987, concerns over environmental quality conditions prompted the designation of the lower St. Louis River as one of 43 Great Lakes areas of concern (AOCs). Remedial Action Plans (RAPs) have been established to address concerns related to impaired uses in the most severely impacted geographic areas in the Great Lakes basin. The RAP process determined that 9 of 14 identified beneficial uses were impaired for the St. Louis River AOC. Some impairments were associated with the physical loss and degradation of habitat. Other problems were related more to pollution and toxicity. A U.S. EPA GLNPO Great Lakes Legacy Act (GLLA) sediment assessment project was conducted in May 2007 to evaluate sediment quality conditions in areas where data gaps exist in the St. Louis River AOC (Wisconsin waters). The GLLA project was co-funded by U.S. EPA and Wisconsin DNR. The results of the assessment will be discussed as well as how the data will be used to guide decisions on the need for further actions.

TP55 Uncertainties in Linking Benthic Impairment to Stressors and Sources for a Small Urban Stream. S.C. Peterson, ERM, Exton, PA. Lewis Creek is an urban stream in Augusta County and the city of Staunton, Virginia, that was first identified as impaired for benthic life in 1996. The Lewis Creek watershed is a relatively small land area (17,683 acres) within the larger regional Potomac River and Chesapeake Bay watersheds. The impaired segment of Lewis Creek was investigated by the Virginia Department of Environmental Quality (VADEQ) to support the development of a Total Maximum Daily Load (TMDL). As a component of this investigation, the most probable stressors contributing to benthic impairment were identified as sediment contaminants (lead and total PAHs) and sediment deposition. Chemical analysis, toxicity testing, mass balance modeling, benthic macroinvertebrate assessment, and other methods were used by VADEQ to link benthic impairment to these stressors, and to identify the sources of contaminant and sediment loading to Lewis Creek. The resulting TMDL

indicates a need for a reduction of 99% in load allocation from contaminated sites in the watershed. An independent evaluation of this load allocation scenario was conducted to determine whether the uncertainties in the data justify this reduction, and whether restoration of the watershed could be expected based on the targeting of contaminants identified by VADEQ. Main points to be presented and discussed include uncertainties in the following: (1) the linkage of probable stressors to the spatial distribution of benthic effects; (2) association of contaminant concentrations with sample toxicity and impairment; (3) correlation of spatial distribution of contaminants with identified sources; and (4) underestimation of other potential sources, including urban runoff. This evaluation indicates that the linkage of sediment contaminants and toxicity to observed patterns of abundance and diversity of benthic life in Lewis Creek was not clearly demonstrated by the TMDL study.

TP56 GEMSS-GIFT: A comprehensive sediment discharge and transport modeling system. M.J. Fichera, V.S. Kolluru, Surfacewater Modeling Group, ERM, Inc., Exton, PA. A non-proprietary sediment transport modeling software called GIFT (Generalized Integrated Fate and Transport) has been made available to the public as part of the GEMSS® (Generalized Environmental Modeling System for Surfacewaters) suite of models. GIFT is a numerical modeling system for simulating the fate of dissolved and particulate material discharged from dredging barges, mine tailings, oil well drill cutting mud and produced water into a water body. This three-dimensional particle-based model describes the sediment transport using Lagrangian algorithms and GEMSS' internal hydrodynamic model. The user may specify the mass load rates, release times and locations, particle sizes, settling velocities, and shear stress values (Shields number). The model provides tremendous flexibility to define the discharge scenarios and specific material properties limited only by the computational resources available. Through GEMSS' post-processing features, model output of sedimentation rate, net thickness deposited, and total suspended solids may be plotted and animated. GIFT has been successfully applied to assess potential biological impacts of offshore drilling off the coasts of Africa and Southeast Asia. Safe drilling location protective of coral reefs were determined using GIFT. Current and future development will enable GIFT to model the fate of contaminated constituents associated with the sediments.

TP57 Evaluation of the toxicity of metal-contaminated sediments in Spring River drainage basin of Missouri to juvenile (*Lampsilis siliquoidea*) and amphipods (*Hyaella azteca*). J. Kunz, toxicology, USGS-CERC, Columbia, MO. The Ozarks provide habitat for numerous freshwater mussels. Lead and zinc mining in the Ozarks has caused elevated concentrations of Cd, Pb, and Zn in both surface water and sediments. Previous studies have documented the toxicity of metal-contaminated sediments from mining areas in the Spring River and Neosho River watersheds located in Kansas, Missouri and Oklahoma. The objective of the present study is to assess the toxicity of whole sediments collected from the Spring River (6 locations) to 2-month-old *Lampsilis siliquoidea* and *Hyaella azteca* in 28-d exposures. The sediment exposures followed USEPA and ASTM methods. Sediments collected in August 2006 were sieved with a #60 sieve (250 um-opening) before the start of the sediment toxicity tests. Toxicity endpoints measured included survival and growth (shell length of mussels, body length of amphipods). Survival on Day 28 of the mussel exposures was equal to or greater than 80% in all treatments except for one treatment where survival was 50%. Survival in the amphipod exposures was equal to or greater than 80% in all treatments. The analysis of the growth data is ongoing for both species. Survival and growth of mussels and amphipods in the laboratory exposures will be compared to whole-sediment chemical analyses of sediment. The survival and growth of mussels in the laboratory exposures will also be compared to 3-month caging studies of mussels conducted in the Spring River at the same location where sediment was collected for conducting the laboratory sediment toxicity tests.

TP58 Great Lakes Legacy Act: Program Overview and Accomplishments. S.E. Boehme, IL/IN Sea Grant, Chicago, IL; M.L. Tuchman, U.S. Environmental Protection Agency, Chicago, IL. The Great Lakes Legacy Act (GLLA) is a new program aimed at accelerating the pace of contaminated sediment remediation in Great Lakes' Areas of Concern. The Act authorizes up to \$50 million for projects that remediate contaminated sediments or lead to remediation. The goal of the U.S. Environmental Protection Agency's Great Lakes National Program Office, who is administering GLLA, is to identify and potentially remediate all eligible contaminated sediment sites within the 31 US areas of Concern. This presentation will provide a description of the GLLA implementation plan and

an overview of the project selection process. As of June 2007, 3 remediation projects have been completed (Black Lagoon, Trenton, MI; Hog Island Inlet and Newton Creek, Superior, WI; and Ruddiman Creek and Pond, Muskegon, MI). Two remediation projects are underway (Ashtabula River, Ashtabula, OH and Tannery Bay St. Marys River, Sault Ste. Marie, MI), and several assessment/feasibility/design projects are also underway. The three completed projects have been highly successful from a technical point of view, attaining and/or exceeding the remediation goals established for the project. The projects have also been highly successful in terms of attaining and/or exceeding the goals of the stakeholders, their communities and the municipal, county and state partners. The impacts of the remediation will be highlighted, as well as the roles and responsibilities from project submittal to completion, and the key factors that made the projects successful.

TP59 Methods of Quantifying Fraction 3 Biogenic and Petroleum Hydrocarbons in Contaminated Muskegs and Drilling Waste Biopiles. E. Kelly-Hooper, Biology, University of Waterloo, Waterloo, Ontario, Canada. Science has established that hydrocarbons can originate from ancient petroleum deposits as well as from newly biosynthesized plant and animal materials. Petroleum hydrocarbons (PHCs) are found in a variety of sources such as crude oil, gasoline, diesel, etc. In contrast, biogenic hydrocarbons (BHCs) can be found in a variety of plant and animal materials such as waxes, tissues, fecal matter, etc. The Canadian Council of Ministers of the Environment (CCME) Total Petroleum Hydrocarbon Analytical Protocols are currently regulated under the assumption that all detectable hydrocarbons originate from petroleum sources only. In reality however, uncontaminated organically rich materials such as those found in muskegs and biopile remediation agents (e.g. manure, straw, wood, etc.) can be falsely identified as exceeding PHC toxicity criteria. As a result, current analytical methods can make it impossible to meet remediation requirements when uncontaminated soils are naturally high in BHCs. The goal of this PhD study is to develop new quantification techniques that are essential for determining if true PHC concentrations are above or below CCME toxicity criteria. This involves a series of microcosm contamination experiments conducted over a nine month study period. The two contamination scenarios include: 1. Pipeline oil spill impacted material in muskeg ecosystems 2. Biopile drilling waste remediation evaluations. The microcosms will be monitored for molecular signature changes. Chemistry parameters will include biomarkers, lipids and ratio indexes. The results of these experiments will then be applied to the development of a new protocol for PHC and BHC quantification methods. These methods may then be used to determine if bioremediated materials have met regulatory requirements.

TP60 Occurrence and Sources of Chlorophenols in the St. Johns River, Florida. L.B. Sonnenberg, Jacksonville University, Jacksonville, FL; J.C. Higman, St. Johns River Water Management District, Palatka, FL. Chlorophenols (CPs) are ubiquitous in the environment, partly due to the high number of potential sources, including herbicide application, waste incineration, wastewater disinfection, wood preservation, and bleached pulp and paper production. Sediments in the Lower St. Johns River (LSJR) were screened for CPs in 1996-1998 as part of a broad sediment quality assessment. The results suggested extensive CP contamination throughout the lower basin (Durrell et al. 2004). The purpose of this study was to reevaluate the extent of CP contamination in the LSJR using more definitive analytical methods, and to elucidate the most probable sources through examination of the CP "fingerprints." In 2006, a judgmental sampling strategy was used to collect sediment and water samples at 13 sites in the mainstem and in tributaries. Samples were taken near two wastewater outfalls, near two Superfund sites, in areas of aquatic herbicide application, near a former medical waste incinerator, at sites where the original screening study showed high CP levels, and at two reference areas with no apparent CP sources. Samples were analyzed by methods modified from USEPA Method 1653. While water quality was good with respect to all 30 CPs we evaluated, sediment contamination was widespread in the mainstem and the tributaries. Nearly all of the sites (92%) exhibited some sediment CP contamination, with total concentrations ranging from nondetect to 113 ppb dw. Tri- and tetrachlorocatechols were found in highest concentrations all throughout the region. Their relative quantities suggest their primary source is historic discharges of pulp and paper industry wastewaters. The prevalence of pentachlorophenol and its microbial metabolites downstream from a wood preservation Superfund site indicated that this was another probable source of CPs in the area. Other less important sources were likely from particle deposition from waste incineration or from

wastewater discharges. Several potential sources of CPs in the LSJR have been eliminated or reduced in recent years, but the CP concentrations in LSJR sediments are still generally equivalent to levels found in heavily urbanized, industrial water bodies worldwide. While information about toxicological effects of many CPs is scant, there is evidence that the total organochlorine burden in the LSJR sediments may be toxic to the benthos.

TP61 DDT residues in the soils of Brazzaville, Congo. B. Ngabe, 8125 Notre Dame Est, Montreal, Quebec, Canada; T. Bidleman, Centre for Atmospheric Research Experiments, Environment Canada, Egbert, Ontario, Canada. DDT is among the twelve POPs to be eliminated worldwide under the Stockholm Convention. However, due to the more important threat from diseases such as malaria as compared to that posed by the pesticide hazards, DDT is still used in many tropical and subtropical regions, including Africa. Despite the continual usage of DDT in Africa, there is a lack of data for soils. Soil samples were taken in the city of Brazzaville in 1999 from farming areas (~50 ha), dirt areas along city streets and yards of schools and office buildings. Soils were Soxhlet extracted with dichloromethane, cleaned up on an alumina column and analysed quantitatively by capillary GC-ECD. Chiral analysis of o,p'-DDT was done using electron capture negative ion mass spectrometry. Relative standard deviations for replicate analyses ranged from 14-33% for DDT, DDE and DDD compounds. The average recovery of a deuterated p,p'-DDT surrogate (chromatographically resolved from unlabelled p,p'-DDT) was 82±16%. The sum of p,p'-DDT, o,p'-DDT, p,p'-DDE and p,p'-DDD (ΣDDT) in soils with detectable residues ranged from 29-266 ng g⁻¹, dry wt., with the higher levels (166-266 ng g⁻¹) found at three farms and a yard at the university. Residues at a fourth farm and office building yards in the downtown area were lower (29-88 ng g⁻¹) and were below the quantitation limit (0.1 ng g⁻¹) in street soils, where sand was often applied to keep the dust down. The p,p'-DDT isomer accounted for 58-88% (mean 69±9%) of ΣDDT. Ratios of p,p'-DDT/p,p'-DDE ranged from 1.8-3.5 at most locations, but higher ratios of 21 and 5.1 were found at two farms. Enantiomer fractions of o,p'-DDT, EF = areas of (+)/[(+) + (-)] enantiomers, were determined for ten soils. EFs for nine soils were not significantly different from racemic and ranged from 0.489-0.504, while the EF for one soil was nonracemic (0.548). Predominance of p,p'-DDT and generally racemic o,p'-DDT suggests that the residues were due in part to recent use of DDT.

TP62 Increased Environmental Risk Associated With Alcohol-Fuel Mixes. K. Bachus, T. Byl, L. Sharpe, Environmental Engineering, Tennessee State University, Nashville, TN; T. Byl, Water Resources, USGS, Nashville, TN. The United States government is promoting alternative fuels that reduce our dependency on foreign oil. One of the most promising fuels in the near future is mixing ethanol, a renewable U.S. product, with gasoline. Et-85, a fuel that consists of 85% ethanol and 15% gasoline, is growing more popular. However, there are no reports in the literature concerning the environmental fate of the gas-alcohol mixtures if there was a spill. The objective of this research was to determine if a commercial grade Et-85 mixture would dissolve more readily in water and move faster through soil than gasoline. Solubility-in-water studies conducted with gasoline and Et-85 found that the Et-85 acted as a co-solvent, enabling gasoline compounds to dissolve more rapidly in water. Soil column studies found that aromatic compounds from the Et-85 would move faster than regular gasoline when pushed by water through the soil. These results raise concerns that if there is an Et-85 leak, it will move faster through water-saturated soils and dissolve more readily in the groundwater. Additional work should be done concerning biodegradation of Et-85 as compared to gasoline.

TP64 Construction and validation of a geostatistical model of PCDD and PCDF deposition from incineration. P. Goovaerts, PGeostat, Ann Arbor, MI; H.T. Trinh, P. Adriaens, Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI. Assessment and predictions of exposure of populations impacted by incinerator plume deposition depends on the accurate spatial delineation of the impacted area. A geostatistical model was constructed for polychlorinated dibenzo-p-dioxin, TCDD and polychlorinated dibenzo furan, TCDF using a regression between publicly available soil dioxin data and dry deposition, to provide guidance for the collection of new human and soil data in the surroundings of the Dow Chemical plant's incinerator located in the city of Midland, Michigan. Although 51 new soil measurements were confined to a few census blocks and so are not representative of the entire area that was initially characterized, the validation study showed that the model of local uncertainty is accurate and precise. The predicted values were on average lower than observed values, and

the uncertainty model indicates that the underestimation occurs mainly in the vicinity of the plant property line. This information can be used to update the estimation model for spatial distribution at the census block level.

TP65 Bioremediation of a 2,4,6-TCP contaminated sandy sediment and associated hydrodynamic changes. B. Antizar-Ladislao, Dept. Water and Environment Science and Technology, University of Cantabria, Torrelavega, Spain; N.I. Galil, Civil and Environmental Engineering, Technion - Israel Institute of Technology, Haifa, Israel. The aim of this research was to investigate the (in situ) bioremediation of a sandy sediment exposed to repeated exposures of an ionisable hydrophobic organic contaminant, i.e. 2,4,6-Trichlorophenol (TCP). Continuous flow laboratory studies were conducted using sand-bed columns (15 cm I.D.; 200 cm L.) at 20±1°C during 365 days. The influence of (i) initial loads of 2,4,6-TCP (15, 30, 45 and 60 mg of 2,4,6-TCP kg⁻¹ sand), and (ii) groundwater velocity (0.09, 0.56 and 1.18 cm min⁻¹) in the degradation of 2,4,6-TCP and hydrodynamic changes in the sand-bed columns were investigated. The experimental results indicated that degradation of 2,4,6-TCP followed first order kinetics in the range of 0.01 to 1.64 day⁻¹, and it was influenced by initial load (p<0.01) and groundwater velocity (p<0.01). Resident biomass growth and changes resulted in a dynamic reduction of hydraulic conductivity versus time and depth in the sand-bed columns by up to two orders of magnitude during bioremediation of 2,4,6-TCP. The highest hydraulic conductivity reductions were observed in the sand-bed column operated at the highest groundwater velocity and highest cumulative load of 2,4,6-TCP following 365 days of continuous treatment (p<0.05).

TP66 Effects of a physico-chemical treatment of dredged sediments on their ecotoxicity assessed with laboratory gravel pit microcosms. B. Clement, G. Vaille, LSE, ENTPE-Universite de Lyon, Vaulx en Velin, France; M. Abdelghafour, LAEPSI, Insa Lyon, Villeurbanne, France; E. Vernus, Polden-Insavalor, Villeurbanne, France; R. Moretto, EEDEMS, Villeurbanne, France. In France, dredged sediments may be dumped into submerged gravel pits. As a consequence, adverse effects may be expected. In addition, groundwater quality may be impacted due to hydraulic communications with gravel pits. The immersion of dredged sediments into gravel pits should thus be restricted to clean or slightly contaminated sediments to minimize the impacts on aquatic ecosystems and human safe. For highly contaminated sediments, alternatives may be treatments aiming at removing or/and neutralizing contaminants. The Novosol® treatment is based on three steps: a phosphatation step consisting in complexing metals by addition of orthophosphoric acid, a drying step where sediment water is removed, a calcination step where organic contaminants are removed by oxidation in an oven. The objective of this study was to assess the efficiency of the Novosol® treatment in a scenario of sediment immersion into experimental laboratory gravel pits (LGP), i.e. 1-m³ tanks filled with gravels. A 180-L water compartment was set up in each system so as to simulate the gravel pit, and various living organisms (cladocerans, benthic invertebrates, gasteropods, aquatic plants, microalgae) were introduced. Following a period of colonization and stabilization, raw and treated sediments were introduced into two different LGPs at a ratio L : S of 10, and the fate and effects of pollutants were studied during the period of deposition and post-deposition (70 days). Unexpectedly, the introduction of the highly contaminated raw sediment did not severely impact the microcosm and the groundwater, as shown by moderate effects on populations and the temporary release of pollutants. The introduction of the treated sediment had positive effects on survival and development of benthic populations and reproduction of pond snails but was followed by an increase in salinity (phosphates, sulphates) and a peak of hexavalent chromium at concentrations above potability limits and likely to have impaired invertebrate populations of the water column. It was concluded that (i) highly contaminated sediments are not necessarily at risks for aquatic ecosystems, depending on the availability of pollutants, and (ii) the Novosol® treatment should be optimized so as to increase efficiency of metal (especially chromium) neutralization by phosphates.

TP67 Wildlife Species at Risk Assessment: Challenges and Approaches for Landscape Scale Analysis. S. McDowell, R.N. Hull, Intrinsik Environmental Sciences Inc., Mississauga, Ontario, Canada; K.A. Enns, Delphinium Holdings Inc., Castlegar, British Columbia, Canada. Species At Risk (SAR) include wildlife designated as Special Concern, Threatened, Endangered, Extirpated, and Extinct. Ecological risk assessment (ERA) involves unique challenges when assessing SAR due to their often low populations, limited toxicological and field data, and multiple threats

including those unrelated to chemicals (e.g., habitat loss, persecution, disease). Fieldwork cannot be conducted directly on the species of interest at a site (beyond evaluation of species presence, habitat suitability). Due to the sensitive nature of the species, locations of individuals are protected by various agencies to deter threats such as harvesting, pet trade collection, and habitat degradation. Several approaches addressing these challenges can be used in an ERA. The relative impact of all factors should be considered including chemical related effects, direct threats (e.g. habitat loss and degradation), as well as indirect effects (e.g. population isolation). ERAs for SAR typically use surrogate data and conservative NOAEL. However, more sophisticated techniques could be used for both exposure modelling and TRV derivation. Identifying habitat appropriate for SAR is also important. Natural Resource agencies have compiled data identifying SAR historical presence. This information can be used to identify additional habitat in the area that may be suitable for SAR so these areas can be further evaluated or considered for protection. It is recommended that risk management plans adopt an adaptive management approach, targeted at mitigating compounding threats. The landscape-scale ERA conducted for the Teck Cominco lead/zinc smelter in Trail, BC evaluated risks to Species At Risk using a combination of approaches, including probabilistic exposure modelling, evaluation of habitat requirements and utilizing records of species presence in the area. This information will tie into the risk management plan for the wide-area site.

TP68 Missing sources and emission inventory updating of polyaromatic hydrocarbons in China. S. Tao, Z. Yanxu, Laboratory for Earth Surface Processes, College of Environmental Sciences, Peking University, Beijing, China. Emission inventory of polyaromatic hydrocarbons (PAHs) in China has been established previously. It was recognized lately that two important emission sources were left out of the inventory. Open-fire burning of straws which is a common practice in rural China was not included in the officially issued total straw burned. The official released statistics on coke production did not cover the coke produced by small-scale coke ovens spread over many rural areas in China. By including these two sources as well as a few other minor sources into the inventory and updating the emission factor database, the emission inventory of PAHs in China was updated. The total amount of 16 USEPA priority PAHs emitted in China in 2003 was 115,000 tons and the dominant sources were indoor straw burning for cooking and heating (35.1%), small scale coke production (25.9%), firewood burning for cooking and heating (21.9%) and domestic coal combustion (6.9%). The substantial difference in the indoor straw burning emission between the previous and current estimations is due to updating of the emission factors which was not available in the literature till we measured them in our laboratory recently. Based on the regression models developed for predicting the energy consumption activities, emission density in China was mapped at square-kilometer resolution to address the geographical distribution pattern of the emission. The temporal changes in the emission from 1950 to 2004 were established, demonstrating a general trend of increase in PAH emission from 1950 to 1990 primarily due to increases in rural population and small-scale coke production. Since the beginning of 1990s, annual emission of PAHs fluctuated primarily driven by the change in small-scale coke production. Since the implementation of recently issued Coal Law, small-scale coke production has been reduced substantially and will be gradually phased out before 2010. As a result, PAH emission from this source reduced significantly and will finally be eliminated. On the other hand, although the open-fire burning of straws is banned in China officially, the practice as well as the PAH emission from this source will continue in future simply due to the cost of the alternative technique and lack of economic incentive.

TP69 Persistent organic pollutants in air and soils of Mexico. F. Wong, T.F. Bidleman, Environment Canada, Toronto, Ontario, Canada; F. Wong, University of Toronto, Toronto, Ontario, Canada; H.A. Alegria, University of South Florida, St. Petersburg, FL. Ambient air and soils were sampled across Mexico in 2002-2006 to study the spatial distribution of organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs). The most abundant OCPs observed were the endosulfans, toxaphenes and DDTs. The highest concentration of endosulfans was found at Mazatlan, Sinaloa (18000 pg m^{-3}), located on the west coast. Peak levels of endosulfan were recorded during the winter and spring periods at this site. From back trajectory analysis, this coincides with a shift in the air mass coming from the Pacific Ocean (summer and autumn) to the inland agricultural area (winter and spring). Furthermore, soils from Mazatlan also contains high concentrations of endosulfans (mean 680 ng g^{-1}), which may due to atmospheric deposition.

Other stations showed variable concentration of endosulfans, ranging from $26 - 2200 \text{ pg m}^{-3}$ in air and up to 2 ng g^{-1} in soil. Toxaphene levels in the atmosphere and soils across the country ranged from $27 - 690 \text{ pg m}^{-3}$ and $0.1 - 400 \text{ ng g}^{-1}$ respectively. Both the air and soils showed depletion of Parlar 39 and 42 which suggests that the source of toxaphenes is from soil emission. DDT levels in air ranged from $6-2400 \text{ pg m}^{-3}$ and were generally higher in the south. PCB concentrations in air showed an urban-rural gradient with higher concentrations ($35-220 \text{ pg m}^{-3}$) detected in the cities and lower ones ($3.2-66 \text{ pg m}^{-3}$) in the rural regions. However, the highest PCB concentration in air (240 pg m^{-3}) was unexpectedly detected at a farm located in the mountainous area of southern Mexico. It is speculated that biomass burning may have triggered the release of PCB from vegetation.

TP70 Monitoring of Organochlorine Pesticides, PCBs and PBDEs in Selected Plant Species from LCP Superfund Site, Brunswick, GA. S.K. Kurunthachalam, K.S. Sajwan, Department of Natural Sciences and Mathematics, Savannah State University, Savannah, GA; M.A. Weber-Goeke, S. Weber-Snapp, Environment Planning Specialists, Atlanta, GA; S. Kelley, B.G. Loganathan, Department of Chemistry, Murray State University, Murray, KY. Levels of organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) were measured in loblolly pine needles (*Pinus taeda*) collected in and around Brunswick Superfund Site, in Georgia, USA. For the comparison purpose, foliage of eastern red cedar (*Juniperus virginiana*) also collected to monitor contaminant levels. This study revealed that concentrations of OCPs were greater in red cedar than pine needles. PCBs concentrations were observed similar in both plant foliages whereas, PBDEs were greater in red cedar. Temporal variation of total OCPs in pine needle have decreased from 10 to 2.3 ng/g dw and similarl, total PCBs decreased from 28 to 8.3 ng/g dw between 1997-2006.

TP71 Atmospheric Deposition as a Potential Source of Polychlorinated Biphenyls (PCBs) to the Willamette River Basin (Oregon, USA). B. Hope, Air Quality, Oregon DEQ, Portland, OR. Owing to their persistence and toxicity, polychlorinated biphenyls (PCBs) continue to be of global concern with respect to human and environmental health. They are also ubiquitous. The Willamette River in northwestern Oregon (USA) runs over 350 km from its headwaters to its confluence with the Columbia River and drains a basin of approximately $32,000 \text{ km}^2$. PCBs have been found in tissues of resident fish collected along the length of the river. Land use in the basin is dominated by agriculture and forestry, uses not typically associated with PCB releases; urban and industrial areas, which may contain PCB sources, are small and highly localized. The Portland Harbor Superfund site, with known significant PCB sources, occupies only the last 16 km of the river. How then do PCBs come to be so widely distributed in fish? Atmospheric deposition of PCBs from local, regional, or global sources was hypothesized as a possible basin-wide loading mechanism. This study employed a seasonally-responsive, dynamic mass balance model to explore this hypothesis. The model divides the river into four reaches and estimates water, sediment, and fish tissue concentrations of selected non- and mono-ortho substituted congeners (PCB-077, -118, -126, -169) in each reach. Ambient air, with measured congener concentrations of up to 2443 fg m^{-3} , was assumed as the only PCB source. Estimated ($2.5 - 11.8 \text{ } \mu\text{g kg}^{-1}$) and observed ($3.8 - 21.3 \text{ } \mu\text{g kg}^{-1}$) tissue levels are not significantly different in three reaches; only in the Superfund reach were observed levels significantly higher than estimated levels. This suggests that atmospheric deposition could account for most of the PCBs observed in resident fish. As there are no known local sources that could produce the loads (up to $\approx 4.5 \text{ kg yr}^{-1}$) estimated as necessary to maintain currently observed concentrations, significant contributions from regional or global sources are suspected.

TP73 Antarctica: A Source or a Sink for POPs? R. Dickhut, H.N. Geisz, M.A. Cochran, Virginia Institute of Marine Science, College of William and Mary, Hayes, VA; A. Cincinelli, Dipartimento di Chimica, Università degli Studi di Firenze/Polo Scientifico, Firenze, Italy. The Antarctic is typically considered pristine, being distant and largely sheltered from the industrialized world. However, an increasing body of evidence suggests that the Antarctic continent has accumulated persistent organic pollutants (POPs) as a result of long-range atmospheric transport from lower latitudes. For example, air mass back trajectories, coupled with measurements of current use organochlorine pesticides and brominated diphenyl ethers (BDEs) demonstrate that long-range atmospheric transport events transport contaminants from lower latitudes to the Antarctic in both the gas phase (e.g. heptachlor) and associated with aerosols (BDEs). However, declining emissions and atmospheric concentrations of legacy POPs, coupled with increasing temperatures in the

western Antarctic, may result in the loss of contaminants previously stored in the western Antarctic ice sheet to the atmosphere and nearby coastal waters. Indeed, two POPs that are currently banned or severely restricted for use (hexachlorobenzene and α -hexachlorocyclohexane) were found to be well correlated in air samples collected along Terra Nova Bay in the Ross Sea, Antarctica during 2003-2004, when air masses were continentally-derived. Moreover, during the austral summer of 2002 we found Σ DDT in glacier meltwater entering Arthur Harbor along the western Antarctic peninsula. Finally, long-term trends demonstrate that Σ DDT in Adélie penguins (*Pygoscelis adeliae*) has not declined in recent decades, but rather has reached a steady-state indicative of a current source of Σ DDT to the Antarctic marine food web.

TP75 Persistent halogenated organic pollutants in Alaskan marine mammals. Q. Li, D. Wang, Department of Molecular Biosciences and Bioengineering, University of Hawaii, Honolulu, HI; D. Wang, Department of Zoology, Fisheries and Illinois Aquaculture Center, Carbondale, IL; S. Atkinson, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks, AK; S. Atkinson, A. Hoover-Miller, Alaska SeaLife Center, Seward, AK. Environmental contaminants potentially could be contributing to fluctuations in Alaskan marine mammal populations by reducing survival and reproduction. We analyzed organo-chlorine pesticides (OCPs), polychlorinated biphenyls (PCBs), polychlorinated naphthalenes (PCNs), polybrominated biphenyl ethers (PBDEs) in various tissues of harbor seals, and fur seals from the North Pacific Ocean. Temporal data suggest a general decline in exposure to PCBs and DDTs. The mammals analyzed, however, were exposed to both traditional and emerging contaminants such as PCNs and PBDEs that were not previously monitored. Studies have shown that males can accumulate pollutants throughout their lifespan while females transfer Persistent halogenated organic pollutants to their offspring through lactation. Our data suggest that HCH, hexachlorobenzene, and low halogenated PCBs, PCNs and PBDEs were selectively transferred from the mother harbor seals to fetuses during pregnancy and distributed among various organs of the fetuses while pp'-DDE and highly halogenated PCBs, PCNs and PBDEs were retained in the mothers. Toxic coplanar PCBs and PCNs appeared to be less transferable from the pregnant harbor seals to the fetuses. Prenatal transfer of POPs not only poses a threat to the critical early development of the fetus, but the retention of toxic congeners in the mother seals threatens the mother's future reproductive success.

TP76 Discriminating different classes of ecotoxins by transcript profiling in medaka (*Oryzias latipes*) at an early time point following exposure. H. Yokota, H. Matsumoto, H. Miyaura, S. Fujishima, M. Seki, Y. Minobe, Chemicals Evaluation and Research Institute (CERI), Saitama, Japan. Toxicogenomics has emerged to expand the possibilities of integrating mechanistic knowledge with ecotoxicology. The aim of the present study was to determine if whole body samples from medaka exposed to various compounds can be classified based on gene expression profiles at an early time point. Male medaka were exposed to one of 15 chemicals including non-polar narcotic, polar narcotic and reactive compounds at one-tenth of each 96h-LC50 value for one hour. After exposure, the gene expression profiles of the whole bodies were analyzed using an oligonucleotide microarray with 10,264 unigenes. Genes differentially expressed between the non-polar narcotic chemicals and the others were identified by statistical scoring (t-test). Then, a supervised learning method (support vector machines; SVMs) was used to build the prediction models with the selected genes. The generalization performance was measured by leave-one-out cross-validation (LOO-CV). We determined a set of two predictor genes of response to non-polar narcotic chemicals. Five of five responders (100% specificity) and nine of 10 nonresponders (90% sensitivity) were classified correctly, for an overall accuracy of 93%. Furthermore, similar methods were used to construct predictive models to differentiate between polar narcotic chemicals and reactive compounds. Optimization of the gene sets for classification with SVMs and LOO-CV resulted in selection of five genes and the prediction accuracy of the model was 100% for polar narcotic chemicals. Overall, these results suggest that our prediction models could serve as a useful method for ecotoxin classification based on the transcript profiling of the fish at the very early stage during exposure (one hour post-exposure). This study was supported by New Energy and Industrial Technology Development Organization (NEDO), Japan.

TP77 Changes in fathead minnow (*Pimephales promelas*) mRNA expression profiling in toxicant target tissues following pulp and paper

mill effluent exposure. J. Werner, S. Skerget, J.D. Ouellet, D.R. Law, Biology, Lakehead University, Thunder Bay, Ontario, Canada. Pulp and paper mill effluents are complex mixtures of chemicals that may contain endocrine disrupting compounds. Exposure of wild fish to these effluents may decrease reproductive success due to lower egg production rates, decreased sexual characteristics and decreased fecundity. The fathead minnow is a model species for aquatic ecotoxicology research. Testing methods used to detect potential toxicants generally employ full life cycle tests and/or shorter term 21 day exposures. Dosed fish possess altered morphology, decreased sex steroid concentrations, increased liver mixed function oxygenase activity and/or decreased reproductive success. In order to explain how these well-characterized physiological changes arise at the molecular level, we are examining changes in the transcriptome of toxicant target tissues in fathead minnows exposed to different types of effluents. Changes in mRNA expression were monitored using the real-time polymerase chain reaction in fish exposed to 5% and 10% (by volume) untreated kraft effluent and 100% treated effluent, all obtained from a pulp and paper mill operation in Thunder Bay, Ontario. Fathead minnows were exposed for 6 days to the different effluents and the expression of genes that are known to change in response to aquatic toxicants, including vitellogenin, metallothionein and CYP1A from liver, gonad and brain tissue were determined. Short term exposures to contaminants and the analysis of mRNA profiles will allow us to develop an early warning test indicating exposure to toxic effluent.

TP78 Novel rapid method of microarray development for a non-model species, the largemouth bass (*Micropterus salmoides*). D.S. Barber, R.J. Griffith, N. Garcia-Reyero, N. Denslow, Center for Environmental and Human Toxicology, University of Florida, Gainesville, FL; W. Farmerie, L. Liu, Interdisciplinary Center for Biotechnology Research, University of Florida, Gainesville, FL. Use of genomics in ecotoxicology studies has been limited to a few model species with genome sequences or for which large amounts of EST sequences are available. While these species may work well for controlled laboratory studies, they may not be appropriate for field studies or for risk assessments. The advent of massively parallel sequencing has made it possible to obtain large amounts of sequence very quickly. We have used the massively parallel GS20 sequencer from 454 to obtain high quality sequence information for largemouth bass (*Micropterus salmoides*), a sensitive species to endocrine disrupting chemicals that is found in lakes and rivers around the United States. Equal amounts of total RNA from brain, liver and gonad were combined and used to construct a cDNA library which was twice normalized. The normalized library was sequenced twice on the GS20 sequencer producing a total of over 58 megabases of sequence. Analysis of sequence revealed 32,882 contiguous sequences with an average contig length of 747 bases. A BLAST analysis of the contigs resulted in 13,000 well annotated genes and roughly 22,000 sequences which remain without annotation, probably because they are too short for identification. The 13,000 annotated segments were used to design a custom array containing 44,000 elements on the Agilent platform. Male largemouth bass were treated with 1 mg/kg 17 beta-estradiol in sesame oil by ip injection. Total RNA was prepared from gonad and liver and these samples were used to evaluate the performance of the array. Results demonstrated a typical estrogen-induced gene expression pattern. This procedure provides a mechanism whereby researchers working on non-model species can construct arrays that cover large portions of the transcriptome in approximately one month.

TP79 Incorporating results of avian toxicity tests into a model of annual reproductive success. R. Bennett, M.A. Etterson, USEPA, ORD, Duluth, MN. Estimating the effects of pesticide exposure on avian populations requires knowledge of how the pesticide changes survival and fecundity rates for the population. Although avian reproduction tests are the primary source of information on reproductive effects in the pesticide risk assessment process, current tests can not provide a direct estimate of the effects of a pesticide on fecundity rates, also known as annual reproductive success. We present a mathematical model that integrates information on specific types of effects from avian reproduction tests and other studies with information on avian life history parameters, the timing of pesticide applications, and the temporal pattern of pesticide exposure levels, to estimate pesticide effects on annual reproductive success. We demonstrate the model by simulating populations of a songbird exposed to a hypothetical pesticide during a breeding season. The model results are used to compare nesting success of females in no-pesticide vs pesticide-exposed populations throughout a breeding season. While the basic model is designed to be useful for species with limited life history information,

we discuss additional features available for improving the quantitative estimation of annual reproductive success. This abstract does not necessarily reflect EPA policy.

TP80 Hornbill Population Dynamics in South India- An Ecological Risk Assessment Approach. B. Kaimal, S. Kaimal, M. Gopalan, R.S. Grippo, Graduate Program In Environmental Sciences, Arkansas State University, Jonesboro, AR; R.S. Grippo, Department of Biological Sciences, Arkansas State University, Jonesboro, AR. The Vazhachal Reserve Forests, a lowland tropical rainforest in southern India, supports diverse biotic communities with a high proportion of endemic fauna and flora. The Great Indian Hornbill, found to exist sympatrically with three other endemic species of Hornbills, is critically endangered. A hydroelectric project is proposed to be constructed in this Hornbill habitat. We conducted a modeling study to understand the temporal dynamics of the Great Indian Hornbill population in the reserve forests. We focused on anthropogenic stressors such as plantations, developmental activities, tourism, collection of Non-Timber Forest Produce (NTFPs) and hunting on Hornbill populations. Data collected from studies conducted at Vazhachal Reserve Forests during January-April 2002 were utilized in simulation modeling (Stella 8.1) to identify and characterize the effects of stressors on the Great Indian Hornbill (*Buceros bicornis*) population trends. Our model trajectory closely followed the observed changes in breeding population size over time. Population modeling suggests that increased logging and hunting could have substantial effects on populations that are currently experiencing a decline. Predicted effects show that the populations could drastically decline by ten years. This study was incorporated into an ecological risk assessment framework to understand the risks posed to the Great Indian Hornbill. However, none of the possible causes discussed in this study can fully explain the decline in the Great Indian Hornbill at Vazhachal Reserve Forests, confirming the need for comprehensive monitoring of the population throughout its range and for demographic monitoring to target effective conservation action. A study of the minimum viable population would further provide a focus for the study of ecological and genetic factors that influence the persistence of a threatened population.

TP81 Toward the Development of Minimally-Invasive Tools for Avian Toxicogenomic Biomonitoring. K.A. Gust, E.J. Perkins, US Army Corps of Engineers, Vicksburg, MS; M.J. Quinn, M.S. Johnson, US Army Center for Health Promotion and Preventative Medicine, Aberdeen, MD. In order for toxicogenomics to enhance biomonitoring efforts, advances must occur to limit invasiveness of biological sampling and to confirm diagnostic genomic responses to toxicants. Clinical toxicology coupled with toxicogenomic inquiry were used to establish neurotoxic mechanisms of action (MOA) for the energetic compounds RDX and 2,6-DNT in Northern Bobwhite (*Colinus virginianus*). A brain-specific cDNA microarray was used to assess effects of each chemical on CNS gene expression. Results indicated the MOA for RDX involved alteration of Ca²⁺ regulation affecting neuron potentiation pathways, conversely CNS was not targeted by 2,6-DNT. A large-scale (20K) multi-tissue (brain, liver, gonad, intestine and feather pulp) microarray is in development for Northern Bobwhite. Feather pulp RNA has been extracted from experimental animals and will be hybridized to the next generation microarrays. The utility of feather pulp tissue for capturing signatures of the systemic effects of each RDX and 2,6-DNT will be evaluated. If feather pulp can represent the genomic state of the organism, development of such minimally-invasive genomic diagnostics will greatly benefit avian biomonitoring efforts.

TP82 Establishing a Profile of Gene Expression in Avian Species Exposed to PCBs. M.E. Barton, T.E. Porter, E.T. Lavoie, M. Ottinger, Animal Sciences, University of Maryland, College Park, MD. Genotoxic effects are a hazard of environmental pollution. Issues of concern include changes in expression of genes associated with detoxification and endocrine systems, among others. We are endeavoring to establish a gene expression profile in birds in response to PCBs using microarray technology. With the power to measure the expression levels of an entire genome at once, microarray technology presents itself as an excellent candidate for detecting patterns of gene expression. Using Japanese quail (*Coturnix coturnix*) as a lab model, we injected eggs on the third day of incubation with a vehicle control or a PCB mixture (6, 12, and 49 µg/g egg) and sampled organs at hatch. RNA was extracted from hatchling livers and applied to the Del_Mar Chicken Integrated Systems Microarray. Validation showed roughly a 90% correspondence between quail liver samples and the chicken microarray, 75% correspondence in quail hypothalamus, as well as 60-85% correspondence

in turkey and duck livers and hypothalamus, and tree swallow and American kestrel livers. Further application of quail samples to the microarray revealed a number of candidate genes, including cytochrome P450 1A5 (CYP1A5), which was expressed greater than control in 6 µg/g and 49 µg/g-injected eggs; and mitochondrial ribosomal protein S16, which was expressed 3-fold under control in 6 µg/g injected eggs, but only 1.24-fold under control in 12 µg/g-injected eggs. These genes may be good toxicogenomic biomarkers for hatchling birds exposed to PCBs.

TP83 40 years of Mackereth oxygen sensor. L. Nei, Institute of Sustainable Technology, Tallinn University of Technology, Tartu, Estonia. Natural waters and sewage contain several dissolved gases of which oxygen is the most important. The concentration of dissolved oxygen in aquatic systems, as well as the rate of its production and removal by metabolic and chemical processes, has proved to be a useful measurement across most branches of aquatic research. Electrochemical Clark-type oxygen sensors have found increasingly wide-spread application since the publication of the pioneering patent in 1959. Due to the low stability of the output signal of the Clark sensor, several investigators still prefer to utilize expensive and elaborate modifications of the Winkler method. 40 years ago the patent proposing a different electrochemical oxygen sensor design (Mackereth sensor) was issued. Probably the claimed high stability of the output signal of the sensor was followed under specific laboratory conditions. This is perhaps the main reason why the Mackereth sensors have not found wide application in environmental monitoring and water pollution control. We have proposed several novel oxygen electrodes, following the lines of the Mackereth sensor. Our results show, that a modified Mackereth oxygen sensor is a very reliable tool for dissolved oxygen determination under various real world conditions.

TP84 Comparison of Analytical Methods for Explosives in Environmental Media. D. Hinckley, EA Engineering, Sparks, MD; P. Ioannides, GPL Laboratories, Frederick, MD. Explosives are an important chemical of concern at former and active military areas. Typical explosives of concern at these sites include 2,4,6-trinitrotoluene and its breakdown products such as 2,4-dinitrotoluene, HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine) and RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine). A variety of analytical methods have been published for the analysis of explosives in soil, sediment and water. These methods combine the following extraction/preconcentration and detectors in differing ways: Extraction/Preconcentration: Solid samples are typically sonicated for a period in various solvents, including acetonitrile and in some cases isopropanol. Water samples are extracted and preconcentrated using one of two methods, salting out and extraction using solid phase extraction (SPE) methods. Separation and Detection: Three methods of analysis have been applied, HPLC with second column confirmations, GC-ECD, and GC-MS. Methods to be Discussed Solid Waste Methods (SW846) that will be discussed include Method 8330 and Proposed Method 8330A. Both of these methods rely on HPLC with second column confirmation and either sonication, salting out, or SPE for extraction/preconcentration. Method 8095 relies on GC-ECD detection with sonication of a solid sample with a solvent and SPE preconcentration of water samples. A Clean Water Method 529 has been published, which utilizes SPE preconcentration and GC-MS analysis. This method is only applicable to water matrices, and is likely problematic for most non-potable water analyses. Finally, CHIPPM has developed an explosives method which utilizes extraction with isopropanol and analysis using GC-ECD. All of these methods will be discussed and the various positive and negative aspects of the methods presented in the poster, providing the viewer with the chance to evaluate the multitude of analytical methods

TP85 A new method for the measurement of fugacity and the Henry's law constant for volatile organic compounds containing chromophores. K.B. Lodge, Chemical Engineering, University of Minnesota Duluth, Duluth, MN; D. Danso, Chemistry, University of Minnesota Duluth, Duluth, MN. A new method for the measurement of the fugacity and the Henry's law constant for volatile organic compounds containing chromophores will be described; this was tested with benzene, toluene and ethylbenzene distributed between air and water. The steadily flowing vapor phase of fixed composition is prepared with a mass-flow controller and syringe pump, a method that has been used to calibrate the adsorption by fibres in solid phase micro extraction. The vapor phase flows in and out of the headspace above pure water in a 1-cm spectrophotometric cell housed in a temperature-controlled holder in a UV-Visible spectrophotometer. The approach to equilibrium, as the chemical is transferred from the vapor to the stirred liquid phase, is monitored

by following the absorbance of the liquid phase at a selected wavelength. Calibration leads to the following molar absorption coefficients ($\pm$ standard errors, units of $\text{L mol}^{-1} \text{cm}^{-1}$) in water at 25 °C; for benzene at 260 nm, 101 ± 1 ; for toluene at 261 nm, 284 ± 1 ; and, for ethylbenzene at 257 nm, 253 ± 3 . The fugacities are linear with respect to the mole fractions in the water. The resulting Henry's law constants ($\pm$ standard errors, units of 10^4 kPa) are comparable to published values; at 25 °C, these are for benzene, 2.22 ± 0.05 ; for toluene, 3.99 ± 0.04 ; and for ethylbenzene, 5.14 ± 0.06 .

TP86 Reductive Transformation of Explosives by Pyrite, Magnetite, and Green Rust. S. Oh, Civil and Environmental Engineering, University of Ulsan, Ulsan, South Korea; D.K. Cha, Civil and Environmental Engineering, University of Delaware, Newark, DE. In order to determine the role of Fe(II)-bearing minerals on the fate of toxic explosives in soil and aquifer, the reductive transformation of the explosives was investigated. Results from batch experiments showed that 2,4,6-trinitrotoluene (TNT) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) were continuously removed from solution in the presence of pyrite under buffered conditions, with showing that 65% and 45% of TNT and RDX were removed after 32 days, respectively. Without buffer solution, as the pH was abruptly decreased from 7.0 to 2.8-3.0, the reduction of TNT and RDX was slow down due to decrease of anaerobic oxidation of pyrite under the acidic conditions. Nitroglycerin (NG) was continuously and more rapidly reduced by pyrite under both conditions. Approximately 90% and complete removal of NG was achieved under unbuffered and buffered conditions, respectively. The reduction of the explosives by magnetite was shown to be by far slower than that by pyrite. Only 25%, 19%, and 37% of TNT, RDX, and NG were reduced by magnetite after 32 days. Pyrite-bound Fe^{2+} was shown to reduce RDX as rapidly as magnetite-bound Fe^{2+} . More than 98% of TNT was also reduced by pyrite-bound Fe^{2+} under identical conditions. TNT was completely removed by carbonate green rust in 30 min, indicating that the reduction of TNT by carbonate green rust was much faster than those by pyrite and magnetite. Our results suggest that the abiotic transformation of the explosives by Fe(II)-bearing minerals may be considered to evaluate the natural attenuation capacity of geologic media under subsurface environment.

TP87 Enhanced Reduction of Nitrate by Zero-Valent Iron at Elevated Temperatures. S. Oh, Civil and Environmental Engineering, University of Ulsan, Ulsan, South Korea; S. Ahn, D.K. Cha, Civil and Environmental Engineering, University of Delaware, Newark, DE. Kinetics of nitrate reduction by zero-valent iron at elevated temperatures was studied through batch and column experiments. It was hypothesized that increasing temperature of solution and zero-valent iron may accelerate the reduction of nitrate by overcoming the activation energy barrier in the reduction of nitrate by zero-valent iron. Results of batch experiment showed that synergistic effects of elevated temperature (75°C) and buffered condition (pH 7.4 with 0.1M HEPES) enhanced the rate of nitrate reduction by zero-valent iron from $0.072 \sim 0.006 \text{ h}^{-1}$ ($(0.35 \sim 0.03) \times 10^{-4} \text{ L}/(\text{m}^2\text{h})$) at room temperature to $1.39 \sim 0.23 \text{ h}^{-1}$ ($(1.03 \sim 0.07) \times 10^{-3} \text{ L}/(\text{m}^2\text{h})$). Complete removal of nitrate was obtained in a Fe(0) column after 30 min under both buffered and unbuffered conditions at 75°C. The buffered condition of the solution did not significantly enhance the reduction rate at 75°C after 15 min or longer retention time in the Fe(0) column. These results indicated that increase of temperature could not only overcome energy barrier but also decrease the effects of buffer on nitrate reduction in the iron-water system. We suggest that an iron reduction process at moderately elevated temperature (50 ~ 75°C) may be an option to consider for removal of nitrate from aqueous phase.

TP88 Recent Regulatory Development on Evaluation of Non-Detects. N. Luke, Camp Dresser & McKee Inc, Edison, NJ; C. Julias, CDM, Edison, NJ. Risk management decisions made for a remedial investigation/feasibility study are based on environmental data analyzed from samples collected at a contaminated site. Analytical data provided by a laboratory usually contain non-detects (NDs) which are the data below reporting limits of the analytical method. In both human health and ecological risk assessments, the most common practice for handling NDs in the calculation of summary statistics, exposure point concentrations (EPCs), and risk estimates is to use half of reporting limits for NDs. This approach has been recognized as an inappropriate way of treating NDs for most data sets. Diverse treatment of NDs in the calculation will subsequently affect the cleanup levels since the computed concentrations are employed in determining the risk estimates in risk assessments. Various statistical methods have been recommended to improve the accuracy of the calculation of the EPCs when considering NDs,

especially when NDs make up a large fraction of a data set. The complexity of statistical analysis usually depends on the number of data below the reporting limits and data distribution. There have been numerous published documents on recommended statistical methods but no specific regulatory guidance to evaluate NDs and compute an appropriate 95% upper confidence limits (UCLs) for use in the risk calculations. EPA has published several documents on this topic, but no definitive approach was recommended until recently. In this recent study, EPA recommends various statistical methods for handling NDs and an appropriate 95% UCL computation based on left-censored symmetric and moderately skewed to highly skewed data sets of varying degrees of censoring intensity. In addition, software package used in the simulation experiment were used and tested to compare and verify the results obtained using a SimCensor program which is in newly developed ProUCL program version 4.0 and soon to be released.

TP89 Aroclor 1268 Congeners and Residues of Polybrominated Diphenyl Ethers in Sediment from a Superfund Site at Brunswick, Georgia, USA. K.S. Sajwan, S.K. Kurunthachalam, Department of Natural Sciences and Mathematics, Savannah State University, Savannah, GA; M.A. Weber-Goeke, S. Weber-Snapp, Environmental Planning Specialists Inc., Atlanta, GA; C. Gibson, B.G. Loganathan, Department of Chemistry, Murray State University, Murray, KY. In 1994, a former chlor-alkali plant located at Brunswick, Georgia, USA disposed a huge amount of Aroclor 1268 in salt marsh regions of Atlantic coast that resulted in PCB contamination in soils, sediment and biota (Kannan et al. 1997, 1998a,b). This site has been designated as Superfund site by the United States Environmental Protection Agency (US EPA). The US EPA conducted enormous remediation work and monitoring of toxic contaminants. Objective of this study was to understand the current status of contamination by Aroclor 1268 and polybrominated biphenyls in sediment collected from ten selected sites in the Superfund site. Total Aroclor-1268 concentrations was 4.1-111,000 ng/g dry wt. and PBDEs was less than detection limit to 150 ng/g dry wt. To our knowledge, this is the first report on PBDE concentrations in sediment samples from the Superfund site at Brunswick, Georgia.

TP90 Quantifying the concentration of crude oil microdroplets in oil-water preparations. A. Redman, HydroQual, Inc., East Syracuse, NY; J. McGrath, HydroQual, Inc, Mahwah, NJ; W. Stubblefield, Parametrix, Corvallis, OR; A. Maki, ExxonMobil, Alpine, WY; D. Di Toro, University of Delaware, Newark, DE. Dissolved constituents of crude oil, particularly polycyclic aromatic hydrocarbons, (PAHs), can contribute substantially to the toxicity of aquatic organisms. It is observed that measured aqueous concentrations of high molecular weight PAHs (e.g., chrysenes, benzo(a) pyrene) as well as long-chain aliphatic hydrocarbons can exceed the solubility of these sparingly soluble compounds. It is attributed to the presence of a microdroplet oil phase. It is important to be able to quantify the dissolved fraction of these compounds in oil-in-water preparations that are commonly used in toxicity assays, because the interpretation of test results often assumes that the compounds are dissolved. A method is presented to determine the microdroplet fraction of crude oil in the oil-in-water preparations using a comparison of predicted and measured aqueous concentrations. The measured concentrations are reproduced by including both microdroplets and dissolved constituents of petroleum hydrocarbons. Microdroplets were found to be present in all oil-water preparation datasets analyzed. Estimated microdroplet oil concentrations typically range from 10 to 700 $\mu\text{g oil} / \text{L water}$. The fraction of dissolved individual petroleum hydrocarbons ranges from near 1.0 for highly soluble compounds (e.g., BTEX) to far less than 0.1 for sparingly soluble compounds (e.g., chrysenes) depending on the microdroplet oil concentration. The presence of these microdroplets, which are presumably artifacts of the experimental procedures, complicates the interpretation of toxicity test, since the microdroplets may exert an additional toxic effect.

TP91 Pentachlorophenol sorption by variable-charge soils through hydrophilic and hydrophobic domains in methanol-water system. S. Hyun, Environmental Science & Ecological Engineering, Korea University, Seoul, South Korea; L.S. Lee, Agronomy, Purdue University, West Lafayette, IN. The impact of soil-solution pH in methanol/water solutions on sorption of pentachlorophenol by variable charge soils with a range of hydrophilic and hydrophobic sorption domains was characterized. PCP sorption by 10 variable-charge soils was measured as a function of apparent pH and methanol volume fraction (f_c) of < 0.6 . Sorption data of both neutral and anionic PCP decreased log-linearly with increasing f_c , but the slope of the relationship was less for anionic PCP. The empirical solvent-sorbent interaction term for

anionic PCP was inversely correlated with the fraction of hydrophilic domain, which is consistent with methanol-induced increases in anion exchange. For neutral PCP, the empirical term was positively correlated with the fraction of hydrophobic domain, supporting methanol-induced increases in solution and sorbent hydrophobicity. A cosolvency model, which was essentially derived assuming only pH-pKa dependent speciation and intrinsic hydrophobic partitioning of the two PCP species with the contribution of hydrophilic domain to PCP sorption not inherently incorporated, predicted well the overall sorption of PCP by two soils with varying in fH_{ph} in the pH range of 3 and 8. The result of this study indicates that cosolvent effects on sorptivity of PCP species by different sorption domains will differ, but the overall sorption on variable-charge soils can be predicted by incorporating both cosolvent-enhanced solubility and cosolvent-induced speciation.

TP92 Pollution by anthropogenic contaminants and trace elements in fish and shellfish of the Nansei Islands, Japan. S. Tanabe, S. Takahashi, T. Ikemoto, G. Malarvannan, T. Agusa, S. Yano, Y. Ochi, C. Mastudaira, Center for Marine Environmental Studies, Ehime University, Matsuyama, Japan; Y. Anan, Graduate School of Pharmaceutical Sciences, Chiba University, Chiba, Japan; T. Miyagi, Department of Environmental Science, Okinawa Prefectural Institute of Health and Environment, Nanjo, Japan; M. Nakamura, Tropical Biosphere Research Center, University of the Ryukyus, Motobu, Japan; S. Yasumura, WWF Japan, Tokyo, Japan. Nansei Islands, located in the south end of the Japanese Islands, have high biodiversity, and a lot of indigenous species. Therefore this region is one of the most important areas from environmental viewpoint. In recent years, the rapid economical growth in China and Southeast Asian countries has resulted in increasing production and usage of anthropogenic chemicals and trace elements; therefore threat by these contaminants to the organisms is a matter of great concern. In the present study, concentrations of organohalogen compounds (PCBs, DDTs, CHLs, HCHs, HCBs and PBDEs), organotin compounds (BTs, PTs and OcTs) and 22 trace elements were determined in fish and shellfish from Nansei Islands, Japan collected during 2005 – 2006. Considerable residue levels of organohalogens, especially CHLs and DDTs were found in tilapia and mullet from main Okinawa Island. These levels were relatively higher than the reported values of seafood from Japanese coast in recent years, indicating that even now pollution sources of these contaminants still exist in this region. Significant negative correlation between HCH concentrations and gonad somatic indices (GSI) was observed in male tilapia. On the other hand, lower concentrations of organohalogen and organotin compounds were detected in biota from Ishigaki Island waters than those in other Japanese coastal waters, suggesting that this region is less contaminated by these chemicals. Levels of trace elements in biota from Nansei Islands were comparable or relatively low in comparison to those of other regions of the world. But, elevated concentrations of some trace elements including Hg were detected in tilapia and orange mud crab samples from Ishigaki Island. Hg levels in some samples from Ishigaki Island exceeded no effect hazard concentration (NEHC) for piscivorous birds, which was estimated using specimens of osprey.

TP93 Polybrominated Diphenyl Ethers and Organochlorine Pesticides in Children's Stuffed Toys. J. Burnett, R. Falconer, Chemistry, Chatham University, Pittsburgh, PA. Polybrominated diphenyl ethers (PBDEs) and organochlorine (OC) pesticides are common organic contaminants which have been shown to possess a wide spectrum of toxicity in laboratory animals and have been found in every level of the food chain. Typically, PBDEs are additive compounds mixed into plastics and other polymers but not chemically bound to the original substance. As such, they may leach out of these products creating possible routes for human exposure. OC pesticides are routinely found in indoor environments. Because of their semi-volatile nature, they can be released from foundations and carpets in homes and from sprayed surfaces in manufacturing facilities and warehouses, where they were applied years ago. Once released, they can travel throughout the indoor environment and deposit on other surfaces. Previous research has shown the presence of both these chemicals in children's toys. This project further looked at toys manufactured in a variety of countries and made from both man-made and natural substances. Brominated flame retardants were found at measurable levels in most samples with the polybrominated diphenyl ether congeners 28, 47 and 99 most commonly seen. A number of organochlorine pesticides were routinely found in the samples including HCHs, chlordanes and DDTs. Levels of contaminants were related to the origin and type of material. The presence of these chemicals in stuffed toys may be a source of exposure to these chemicals for children.

TP94 The Comparative Efficacy of Produce Washes for Removing Organochlorine Pesticides from Produce. J. Anderson, A. Yousef, R. Falconer, Chemistry, Chatham University, Pittsburgh, PA. The presence of pesticides, including past-use organochlorine (OC) pesticides, in produce and other human foods has been well documented. The increased awareness of consumers as to possible risks of pesticide exposure has led to the rise in use of commercially available produce washes. However, these products can be expensive and little research is available to support their claims of effectiveness. Both commercial washes and non-commercial methods have been marketed as viable produce cleansers. This study looked at the comparative efficacy of several commercial and non-commercial produce washes for removing OC pesticides from produce. Store bought produce was washed with water to remove visible dirt and each sample item cut in half. The skin from one half was removed and analyzed for OC pesticides as is (untreated). The other half of the sample was treated with one of the produce washes, the skin removed and analyzed for OC pesticides (treated). The difference in the amount of OC pesticides on the skins of the two halves of each fruit/vegetable (treated and untreated) was determined. For most of the commercial washes, only a slight improvement was seen over washing with water alone. Several of the non-commercial washes were slightly better at removing pesticide residues from produce. This preliminary study shows the need for further study of products reported to lower human exposure to harmful chemicals on food items.

TP96 Vibrational Spectroscopic Study of Dibenzo-P-Dioxin Sorption to Cs-Saponite. K. Rana, C.T. Johnston, G.S. Premachandra, Crop, Soil and Environmental Sciences, Purdue University, West Lafayette, IN; S.A. Boyd, B.J. Teppen, H. Li, Crop and Soil Sciences, Michigan State University, East Lansing, MI. The sorption of polyaromatic hydrocarbons (PAHs), polychlorinated biphenyl (PCBs), and dioxins in soils and sediments is critical to understanding their environmental fate and transport. Recently, expandable clay minerals have been shown to have a higher-than-expected affinity for these intrinsically non-polar compounds. To gain additional perspective on the mechanisms that govern dioxin-PAH-PCB sorption to soil minerals, this study focused on the interaction of dibenzo-p-dioxin with Cs-saponite as a model system by integrating macroscopic batch sorption experiments with spectroscopic analysis. Sorption of dibenzo-p-dioxin (Dioxin) from aqueous suspension to Cs-saponite was investigated by high-performance liquid chromatography (HPLC) combined with parallel experiments using Fourier transform infrared spectroscopy (FTIR), Attenuated total reflectance ATR-FTIR, and Raman spectroscopy. In order to assign the IR- and Raman-active vibrations of dioxin polarized single crystal Raman spectra of oriented dioxin crystals were obtained and compared to ATR-FTIR and FTIR spectra of dioxin. Excellent agreement was found between the HPLC batch sorption study and a *in situ* ATR FTIR study of dioxin sorption to Cs-saponite. IR- and Raman-active bands of dioxin sorbed to Cs-saponite in the 1280 to 1500 cm⁻¹ region were perturbed compared to the 'reference' IR and Raman spectra of dioxin. Sorption mechanisms of dioxin to Cs-saponite will be related to clay surface chemistry and to the molecular properties of dioxin.

TP97 Optical Fiber Platform for Real-Time, Remote, and Spatially Resolved Sensing of Oxygen. V. Rigo, P. Geissinger, Univ. of Wisconsin-Milwaukee, Milwaukee, WI. Dissolved oxygen (DO) is essential for many organisms in aquatic environments. Thus, spatially resolved, real-time remote measurement of DO-concentration is of great interest for monitoring the dynamics of an aquatic system and locating the sources of pollution. We describe the development of a novel generic approach to optical-fiber oxygen sensing based on metal-enhanced fluorescence (MEF) to improve signal intensities. Oxygen-sensing is based on the fluorescence quenching of a ruthenium compound. To employ metal-enhancement effects, a thin silver film was deposited by vacuum evaporation onto optical fiber cores. Subsequently, SiO₂ was deposited as an optically transparent spacer layer between the metal and the fluorosensor and to protect the metal film as well as the optical fiber from degradation. A photo-polymerized hydrogel matrix containing the fluorosensor was covalently attached to the spacer layer. The sensor was tested using a two-crossed-fiber sensor array with two regions excited by a ND:YAG laser, with the second region used as intensity reference. The sensor was mounted in a home-built flow chamber where both oxygen and nitrogen were pumped into the chamber at different partial pressures. The fluorescence emitted by the sensor molecules was captured by a second fiber at right angle to the fiber carrying the excitation light. This crossed-fiber configuration allows for creating multiple sensor regions with a minimum spatial resolution of only millimeters. The sensor fluorescence was detected by a photomultiplier

tube, whose output current was analyzed with an oscilloscope. Response of the sensor towards oxygen was described in terms of fluorescence spectra, repeatability and reproducibility. The second part of this study involves the fabrication of different nanostructured surfaces using chemical deposition routes. Metal nanostructures, especially those with sharp edges and corners promise to induce the largest sensor fluorescence enhancement effects. We used high-resolution TEM imaging and optical spectroscopy to study the relationship of geometrical features of individual silver nanostructures and their optical plasmon resonant properties, which are responsible for the MEF effects. This allows matching of the plasmon resonance frequencies to the fluorosensors spectral properties, which is crucial to successfully employ the MEF effect, and to develop ultra-sensitive chemical sensors.

TP98 Chemical fingerprinting to trace the habitat of origin of birds. B. Kaimal, R. Hannigan, Graduate Program in Environmental Sciences, Arkansas State University, Jonesboro, AR. We developed a method for analysis of trace elements in feathers using Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS). The main objective of this study was to determine whether LA-ICP-MS derived elemental concentrations in feathers can be used to distinguish populations of birds from distinct known localities. Bird feathers acquire trace elements from the habitat in which the bird lives at the time of feather growth. Trace element content of feathers thus reflects the chemistry of the habitat (soil, water, and air) and diet of the bird. Central to the use of LA-ICP-MS in trace element quantification is the use of a matrix-matched standard. We developed an internal reference standard composed of keratin powder doped with trace elements. DRC-ICP-MS with pneumatic nebulization was used to quantify the metal concentrations in bird feathers by solution ICP-MS. A Laser ablation system yielding 213nm wavelength was coupled to the ICP-MS for solid sample introduction. Feathers from the Mourning dove (*Zenaidura macroura*), Brown-headed cowbird (*Molothrus ater*), Wild Turkey (*Meleagris gallopavo*) and the Mallard duck (*Anas platyrhynchos*) were used for method development and testing. Feathers were digested by microwave digestion using ultra pure HNO₃. For analysis by LA-ICP-MS three 100 μ m scan lines were ablated on each feather sample and also on the reference keratin standard. The same suite of elements was analyzed by solution ICP-MS in feathers and the internal reference standard. Differences in concentration between ICP-MS and LA-ICP-MS samples were identified using a two sample t-test. Differences between populations were also statistically assessed in the same manner. Our results demonstrate that the chemical fingerprint of bird feathers obtained using LA-ICP-MS are statistically the same as those obtained through solution-based ICP-MS. Further, our results show that LA-ICP-MS elemental abundances were significantly different between populations of birds. Although these results show great promise for the application of LA-ICP-MS in feather chemistry studies further research is required. Ultimately trace element maps developed from the chemistry of feathers from birds from different regions will provide unique insights into migratory pathways as well as allow molted feather chemistries to be used to identify habitat use by different populations.

TP99 Effect of aging on the volatilization of organochlorine pesticides from soils. F. Wong, T.F. Bidleman, Environment Canada, Toronto, Ontario, Canada; F. Wong, University of Toronto, Toronto, Ontario, Canada. As chemicals age, they may relocate within the soil matrix to sites that microorganisms and plants cannot access. Studies have shown that the bioavailability of OCPs in soil declines over time. Analogous to bioavailability, it is hypothesized that aged chemicals may be less available for soil-air exchange, thereby decreasing their re-emission to the atmosphere. The effect of aging on the "aeroavailability" of organochlorine pesticide (OCPs) is being investigated using a fugacity meter in a controlled laboratory environment (design of Meijer et al., Environ. Sci. Technol., 2003). In the fugacity meter, air is first passed through a water reservoir to achieve ~100% relative humidity before it enters a soil column, where soil-air exchange takes place. Effluent air is passed through an adsorbent trap to capture volatilized OCPs, which are determined by GC-electron capture negative ion mass spectrometry. A Canadian organic rich soil which is highly contaminated with native OCPs was obtained and spiked with known amounts of ¹³C-labelled OCPs. Soil-air steady state was reached with an air residence time from 4 to 160 s, and the measured soil-air partition coefficients (K_{SA}) correlated well with the octanol-air partition coefficients (K_{OA}) with $r^2 = 0.92$. For aging experiments, spiked soils will be stored at room temperature in dark glass jars and K_{SA} measurements will be performed every 30-60 days for at least one year. The 'aeroavailability' of added labelled chemicals will be compared to native

residues that have been aged in the soil for decades. Results of these studies will improve soil-air exchange models by allowing the aging effect on secondary emissions to be taken into account.

TP100 Sonochemical Degradation of PFOS and PFOA as a Surface Catalyzed Process. C.D. Vecitis, H. Park, J. Cheng, M.R. Hoffmann, Environmental Science & Technology, Caltech, Pasadena, CA; B.T. Mader, 3M Environmental Laboratory, 3M, Maplewood, MN. The perfluorinated surfactants, perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) are recognized as ubiquitous in the environment as well as bio-accumulative, persistent, and recalcitrant towards conventional water treatment technologies. Acoustic cavitation as driven by high-frequency ultrasound has been shown to mineralize dilute aqueous solutions of these perfluorinated chemicals. The effect of initial PFOS and PFOA concentration, 10 nM to 1 mM each, (they were degraded simultaneously) on the sonolytic rate of degradation was evaluated at 354 kHz and 150 W L-1. The initial concentrations of PFOS and PFOA determine the relative partitioning of the surfactants to the bubble-water interface controlling the rate of degradation. The concentration dependent kinetics follow a Langmuir-Hinshelwood mechanism; at low concentrations the interface is sparsely covered and the kinetics are diffusion-adsorption controlled, at high concentrations the interface is completely covered and the kinetics are pyrolytically controlled. Alternatively, the kinetics can be modeled using the Michelis-Menton enzyme catalysis formalism or using a more statistical model based on the number of PFOX degraded per single transient bubble event.

TP101 Do lipid-soluble metal complexes exist in aquatic environments? D. Kilgore, S. Apte, Land and Water, CSIRO, Lucas Heights, New South Wales, Australia; M.P. Taylor, Physical Geography, Macquarie University, North Ryde, New South Wales, Australia. Information on the occurrence and concentration of lipid-soluble metal complexes in aquatic systems is scarce. This is somewhat surprising given the potential for these species to be more toxic than ionic metal species. In this presentation, we describe the development of robust analytical methods for the determination of lipid-soluble copper, nickel, cadmium and lead complexes in both waters and sediments. Water samples are analysed by liquid-liquid extraction with octanol, back-extraction into an acidic medium followed by quantitation by GFAAS. Overall, the method afforded a preconcentration factor of greater than 50, resulting in detection limits in the low part per trillion range. Sediment porewaters were sampled using an in situ technique involving octanol-filled dialysis cells. The cells were inserted into sediment and allowed to equilibrate for a period of several days. This technique overcomes the problem of sediment entrainment into the octanol phase. A range of aquatic environments were sampled ranging from pristine marine and freshwater sites to industrial and domestic wastewaters. Sediments from a range of contaminated environments were also sampled. Total metal and lipid-soluble metal concentrations will be presented and inferences drawn regarding the origin and formation of lipid-soluble metal complexes.

TP102 Effects of physical-chemical properties on the fate and partitioning of selected pharmaceuticals in the aquatic environment. Y. Nakamura, H. Yamamoto, S. Moriguchi, A. Hayashi, J. Sekizawa, Faculty of Integrated Arts and Sciences, University of Tokushima, Tokushima, Japan. Since pharmaceuticals have recently been detected by several researchers in the aquatic environment all over the world, the fate in the environment of these emerging contaminants became great concern. In this study, effects of physical chemical properties on the partitioning of pharmaceuticals between aquatic and solid or colloidal phase were investigated in detail. The selected pharmaceuticals were acetaminophen, atenolol, carbamazepine, ibuprofen, ifenprodil, indomethacin, mefenamic acid, and propranolol. The experiments were conducted to elucidate the sorption behavior of selected pharmaceuticals by sediments, natural organic matter (NOM), clay minerals and metal oxides. Organic carbon contents, grain diameter distribution, pH, zero point of charge, and cation exchange capacity (CEC) were determined to characterize the selected sediments/clays. The results of the experiments show that relatively large sorption coefficients were obtained for these with amino group(s), positively-charged at neutral pH while relatively low coefficients were obtained for these with carboxyl group, negatively-charged at neutral pH. No significant correlation was found between octanol-water distribution coefficients and the sorption coefficients but the organic contents of sediments showed moderate or strong linear correlation with the sorption coefficients for most of the selected pharmaceuticals. These results suggest the relatively large contribution of electrochemical affinity, cation exchange and the interaction

between π -electrons of pharmaceuticals and soil organic matter to the sorption in addition to the hydrophobic interaction.

TP103 Biodegradation Kinetic and Estimated Half-life of a Clariant Fluorotelomer-based Acrylate Polymer – Results from a Test on Aerobic Transformation in Soil after 15 Month of Exposure. V. Koch, Corporate Product Safety Env. Risk Assessment, Clariant Products (Germany) GmbH, Sulzbach, Germany; W. Knaup, R & D Fluorochemicals, Clariant Products (Germany) GmbH, Burgkirchen-Gendorf, Germany; S. Fiebig, T. Geffke, D. Schulze, Dr. U. Noack Laboratory, Sarstedt, Germany. Fluorotelomer-based substances like 8-2 Fluorotelomer alcohol (2-Perfluorooctylethanol) are speciality chemicals being used to synthesize e.g. high molecular weight Fluorotelomer-based acrylate polymers (FBAPs). FBAPs are used for coating of textiles, paper and carpet to achieve oil, stain and water repellency properties. Concerns that fluorotelomer-based polymers may be a source for low molecular Fluorotelomer-based substances which could be transformed to perfluorinated carboxylic acids like PFOA have triggered investigations on the biodegradation potential of a purified FBAP in aerobic soil. The PFOA measured in soil during this test on Aerobic Transformation may be residual PFOA in the FBAP and PFOA formed from degradation of the FBAP as well as from degradation of 8-2 Fluorotelomer alcohol. A three component 1st order kinetic model allows to attribute the origin of PFOA in the soil and the estimation of the half-life of 8-2 Fluorotelomer alcohol as well as the half-life of the Fluorotelomer-based acrylate polymer (FBAP).

TP104 Biodegradation of 8-2 Fluorotelomer alcohol in Digested Sludge – Transformation Products and relative Composition under Anaerobic conditions. V. Koch, Corporate Product Safety Env. Risk Assessment, Clariant Products (Germany) GmbH, Sulzbach, Germany; W. Knaup, R & D Fluorochemicals, Clariant Products (Germany) GmbH, Burgkirchen-Gendorf, Germany; S. Fiebig, T. Geffke, D. Schulze, Dr. U. Noack Laboratory, Sarstedt, Germany. 8-2 Fluorotelomer alcohol (2-Perfluorooctylethanol) is a speciality chemical being used to synthesize e.g. high molecular weight Fluorotelomer-based acrylate polymers (FBAPs). FBAPs are used for coating of textiles, paper and carpet to achieve oil, stain and water repellency properties. It is known from aerobic degradation studies in sludge and soil that 8-2 Fluorotelomer alcohol depending on the conditions may be transformed to 8-2 Telomer acid the corresponding unsaturated acid as well as PFOA. Before investigating the biodegradation behaviour of FBAPs under anaerobic conditions it has to be proven that 8-2 Fluorotelomer alcohol is transformed to the same products as under aerobic conditions for analytical reasons. Main product in this 63 day OECD 311 study is 8-2 Telomer acid. The unsaturated Telomeric acid as well as PFOA could be observed only in very small quantities.

TP105 Results from a Study on the Biodegradation Behaviour of a Clariant Fluorotelomer-based Acrylate Polymer coated on Polyester and Cotton Fabric under Landfill Simulation Conditions. V. Koch, Corporate Product Safety Env. Risk Assessment, Clariant Products (Germany) GmbH, Sulzbach, Germany; W. Knaup, R & D Fluorochemicals, Clariant Products (Germany) GmbH, Burgkirchen-Gendorf, Germany; H. Roepert, R. Stegmann, Waste Management, Hamburg University of Technology, Hamburg-Harburg, Germany; S. Fiebig, T. Geffke, D. Schulze, Dr. U. Noack Laboratory, Sarstedt, Germany. Fluorotelomer-based substances like 8-2 Fluorotelomer alcohol (2-Perfluorooctylethanol) are speciality chemicals being used to synthesize e.g. high molecular weight Fluorotelomer-based acrylate polymers (FBAPs). FBAPs are used for coating of textiles, paper and carpet to achieve oil, stain and water repellency properties. Concerns that fluorotelomer-based polymers may be a source for low molecular Fluorotelomer-based substances which could be transformed to perfluorinated carboxylic acids like PFOA have triggered investigations on the biodegradation potential of a commercial FBAP coated on Polyester and Cotton Fabric under landfill conditions. Due to the long residence time of waste in a landfill and the unknown sources of the waste the degradation behaviour of FBAPs in a municipal landfill is difficult to study. Instead a Landfill Simulation Study has been set up using artificial waste which is representative for the waste composition of municipal solid waste being dumped on American landfills today. Experimental set up of the Landfill Simulation and results are reported.

TP106 Critical Assessment of the Partitioning Properties of Permethyated Cyclosiloxanes in the Environment. S. Xu, G.E. Kozerski, D. Powell, Health and Environmental Sciences, Dow Corning Corporation, Midland, MI; J. Bazinet, Clariant LSM, Gainesville, FL; R. Gerhards, Degussa, Essen, Germany. Low molecular weight permethyated

cyclosiloxanes, known as cyclic volatile methyl siloxanes (cVMS), are intermediates in the synthesis of polydimethylsiloxanes and are also used in a wide variety of consumer products. Through these uses, cVMS may enter various environmental compartments. To accurately predict the environmental fate and transport of these materials, reliable physicochemical properties data are needed. New and previously published measurements or estimations of the air-water (K_{AW}), octanol-water (K_{OW}), and octanol-air (K_{OA}) partition coefficients of cVMS are presented. A critical assessment of the values is presented and recommendations are made for the selection of reliable and self-consistent values of K_{AW} , K_{OW} , and K_{OA} for cVMS based on best available data. Finally, the impact of the revised partition coefficients on the predicted environmental fate of cVMS is explored using multimedia fate models. This work was funded in part by the Silicones Manufacturers.

TP107 PBDEs and PCBs in environmental samples. H. Wei, M. Turyk, S. Dorevitch, A. Li, School of Public Health, University of Illinois at Chicago, Chicago, IL. PBDEs and PCBs are halogenated persistent organic pollutants found ubiquitous in the environment. They are semi-volatile, bioaccumulative and subject to long-range transport. In this study, 13 BDE and 39 PCB congeners were measured in environmental samples including indoor dust collected from residential homes and cars, urban airborne particles, lake sediments, and sludge (biosolids) generated from wastewater treatment process. For the six dust samples, the total PBDE (Σ 13BDEs) concentrations ranged from 948 to 6944 ng/g, with a median of 4010 ng/g and mean of 3530 ng/g; the total PCB (Σ 39PCBs) concentrations were in the range of 110~1250 ng/g, with a median of 220 ng/g and mean of 341 ng/g. For the four urban air particle samples, the concentration ranges were 264~304 and 11~32 ng/g, the medians were 292 and 30 ng/g, and the means were 288 and 26 ng/g, each respectively for Σ 13BDEs and Σ 39PCBs. The Σ 13BDEs concentrations were 4 and 22 ng/g dry weight in the two samples of inland lake surface sediments. Not surprisingly, the Σ 13BDEs concentrations were as high as 3016 and 5377 ng/g dry weight, compared with Σ 39PCBs of 3306 and 726 ng/g dry weight, in the biosolids collected from two wastewater treatment plants. Relative congener abundance patterns and Influencing factors for individual and total congener concentration differences of PBDEs and PCBs in different samples are discussed.

TP108 Occurrences of pharmaceutical and personal care products (PPCPs) in Mangyeong river, South Korea. J. Kim, H. Ishibashi, M. Hirano, K. Arizono, Toxicological Sciences, Prefectural University of Kumamoto, Kumamoto, Japan; J. Kim, Faculty of Civil & Environmental Engineering, Kunsan National University, Kunsan, South Korea; Y. Takao, Faculty of Environmental Studies, Nagasaki University, Nagasaki, Japan. The present study demonstrates the occurrence of pharmaceutical and personal care products (PPCPs) in sewage treatment plant effluents and surface waters in Mangyeong river, South Korea. PPCPs were analyzed by a liquid chromatograph coupled with a tandem mass spectrometer (LC-MS/MS). The analytical method was used in study of the Mangyeong river water for contamination by PPCPs and the following concentrations (ng/L) have been obtained: ibuprofen (ND-1768.0), mefenamic acid (23.5-4993.2), indomethacin (ND-648.5), carbamazepine (20.2-1444.0), propranolol (ND-179.0), atenolol (4.2-3356.4), disopyramide (ND), ifenprodil tartrate (ND), famotidine (ND-1158.7), fluconazole (73.4~2043.2), erythromycin (2.8-936.1), clarithromycin (9.8-4981.6), levofloxacin (ND-922.1), triclosan (ND). The concentrations of mefenamic acid, atenolol and clarithromycin were higher than those of other compounds. The high concentration was detected in the downstream area where population was concentrated. To our knowledge, this is the first report on the contaminants of PPCPs in Mangyeong river of South Korea.

TP109 Advanced Oxidation Processes in the Treatment of Contaminant Candidate List (CCL) Compounds. J.R. Peller, K. Vinodgopal, Department of Chemistry, Indiana University Northwest, Gary, IN; M. Elovitz, U.S. EPA, Cincinnati, OH. The current (2nd) Contaminant Candidate List was completed in 2005 by the United States EPA as an update to the Safe Drinking Water Act. The list of 42 chemical contaminants spans a wide array of classes, from pesticides to chlorinated solvents to elements, all of which are anticipated or known to be present in public water supplies. One focus of the EPA, in relation to the CCL, is to conduct research on these contaminants to determine the most useful means for remediation. Gaining most recent attention are the Advanced Oxidation Processes (AOPs), techniques that generate the hydroxyl radical, a strong, relatively nonselective oxidant, in aqueous environments. In reactions with most organic compounds, the

hydroxyl radical effectively oxidizes the compounds by addition of the $\bullet\text{OH}$, by electron transfer or by hydrogen abstraction. Further hydroxyl radical reactions typically take place with the oxidized intermediates, and complete oxidation to form carbon dioxide and water often is the result with longer time exposures. The efficiency of these reactions, or the rate at which the hydroxyl radical reacts with the contaminant, is essential knowledge to assess the effectiveness of the AOPs. The best means to determine these reaction rates involves the technique of pulse radiolysis, where high energy radiation is used to form hydroxyl radicals and short timescale detection methods are implemented. Rate constant determinations were performed for sixteen of the chemical listed on the CCL using pulse radiolysis techniques at the Radiation Laboratory on the campus of the University of Notre Dame. All of the tested compounds reacted with the hydroxyl radical, and in most cases, the UV spectrum of the reactive intermediate (transient) was readily detected. With the compounds that did not display a measurable UV absorption, competition kinetics experiments were conducted to measure the rate constants. In all cases, solutions were pre-saturated with nitrous oxide gas to ensure that only the hydroxyl radical reaction took place and typical calculated rate constants fell in the $2\text{--}6 \times 10^9 \text{ M}^{-1}\text{s}^{-1}$ range. Absolute rate constants for all 16 compounds are reported and chemical structures are linked to reactions rates for an evaluation of the potential of Advanced Oxidation Processes.

TP111 Distribution, mutagenesis, and biochemical toxicity of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and its N-nitroso metabolites in rodents. X. Pan, G.P. Cobb, Texas Tech University, Lubbock, TX; X. Pan, Western Illinois University, Macomb, IL. Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) is one of the most important explosives used nowadays. In the environment, RDX can be transformed to its potential carcinogenic N-nitroso metabolites: hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine (MNX), hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine (DNX), and hexahydro-1,3,5-trinitroso-1,3,5-triazine (TNX) by various bacteria. The Salmonella tryphimurium reverse mutation assay using a pre-incubation and high S9 activation at dose range of 20-1000 $\mu\text{g}/\text{plate}$ revealed that RDX induced weak mutagenesis to strain TA97a, while MNX and TNX induced moderate mutagenesis. In the stomach of B6C3F1 mice exposed to RDX contaminated diet at 0, 0.5, 5, 50, and 500 mg/kg for 28 days, the MNX and DNX concentrations were 0-490 $\mu\text{g}/\text{kg}$ and 0 - 119 $\mu\text{g}/\text{kg}$, respectively. The average RDX and MNX concentrations in the brain of B6C3F1 mice were 15144 and 165 $\mu\text{g}/\text{kg}$ for the 500 mg/kg group, respectively. Despite that RDX was transformed to notable amount of its N-nitroso metabolites in the GI tract, the overall intestinal enzymes activity was not significantly affected: including nitroreductase (NR), β -galactosidase (GAL), β -glucuronidase (GLR), and β -glucosidase (GLU). Other toxic endpoints including body weight gains, food consumptions, organ weights, and behaviors were also reported.

TP112 Predicting Chemical Hydrolysis. R.S. Boethling, Office of Pollution Prevention and Toxics, US EPA, Washington, DC; W.M. Meylan, P.H. Howard, Environmental Science Center, Syracuse Research Corporation, N. Syracuse, NY. Hydrolysis is a bond making/breaking process in which a molecule reacts with water, forming a new bond with the oxygen atom from water and breaking the susceptible linkage in the original molecule. It provides not only the baseline loss rate for chemicals in the water compartment, but is also relevant to environmental fate wherever water is present; e.g. clouds, fog and moist soil. The Hydrowin program (v1.67), in EPI Suite (<http://www.epa.gov/opptintr/exposure/pubs/episuite.htm>), estimates hydrolysis rate constants and half-lives from chemical structure but is one of EPI's oldest programs. Currently it estimates acid and base catalyzed hydrolysis but not neutral hydrolysis for a limited set of chemical classes: esters, carbamates, epoxides, halomethanes and some alkyl halides. We have developed a new version that greatly expands Hydrowin's scope and utility. Some additional classes such as organophosphorus compounds are now estimated quantitatively. However, a different approach is taken for other chemical classes in which chemicals are assigned to half-life ranges (e.g. minutes-hours; hours-days) based on functional groups. The new version of Hydrowin contains an extensive database of measured values which are either in the help menu or are displayed in the output for quantitative (i.e. from QSAR) or qualitative estimates. For example, if a chemical is an aliphatic anhydride the program gives a qualitative prediction (e.g. hours to days), but it also displays the full range of compounds with this functionality in the database, along with their measured half-lives. This new Hydrowin will be integral to an updated version of EPI Suite.

TP113 Spatial Distribution and Pathways of HCHs in the Canadian Archipelago. T. Bidleman, L. Jantunen, Centre for Atmospheric Research Experiments, Environment Canada, Egbert, Ontario, Canada; H. Kylin, Department of Environmental Assessment, Swedish University of Agricultural Sciences, Uppsala, Sweden; H. Kylin, Norwegian Institute for Air Research, Tromsø, Norway; P. Helm, Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, Toronto, Ontario, Canada; R. Macdonald, Institute of Ocean Sciences, Department of Fisheries and Oceans, Sidney, British Columbia, Canada. Hexachlorocyclohexanes (HCHs) in the surface water of the Canadian Archipelago and south Beaufort Sea were measured in summer, 1999. Concentrations of HCH isomers were in order of abundance: alpha-HCH ($3.5 \pm 1.2 \text{ ng L}^{-1}$) > gamma-HCH ($0.31 \pm 0.07 \text{ ng L}^{-1}$) > beta-HCH ($0.10 \pm 0.03 \text{ ng L}^{-1}$). Concentrations and ratios of alpha-HCH/gamma-HCH decreased significantly ($p < 0.001$ to 0.003) from west to east, but there was no significant variation in alpha-HCH/beta-HCH. The (+) enantiomer of alpha-HCH was preferentially degraded, with enantiomer fractions (EFs) ranging from 0.432 - 0.463 and increasing significantly ($p < 0.001$) from west to east. Concentrations also varied latitudinally for alpha-HCH and gamma-HCH ($p < 0.002$), but not for beta-HCH. Principal component analysis with variables alpha-HCH and gamma-HCH concentrations, EF, latitude and longitude accounted for 71% (PC 1) and 16% (PC 2) of the variance. Mixing in the eastern Archipelago was modelled by assuming three end members with characteristic concentrations of alpha-HCH and gamma-HCH. The model accounted for the observed concentrations and higher EFs of alpha-HCH at the eastern stations.

TP114 Air-Water Gas Exchange of HCHs in the Canadian Archipelago. T. Bidleman, L. Jantunen, Centre for Atmospheric Research Experiments, Environment Canada, Egbert, Ontario, Canada; P. Helm, Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, Toronto, Ontario, Canada; H. Kylin, Department of Environmental Assessment, Swedish University of Agricultural Sciences, Uppsala, Sweden; H. Kylin, Norwegian Institute for Air Research, Tromsø, NORWAY. Air and water were sampled in the Canadian Archipelago during summer on the Tundra Northwest 1999 (TNW-99) expedition and air was sampled at Resolute Bay (RB), Nunavut, to determine the gas exchange of alpha- and gamma-hexachlorocyclohexanes (HCHs) and the enantiomers of alpha-HCH. Air concentrations of total HCHs during TNW-99 and at RB were similar, averaging 55 and 53 pg m^{-3} , respectively. The net gas exchange direction was volatilization for alpha-HCH and near equilibrium or deposition for gamma-HCH, while actual fluxes depended on the fraction of open water. EFs in air sampled from ship were significantly correlated to those in surface water for events with >90% open water, but were closer to racemic and not correlated to EFs in water for events with 0-50% open water. Levels of alpha-HCH in air at RB averaged $37 \pm 9 \text{ pg m}^{-3}$ from June - early July and EFs were close to racemic (0.496 ± 0.003). In mid-July the ice pack broke up around RB. From this point through August, alpha-HCH in air increased significantly to $53 \pm 5 \text{ pg m}^{-3}$ and the mean EF decreased significantly to 0.482 ± 0.010 . Air concentrations of gamma-HCH at RB did not differ significantly before ($8.0 \pm 3.8 \text{ pg m}^{-3}$) and after ($6.6 \pm 0.76 \text{ pg m}^{-3}$) ice breakup. Results show that alpha-HCH enantiomers are sensitive tracers for following the impact of ice cover loss on gas exchange in the Arctic.

TP115 Chiral Taste and Odour Compounds in the St. Lawrence River and Lake Ontario. T. Bidleman, Centre for Atmospheric Research Experiments, Environment Canada, Egbert, Ontario, Canada; S. Watson, Environment Canada, National Water Research Institute, Burlington, Ontario, Canada; J. Ridal, St. Lawrence River Institute of Environmental Sciences, Cornwall, Ontario, Canada. Geosmin (*trans*-dimethyl-*trans*-9S-decalol) is a principal cause of musty odour and taste in drinking water drawn from the Great Lakes. Geosmin is a sesquiterpenoid produced by several microorganisms, including actinomycete bacteria, cyanobacteria, fungi and other moulds. It is a principal odour component in soil and has been identified in lakes, reservoirs, pulp mill effluent treatment ponds and wine contaminated by moulds. Most reports indicate that the (-) enantiomer is the naturally synthesized form of geosmin. The enantiomer composition of geosmin found in the Great Lakes has not been characterized. This is important, since the odour threshold of (-) geosmin ($< 10 \text{ ng/L}$) is about 10 times lower than the (+) form. The commercial standard used by most labs for sensory and chemical analyses is a racemic mix. Extracts of water collected from the St. Lawrence River and Lake Ontario, and from pure cultures of microorganisms, were analysed for geosmin and a second musty-flavoured

terpenoid, 2-methylisoborneol (2-MIB). Concentrations ranged from 2.2-8.7 ng/L for geosmin and 1.1-2.5 ng/L for 2-MIB. Separation and identification of enantiomers was achieved by GC-MS on chiral-phase columns. Only the (–) enantiomer of geosmin was found in all water samples.

TP116 Enantiomeric composition of polychlorinated biphenyls (PCBs) in the aquatic and riparian food web of Twelve Mile Creek, South Carolina (USA). V.D. Dang, C.M. Lee, Environmental Engineering & Science, Clemson University, Anderson, SC; D.M. Walters, National Exposure Research Laboratory, US EPA, Cincinnati, OH. Enantioselectivity of eight PCB atropisomers, (95, 91, 84, 136, 132, 176, 149, and 176) were measured for members of an aquatic and riparian ecosystem of Twelve Mile Creek. Twelve Mile Creek, a tributary of Lake Hartwell, drains the former Sangamo Weston plant, which is a PCB-contaminated Superfund site in Pickens County, SC. Riparian amphibian and spider predators were collected in the spring, summer, and autumn 2005 and fish was collected in autumn 2005 and 2006 from four sites spanning 25 stream km. Enantiomer fractions (EFs) of PCB atropisomers were separated by capillary gas chromatography (GC-ECD) with a Chirasil-Dex column. PCB 95 and 149 were detected in samples from all four sites while PCB 136 was detected at three sites and PCB 174 at only one location. The EF for PCB 95 was racemic (0.5) in most samples meanwhile the EF for PCB 149 was often non-racemic ($\neq 0.5$). The EF values for PCB 136 and 174 were also found to be non-racemic. The observations revealed a site-dependent pattern, which suggests that the bioprocessing of PCB atropisomers in the aquatic and riparian food web may be controlled by several different site-specific variables.

TP117 Association of Polybrominated Diphenyl Ethers (PBDEs) Concentrations in Blubber with Health Status in Bottlenose Dolphins (*Tursiops truncatus*) Along the Southeast United States. P.A. Fair, G. Mitchum, E. Wirth, J.D. Adams, E. Zolman, National Ocean Service, Charleston, SC; J.S. Reif, College of Veterinary Medicine and Biomedical Sciences, Colorado State University, Fort Collins, CO; T.C. Hulsey, Pediatric Epidemiology, Medical University of South Carolina, Charleston, SC; P.A. Fair, G.D. Bossart, Center for Coastal Research, Harbor Branch Oceanographic Institution, Fort Pierce, FL. Polybrominated diphenyl ethers (PBDEs), a class of brominated flame retardant chemicals, are known to bioaccumulate and biomagnify in aquatic ecosystems. Serious concern exists on potential health risks from exposures to these chemicals. Six PBDE congeners (28, 47, 99, 100, 153, and 154) were routinely detected in blubber tissue samples ($n = 145$) collected during dolphin capture-release health assessment studies in 2003-2005 near Charleston, SC (CHS) and the Indian River Lagoon, FL (IRL). Significantly higher ($P \leq 0.001$) median Σ PBDE blubber concentrations were observed for CHS dolphins (4,599 ng/g lipid; range = 295-22,783 ng/g lipid) compared to IRL dolphins (1,257 ng/g lipid; range = 195-3,791 ng/g lipid). PBDE concentrations were evaluated with biological factors such as age and gender, and temporal and spatial data. To examine the association between PBDE concentrations and health status, dolphins were classified as normal, possible disease or definite disease by an expert marine mammal panel using a host of clinical parameters. Dolphins from both populations had a high prevalence of definite disease (28%) and less than half of the dolphins at each site were classified with normal health (49% IRL; 43% CHS). The definite disease category contained dolphins with two diseases, lobomycosis and orogenital neoplasia, which comprised 62% of the definite disease diagnoses while abnormal hematology/serum chemistry accounted for the remaining diagnosis. In CHS dolphins, significant differences ($P \leq 0.04$) in median Σ PBDE were observed among the different disease classifications with increasing concentrations found for normal (4,288 ng/g), possible disease (4,494 ng/g) and definite disease (6,512 ng/g) categories. In contrast, no differences in the levels of PBDEs and disease classifications were found in the IRL dolphins. The levels of PBDEs in Charleston dolphins represent some of the highest measured in marine mammals and the association found in assessing PBDEs in relation to health status may further elucidate potential deleterious effects of these emerging, bioaccumulative chemicals.

TP118 In vitro exposure to methyl mercury (MeHg) or perfluorooctane sulfonate (PFOS) alters gene expression in primary epidermal cells of the bottlenose dolphin, *Tursiops truncatus*. M. Mollenhauer, M. Peden-Adams, Medical University of South Carolina, Charleston, SC; B. Carter, Ecoarray, Inc., Alachua, FL; G. Bossart, Harbor Branch Oceanographic Institution, Fort Pierce, FL; P. Fair, National Ocean Service, Charleston, SC. Methylmercury and perfluorooctane sulfonate bioaccumulate and biomagnify in the

environment and increasing concentrations of these pollutants have been found in wildlife and humans. Both chemicals are worldwide contaminants with wide ranging biological effects and have been identified in relatively high concentrations in wild bottlenose dolphins. The primary objective of this study was to determine if exposure to MeHg and PFOS would alter gene expression in primary bottlenose dolphin epidermal cell cultures. Secondly, this study aimed at developing a novel tool for analyzing the cellular affects of marine mammal exposure to environmental agents, a bottlenose dolphin skin macroarray. Primary skin cells were isolated and cultured from skin samples collected from wild bottlenose dolphins. The cells were subsequently exposed to 13ppm PFOS or 1ppm MeHg and used to construct a subtractive cDNA library resulting in 130 unique genes, representing the differentially expressed genes in contaminant exposed cells versus unexposed cells. These 130 genes were used to construct a bottlenose dolphin gene macroarray for identification of gene expression patterns following *in vitro* exposure to MeHg and PFOS. Quantitative real time PCR was performed to further analyze patterns of expression for 20 genes. Results indicate MeHg significantly alters gene expression patterns following 24hrs, but has no measurable effect after only one hr. PFOS exposure, however, caused significant alterations following both one and 25hrs. Overall, the alterations in gene expressions observed indicate these concentrations of MeHg and PFOS significantly alter normal gene expression patterns indicative of a modified cellular environment. Data from these experiments show that exposure of primary dolphin skin cells to these concentrations of MeHg and PFOS significantly alter normal cellular functioning. Alterations in normal cellular biology may lead to changes in health in marine mammals exposed to contaminants, however, this warrants further investigation.

TP119 Concentrations of persistent organic pollutants in an endangered species, the West Indian manatee (*Trichechus manatus*), sampled in southeastern Mexico. E.L. Pulster, D. Wetzel, Center for Ecotoxicology, Mote Marine Laboratory, Sarasota, FL; J. Reynolds, Center for Marine Mammal Research, Mote Marine Laboratory, Sarasota, FL; B. Morales-Vela, Te'cnico Proyecto Manatí, El Colegio de la Frontera Sur (ECOSUR), Chetumal, Mexico. Persistent organic pollutants (POPs) have existed since the 1800's and have since been measured in many marine organisms globally; however, studies of contaminants of any type have been exceedingly rare in endangered manatees (*Trichechus manatus*). Although manatees have no natural predators, they are threatened by a variety of human activities, including boating, habitat destruction, and use of pesticides and other contaminants. Given the prevalence of fat/blubber, coastal habitat (i.e., in proximity to agricultural areas and other habitats impacted by people), and the long lifespans of marine mammals such as manatees, certain pollutants can bioaccumulate at very high levels. The objective of this study was to determine baseline concentrations of polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) in manatees sampled in Chetumal Bay, in southeastern Mexico. Although concerns exist in this region about contaminant levels and effects, no studies of body burdens in manatees have been done in this region. Blubber biopsies were collected from nine manatees and analyzed by GC-ECD and GC-MS. Measurable amounts were detected of OCPs, including BHC, HCB, oxychlordane, methoxychlor, mirex, DDT, and DDT metabolites. The PCB concentrations ranged from 0.022 to 20.1 $\mu\text{g/g}$ wet weight in blubber. These high levels exceed current thresholds for toxic endpoints and warrant further research.

TP120 Mercury and Selenium in Beluga Whale and Irrawaddy Dolphin Tissues. N.V. Ralston, Energy & Environmental Research Center, University of North Dakota, Grand Forks, ND; J. Robertson, Research Reactor, University of Missouri, Columbia, MO. Mercury (Hg) bioaccumulates in animal tissues and can cause toxic effects if it accumulates in brain tissues at molar concentrations that approach or exceed those of selenium (Se). The molecular mechanisms of Se-dependent Hg-accumulation in animals, Hg toxicity, and Se-protective effects against Hg-toxicity all depend on the extraordinarily high binding affinity between Hg and Se ($10E45$). The molecular form of Hg that accumulates in tissues is the highly insoluble HgSe. All forms of animal life that possess nervous systems require Se in order to form the rare but essential amino acid selenocysteine, the bioactive form of Se. Selenocysteine is required by 25-35 Se-proteins. Several of the characterized Se-enzymes are known to either reverse oxidative damage and/or detoxify reactive oxygen metabolites formed as a natural consequence of aerobic metabolism. Se-dependent physiology is extremely vulnerable to Hg toxicity because Hg can sequester the Se that is required for selenocysteine synthesis.

Supplemental Se has been shown to protect against Hg toxicity in all animal species studied, but it is very important to maintain additional Se in the normal dietary range since excessive Se can also have toxic effects. Resistance to Hg toxicity is inversely related to intracellular Se availability in brain and other vulnerable tissues that depend on Se-dependent enzyme activities. Although seafoods all contain some level of accumulated Hg, ocean fish tend to be relatively rich in Se. However, it is important to note that Se in bodies of fresh water can be highly variable. Geological distribution of Se tends to follow regional trends, but Se availability can vary dramatically and its bioavailability is highly dependent on pH. Therefore, although beluga whales will tend to be well supplied with Se to protect against toxic effects of Hg, animals exposed to Hg in bodies of fresh water can be far more vulnerable. Anthropogenic releases of Hg can cause high local accumulations of Hg in fish, particularly if Se is poorly available in the ecosystem. The Se status of the Mekong river that Irrawaddy dolphins occupy is currently unknown. If Se availability is poor in the soils that drain into the Mekong, Hg accumulation in fish will be increased and vulnerability of dolphins and humans that consume these fish will be greater.

TP121 Why do current regulations and guidelines fail to protect marine mammals from persistent organic pollutants (POPs)? B. Hickie, Environmental Science, Trent University, Peterborough, Ontario, Canada; P.S. Ross, L. Mos, Fisheries & Oceans, Inst. of Ocean Sciences, Sidney, British Columbia, Canada; L. Mos, Hemmera Consulting, Victoria, British Columbia, Canada; S. Jeffries, Washington Dept. Fish & Wildlife, Tacoma, WA; J. Ford, Pacific Biological Station, Fisheries & Oceans, Nanaimo, British Columbia, Canada; F. Gobas, Simon Fraser University, Burnaby, British Columbia, Canada. While industrialized nations banned many persistent organic pollutants (POPs) three decades ago, their legacy continues to haunt marine mammals the world over. While the 'complex mixtures' to which marine mammals are exposed render it difficult to generate the certainty often required for regulatory action on specific chemicals, a weight of evidence suggests that polychlorinated biphenyls (PCBs) have affected reproductive health, immune function and endocrine function in pinnipeds and cetaceans inhabiting industrialized regions. However, our discovery that the killer whales of the more remote NE Pacific Ocean are the most PCB-contaminated marine mammals in the world provides evidence of a regulatory failure on a global scale. Using individual and life history-based models, we estimate that it will not be until the 22nd Century that 95% of the endangered southern resident killer whale population will fall below the currently-used health effects threshold. In addition, we predict that the most conservative international dietary guidelines (exposure via prey) designed to protect aquatic animal life from PCBs would lead to contaminant burdens in killer whales that exceed this threshold by six-fold. Finally, our recent field studies of harbour seals support a revised, more conservative effects threshold of approximately 1 mg/kg in harbour seals, more than ten times lower than the previously established threshold in captive seals. Since both legacy (e.g. PCBs) and currently-used (e.g. PBDEs) chemicals present health risks to biota, there is an urgent need for national and international regulatory sectors to address the particular vulnerability of marine mammals to contaminants. Collectively, our research suggests that regulatory paradigms for POPs have failed to protect marine mammals, due to their lack of consideration of longevity and high trophic level. Given the rapid dispersion of many pollutants away from sources and into remote regions, chemicals considered to be Persistent, Bioaccumulative, and Toxic, will continue to present conservation threats to marine mammals around the world.

TP122 A weight-of-evidence framework for reaching scientific consensus on causality. J.L. Durda, A. Bradley, Integral Consulting Inc., Annapolis, MD; L.P. Brzuzu, Shell Chemical LP, Houston, TX. A site-specific, weight-of-evidence (WOE) decision framework was developed and applied by a multi-stakeholder group to assess the potential contribution of groundwater discharges to sediment toxicity in a Texas bayou. The framework was developed because existing published WOE frameworks were too narrow in focus to address the types of information being considered in the assessment, did not consider causality, and/or used decision criteria that were not explicitly defined *a priori*. This framework incorporates analyses of four independent lines of evidence: chemical correspondence between groundwater and sediment; chemical loading from groundwater to sediment; risk analysis; and spatial analysis of toxicity data. It requires stakeholders to weight types of data and lines of evidence on a relative scale that reflects data quality and certainty as well as overall relevance to the questions being addressed. Analyses that are

tied most closely to the assessment question are given a higher weight, and ultimately have the greatest influence on the conclusions. The framework is being used to reach consensus on whether groundwater has contributed to measured sediment toxicity in the bayou. The scientific answer is then linked to a pre-defined management decision for the site. We present the results of this specific application and discuss how this WOE framework, or the process used to develop it, can be applied to similar cases to synthesize, reconcile, and integrate multifaceted data to understand causality and inform management decisions.

TP123 The OECD Validation Program of the H295R Steroidogenesis Assay for the Identification of Inhibitors and Inducers of Hormone Production. M. Hecker, ENTRIX, Inc., Saskatoon, Saskatchewan, Canada; M. Hecker, E. Higley, J. Giesy, Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; H. Hollert, Department of Zoology, University of Heidelberg, Heidelberg, Germany; R. Cooper, RTD, NHEERL, ORD, US-EPA, RTP, NC; Y. Akahori, CERL, Chemicals Assessment Center, Saitama, Japan; M. Murphy, J. Giesy, Department of Biology & Chemistry, City University of Hong Kong, Hong Kong, SAR, China; C. Nellesmann, Department of Toxicology & Risk Assessment, Technical University of Denmark, Soborg, Denmark; J. Newsted, ENTRIX, Inc., Okemos, MI; G. Timm, Office of Science Coordination & Policy, US-EPA, Washington, DC. In response to concerns about chemical substances that may adversely alter the function of endocrine systems and affects human health, an OECD initiative was undertaken to develop and validate in vitro and in vivo assays to identify chemicals that may interfere with endocrine systems of vertebrates. Here we report on the development and standardization of a cell-based screening assay using the H295R cell line to prioritize chemicals that may act on steroidogenic processes that are part of this OECD initiative. Six laboratories from five countries each tested the effects of three model chemicals on the production of testosterone (T) and estradiol (E2) using the H295R Steroidogenesis Assay. Chemicals tested were well described inducers or inhibitors of steroidogenic pathways (forskolin, prochloraz, and fadrozole). All laboratories successfully detected increases and/or decreases in hormone production by H295R cells after exposure to the different model compounds and there was good agreement in the pattern of response for all groups. Forskolin increased both T and E2 while fadrozole and prochloraz decreased production of both hormones. Some inter-laboratory differences were noted for hormone production measured in some chemically exposed cells. However, with the exception of the production of T measured at one laboratory in cells exposed to forskolin, the calculated EC50s were comparable (coefficients of variation 34 - 49%) for all hormones. The results indicated that the H295R Steroidogenesis Assay protocol was robust, transferable, and reproducible across all laboratories. The next phase of the OECD validation program will test the refined protocol across the same group of laboratories using an extended set of chemicals (~30) including positive and negative chemical controls as well as a broad spectrum of different potential inducers and inhibitors of steroidogenic pathways.

TP124 Professional Integrity and Environmental Ethics: A Perspective for Discussion and further Mentoring. C.M. Erickson, at time of submission, XXX, Glen Allen, VA. The objective of this presentation is to begin a dialog among scientists on a highly requested, appropriate, and necessary topic: professional integrity and environmental ethics. This presentation is designed to segway into further professional and scientific discussions on keeping environmental ethics and professionalism in a field where: * funding is scarce and ever changing in the university settings, * contracting for consulting is often challenging, and * scientists are subjected to pressure to falsify or compromise data, to get published in scientific journals, keep contracts, or win bids, and * scientists piecemeal results or publish similar results in more than one journal. Lastly, the goal of this presentation is to further initiate a discussion on how to conduct ethical science while avoiding potential political and legal conflicts, where possible. Respecting professional differences in opinion and gender may also be discussed in order to encourage not only a healthy work environment, but a more professional society. This presentation is designed to help 1) segway into a session on environmental ethics and professional integrity, and 2) propose mentoring of scientists, with emphasis on junior scientists and women in preparing for a career in environmental science once one has left graduate school.

TP125 Vegetated Ditches as a Management Practice in Irrigated Alfalfa. S. Gill, F.C. Spurlock, K.S. Goh, C.R. Ganapathy, CA Dept. Pesticide Regulation, Sacramento, CA. The organophosphate (OP) insecticides

diazinon and chlorpyrifos have been frequently detected in the San Joaquin River, California, USA. Irrigation tail waters are a source of OP pesticides in the watershed. This study tested a constructed, vegetated irrigation tailwater water conveyance ditch as a potential management practice for reducing off-site movement of chlorpyrifos to surface water from flood irrigated alfalfa. Chlorpyrifos concentrations in whole-water samples of irrigation runoff were variable and ranged from 0.22 ppb to a maximum of 1.67 ppb. The median concentration reduction at the end of a 200 m vegetated ditch was 38% compared to 1% in an adjacent conventional tail water ditch. Runoff data collected represented first flush runoff from sets that were irrigated between 48h and 144h after chlorpyrifos application. There was no consistent effect of irrigation lag time on chlorpyrifos concentration in tailwater for lag times of up to 144h. Consequently these data indicate that delayed irrigation is not an effective management practice for reducing chlorpyrifos off-site movement to surface water in California flood irrigated alfalfa.

TP126 Unified assessment of biological condition: Expert judgment and fuzzy set models. J. Gerritsen, Tetra Tech, Inc., Owings Mills, MD. Aquatic Biological Criteria in many states of the US are set very low so that substantial degradation is permitted before any regulatory action is required. As a result, high quality waters lack protection from incremental, cumulative degradation. Furthermore, the one-size-fits-all criteria are often unrealistic targets for historically urban waters. EPA's Biological Condition Gradient (BCG) model is a framework for establishing and assessing consistent, multiple levels of condition that correspond to the observed response of aquatic biota to increasing human alteration. Assessment of a water body and assignment to a condition class is based on decision rules such as: 'If richness of sensitive taxa is high, then condition is nearly natural.' Quantitative rules can in turn be developed from the qualitative descriptions of natural and stressed aquatic assemblages. We have developed BCG models for streams in the Northeastern US, including single state data as well as multiple-agency databases collected with multiple methods. An iterative procedure including multivariate analysis of taxonomic and stressor variables, and expert consensus to determine taxa sensitivity and biological condition classes, reduces bias of individual experts. To automate site class assignment, we developed quantitative fuzzy set models which replicated consensus of experts. The fuzzy set approach is a direct application of the decision rules; it can be nonlinear; it is robust to missing information; and it is open to new information on taxa, natural history, and ecosystem processes. The BCG meets the need for consistency: the final rule statements and assessments were consistent among states and stream types (though not identical), and the quantitative fuzzy set models replicate and automate the expert decision methods.

TP127 Technical Review of Toxic Air Contaminant Regulations. D.R. Huff, Shaw Environmental, Inc., Onalaska, WI. A technical review of the Ohio Environmental Protection Agency's (OEPA) proposed toxic air contaminants (TAC) list was completed. To provide a context for the TAC selection process, a state-by-state review of air toxics regulations in ten other states (California, Indiana, Illinois, Kentucky, Michigan, New Jersey, North Carolina, Oklahoma, Texas and Wisconsin) was further evaluated. The intent of this review was to identify and confirm methods and criteria used by other states to select TACs and to regulate air toxic emissions. The USEPA hazardous air pollution (HAP) list listing/delisting procedure was also reviewed. This presentation will provide state specific summaries along with highlights of the air toxics rules and statutes. The review focuses primarily on selection of TAC lists. In the review of the selected state TAC programs it was discovered that there are a number of different approaches used to create TAC lists. None of the states select TACs in the exact same way. TAC lists range from less than 40 to greater than 1800 substances. Likewise the approaches to regulating emissions of air toxics are varied and state-specific. The presentation will also discuss the application of risk assessment to air quality compliance now and in the future. The discussion will include the potential broad geographic schedule of national risk based air quality standards to be implemented over the next several years.

TP128 Using the Bacteroides host-specific Bacterial Source Tracking method to identify fecal contamination sources in two areas of British Columbia. H. Osachoff, M. Linsen Sauve, G. van Aggelen, Environmental Toxicology, Environment Canada, North Vancouver, British Columbia, Canada; H. Osachoff, Department of Biology, Simon Fraser University, Burnaby, British Columbia, Canada; R. Nordin, A. Mazumder, Department of Biology, University of Victoria, Victoria, British Columbia, Canada; K. Broersma, Kamloops Range Research Station, Agriculture and Agri-Food

Canada, Kamloops, British Columbia, Canada; W. Harper, Department of Microbiology, University of British Columbia, Vancouver, British Columbia, Canada. As a part of a larger project funded by the Canadian Institutes of Health Research (CIHR), we used the host-specific *Bacteroides* Bacterial Source Tracking (BST) method to analyze fresh and marine water samples from two distinctly different geographical areas of British Columbia, Canada. This BST method can show the presence or absence of fecal material from humans, ruminant animals, pigs, elk, dogs and horses. The overall objective of the CIHR-funded project was to improve human health by eliminating fecal pollution from water. The first step towards meeting that objective was identifying the organism or organism(s) responsible for the fecal pollution. There are many fecal source tracking methods available and the environmental samples taken for the CIHR project compared multiple methods, including: antibiotic resistance, ribotyping, rep-PCR, host-specific *Bacteroides*, and more. Water samples were taken over the course of a year from six fresh water and six marine water sites on Saltspring Island, and from six fresh water sites in the Okanagan Valley. The host-specific *Bacteroides* BST method results from these samples will be shown and discussed in regards to the reproducibility of the method and the seasonal trends at the sampling sites.

TP129 Development of Delisting Targets for the St Louis River Area of Concern on Lake Superior. J. John, WDNR, Superior, WI; M. Brose, SEH Inc., Chippewa Falls, WI; R. Schramek, S. Sinha, ECT Inc., Ann Arbor, MI. This paper describes a recently completed review of citizen-developed restoration goals for the St. Louis River Area of Concern (SLAOC) by the State of Wisconsin Department of Natural Resources (WDNR), with financial support from the United States Environmental Protection Agency (USEPA)'s Great Lakes National Program Office (GLNPO). The St Louis River AOC is located within the largest U.S. tributary to Lake Superior and is jointly shared by the States of Wisconsin and Minnesota. Together with stakeholders, WDNR and its consultants developed draft delisting targets for each of nine beneficial use impairments (BUIs). This work is a culmination of effort that began in 2004 when the St Louis River Citizens Action Committee (SLRCAC) proposed restoration goals for each of the nine BUIs. Special attention was given to review delisting guidance documents developed elsewhere, including for AOCs located in Michigan, Ohio, and Canada. Detailed technical and programmatic review of the restoration goals, and subsequent draft delisting targets was conducted by geographically dispersed experts located within several departments of the WDNR, the Wisconsin Department of Health and Family Services (DHFS), Douglas County, the City of Superior, University of Wisconsin, and the US Geologic Survey. Concurrently, the WDNR (and its contractors) met with members of the SLRCAC, the Minnesota Pollution Control Agency (MPCA) and the USEPA-GLNPO to develop consensus for draft delisting targets. Evolution of the draft delisting criteria will continue through 2008 as the Minnesota programmatic review is completed and integrated with the Wisconsin proposed goals, and subsequent public review and comment ensues. On a final note, the WDNR's experience in the development of the draft delisting criteria for the St Louis River AOC will prove valuable for similar activities at the other four AOC's located in Wisconsin on Lake Michigan.

TP130 How to draft a Sustainable Balanced Scorecard via the analysis of the Life Cycle Inventory. S. Sparacia, DETA - Diritto dell'Economia, Trasporti e Ambiente, Università degli Studi di Palermo - Facoltà di Economia, Palermo, Italy. Many companies already have performance measuring system that incorporate finance and non financial measures. Balanced scorecards, devised by Kaplan in collaboration with Norton, were initially created to assist US managers by means of a balanced set of information based on financial and non financial parameters. This tool is designed to "translate strategy into operations that unequivocally convey strategy throughout an organization" (Kaplan & Norton, 2000). Kaplan and Norton's theory is also applicable to eco-efficient resource management for understanding how profits are affected by adopting a sustainable management strategy, i.e. a business strategy that adopts a set of indicators interlinked by cause-effect relations in a Sustainable Balanced Scorecard. This paper illustrates how to draft a Sustainable Balanced Scorecard via the analysis of the direct relations that are formed between the life cycle inventory and the different dimensions (or determinants) that make up the "triple bottom line" (Elkington, 1997), namely the economy, the environment and the social meaning of the business. These diverse dimensions, which are the building blocks of sustainability, affect the entire organization and imply major changes in the operations management which, if not correctly

handled, will increase the complexity of the business system to an impossible degree or lead to inconsistent objectives being set in the reorganization.

TP131 An integrated approach for source water protection and awareness in rural agricultural karst watersheds. J. Brown, R.D. Taylor, V. Golla, Department of Public Health, Environmental Health Science Program, Western Kentucky University, Bowling Green, KY. Atrazine, a triazine herbicide and chemically an organochlorine, is used worldwide for controlling broad leaf weeds in corn, sorghum, and wheat. Atrazine is regulated by the Safe Drinking Water Act (SDWA) through the United States Environmental Protection Agency (U.S. EPA) and has a Maximum Contaminant Level (MCL) of 3.0 parts per billion (ppb). Atrazine has been found to contaminant public water supplies in agricultural watersheds and is under special review by the U.S. EPA. Transport of atrazine to streams, rivers, groundwater, and reservoirs occurs primarily by nonpoint source runoff from fields. However, inadequate disposal and atmospheric deposition can increase transport to water supplies. During the period from 1999, studies have been ongoing in rural agricultural karst watersheds in western Kentucky to quantify both the distribution and occurrence of atrazine. Beginning in 2001, farmers in two rural watersheds, one being karst, agreed to reduce the usage of atrazine and work with stakeholders to assess how use reductions would affect the distribution and occurrence. The goals of this study were realized as we used the assessment of the environmental occurrence and distribution of atrazine as a tool for public health protection and source water awareness in agricultural watersheds. Results of the study were incorporated in a statewide education campaign for corn producers and professional pesticide applicators conducted through the Kentucky Pesticide Workgroup.

TP132 Toxicity of bifenthrin to *Hyaella azteca* is dependent on type and combination of solid matrix substrates in aquatic systems. J.D. Maul, The Institute of Environmental and Human Health and Department of Environmental Toxicology, Texas Tech University, Lubbock, TX; J.D. Maul, A.J. Trimble, M.J. Lydy, Fisheries and Illinois Aquaculture Center and Department of Zoology, Southern Illinois University, Carbondale, IL. Synthetic pyrethroids readily partition from the aqueous phase to sediment and other sources of organic carbon within aquatic systems. In previous bifenthrin partitioning studies we have reported variation in K_d and K_{oc} among sediments and detrital leaf material of varying particle size. Log K_{oc} was greatest within sediment (6.63 ± 0.23) and lowest in coarse particulate leaf material (4.86 ± 0.03). Both of these matrices can be important to certain benthic invertebrates with some species readily ingesting or processing leaf material, a key process in ecosystem functioning. However, toxicity assessments have primarily focused on sediment-associated bifenthrin. In the current study, objectives were to compare variation in bifenthrin toxicity to *Hyaella azteca* in systems containing sediment, leaf material, and a combination of both. *H. azteca* LC50s were 0.07, 0.11, and 0.15 $\mu\text{g/g}$ organic carbon (OC) for leaf material, sediment, and an even mix (OC basis) of leaf and sediment, respectively. Non-overlapping 95% confidence intervals occurred between the leaf treatment and the leaf-sediment treatment. This pattern was supported in an additional experiment and at a treatment of 0.22 $\mu\text{g/g}$ OC (nominal), *H. azteca* survival was greater in the leaf-sediment mixture than both sediment or leaf material alone ($F = 29.5$; $p < 0.0001$). In systems that contain sediment and leaf material, increased *H. azteca* survival may be driven by both greater partitioning of bifenthrin to the sediment fraction and preferential use of leaf substrates by *H. azteca*.

TP133 Assessing toxicity of pyrethroid insecticides to *Hyaella azteca* using Tenax extraction - influence of bioavailability on toxicity. J. You, S. Pehkonen, M.J. Lydy, Fisheries and Illinois Aquaculture Center and Department of Zoology, Southern Illinois University, Carbondale, IL; D.P. Weston, Department of Integrative Biology, University of California, Berkeley, CA; J. You, Department of Biochemistry, Chemistry & Physics, University of Central Missouri, Warrensburg, MO. Tenax extraction is a simple and inexpensive approach to estimate bioavailability of hydrophobic organic contaminants from sediment. In this study, a single time point Tenax extraction at 6 and 24 h was used to assess the acute toxicity to *Hyaella azteca* using field-collected sediments from agricultural and urban areas of California. Pyrethroids were the primary contributor to the observed toxicity, and a significant correlation existed between toxicity units (TU) and actual mortality. A TU is defined as the ratio of organic carbon (OC) normalized pyrethroid concentration in sediment and the OC normalized 10-d LC50 concentration, and it was an effective predictor of sediment toxicity at most study sites. However, TU could not explain the observed low toxicity to *H.*

azteca found for some sediment, which had high concentrations of detectable pyrethroids. Therefore, a bioavailable TU measurement, which was the ratio of OC normalized bioavailable pesticide concentration estimated by Tenax extraction and the OC normalized 10-d LC50 concentration, was applied to assess the sediment toxicity. Over 60% of the un-expected low toxicity of pyrethroids in sediments was explained using the Tenax extraction measurement and this procedure was successful because it took bioavailability into consideration.

TP134 Assessment of Pesticide Attenuation Using Mesocosm-Scale Agricultural Drainage Ditches. J.E. Heatley, G.M. Huddleston, ENTRIX, Inc., Pendleton, SC; J. Wrynski, Yolo County USDA Resource Conservation District, Woodland, CA; B.M. Johnson, D.A. Eggert, J.H. Rodgers, Department of Forestry and Natural Resources, Clemson University, Clemson, SC. In watersheds dominated by agriculture, irrigation water runoff may be coupled with applications of organo-phosphates, pyrethroids or other pesticides on the surrounding agricultural landscape. Vegetation may play several roles in mitigating impacts of cropland runoff, including uptake, adsorption and/or absorption of potentially toxic pesticides in runoff, increased contact time with plants and soils by slowing runoff and enhanced degradation or transformation of pesticides. If vegetated areas can mitigate risks for runoff from croplands that are periodically treated with pesticides, these buffers should be considered an important part of an effective mitigation strategy. The pesticides permethrin and diazinon are found in agricultural runoff waters and are appropriate candidate pesticides for treatment with vegetation. The objectives of this study were to: 1) determine if there is a difference in concentrations of pesticides (permethrin and diazinon) following treatment in a vegetated ditch versus an unvegetated ditch, 2) compare pesticide attenuation between ditches planted with different vegetation types (lambsquarters (*chenopodium album*) and a mixture of barley (*Hordeum vulgare*) and ryegrass (*Lolium multiflorum*)), and 3) measure the concentrations of pesticides (permethrin and diazinon) associated with water, sediments and plants over distance and time in a mesocosm-scale ditch system. Mesocosm studies (e.g., greenhouse-scale systems) can be used to assess mitigation efficacy and produce data that are useful for scaling to the field.

TP135 A proposed approach for using available toxicity test data on individual-level to predict the effect on population persistence. B. Lin, Y. Meng, CRM/AIST, Tsukuba City, Japan. An extrapolation approach was demonstrated and validated in this study on using available toxicity test data on individual-level to derive a reference value defined as predicted-no-effect concentration (PNEC) on population persistence for population-level ecological risk assessment (PLERA) on chemicals. A matrix population model of natural medaka (*Oryzias latipes*) was employed as the tool to integrate the available individual-level toxicity test data on reproduction and survival into population growth rate (λ) that provides information regarding the status of the population persistence. After demonstrating the approach by using all of the toxicity data on fish of nonylphenol to calculate the PNEC defined as the concentration at which $\lambda=1$, this proposed approach were then validated by a comparative investigation on several derived PNECs by different approaches that employed the same full-life cycle toxicity test data of nonylphenol. We conclude that the extrapolation approach presented is widely applicable and is an encouraging approach for performing PLERA on a more general basis that support rational chemicals management.

TP136 Occurrences and photostabilities of particulate brominated polycyclic aromatic hydrocarbons in urban air. T. Ohura, K. Sawada, T. Amagai, Institute for Environmental Science, University of Shizuoka, Shizuoka, Japan; M. Shinomiya, The National Environmental Research and Training Institute, Saitama, Japan. Concentrations of brominated polycyclic aromatic hydrocarbons (BrPAHs) with 3 to 5-ring have been investigated in urban air throughout a year. Seven of 11 target compounds were detected from particles in the air, total concentrations of which ranged from 0.017 to 156 pg/m³. 9,10-Dibromoanthracene, 1-bromopyrene, and 5,7-dibromobenz[a]anthracene were relatively high detection rates in the air samples. Much of the BrPAH concentrations trended to elevate in winter compared to those in summer. Also, there were no significant correlations among the detected BrPAHs concentrations. These findings suggest that ambient BrPAHs concentrations may come from the different emission sources for individual BrPAH, and/or be significantly driven by seasonal factors such as meteorological conditions, gas-to-particle partitioning, and photolysis reaction. To reveal the differences of physicochemical characterization for BrPAHs, photostabilities of BrPAHs were investigated in laboratory

experiments using a chemical model system. The BrPAHs decayed according to first-order kinetics. The reaction rates trended to decrease with increasing the ring numbers of BrPAH skeleton. However, the significant relationship between the ambient concentration and extend of photostability for each BrPAH was not observed, so that the occurrences of ambient BrPAHs may be contributed to the specific emission sources. Accordingly, BrPAHs should mainly be considered a health problem at locations close to these sources.

TP137 Finding evidence for the Intermediate Disturbance Hypothesis in the ecotoxicology literature: Chemical contamination can increase biodiversity. M. Hanson, Environment and Geography, University of Manitoba, Winnipeg, Manitoba, Canada. Ecotoxicology tends to focus on characterizing the direct effects of chemical contamination on individuals, populations and communities. This paradigm places the experimental emphasis on quantifying the adverse effects, as opposed to being neutral in its approach and allowing for the possibility of what might be considered positive responses. Hand in hand with this approach, ecotoxicology incorporates little ecological theory or examination of ecological mechanisms into its study designs. While ecological theory may be used to explain some observed results and their implications beyond the species used, rarely are ecological theories explicitly tested. Perhaps one of the most straightforward theories to test from an ecotoxicological perspective is the Intermediate Disturbance Hypothesis (IDH). The IDH is based on the premise that certain levels of a natural disturbance, such as floods or fires, will increase the patchiness within a larger ecosystem, creating opportunities for species that may have been extirpated as the system reaches its climactic state. The disturbance of established or climatic communities provides an opportunity for colonizers and secondary stage species to reestablish, increasing the overall biodiversity of the ecosystem. Spatial and temporal scales play an important role in defining the extent and duration of changes in biodiversity in these disturbed systems. Hypothetically, it should be possible to test the strength of the IDH using a chemical stressor in lieu of a natural stressor. In fact, a chemical toxicant could be an ideal model, as you are able to control not only the intensity, but also the duration and area over which the stressor acts, much more readily than a natural stressor such as fire. A review of the ecotoxicology literature shows evidence supporting the IDH in terrestrial and aquatic systems, with microbial, phytoplankton, zooplankton, vascular plant and benthic invertebrate biodiversity increasing at certain levels and durations of chemical contamination. This poster will summarize the literature and provide a framework for the testing of the IDH from an ecotoxicology context. Please note that chemical contamination is not a natural environmental stressor in the same vein as fire or flooding, and increases in biodiversity observed with exposure to such stressors should not be used as a rationale for allowing contamination under any circumstances.

TP138 Effect of Temperature on Respiration in Earthworm *Lumbricus terrestris*. M.A. Khan, S.A. Ahmed, A. Bixby, O.J. Lawal, Biological Sciences, University of Illinois at Chicago, Chicago, IL. Earthworms (*Lumbricus terrestris*) acclimated at 20°C (12-14°C) above their habitat temperature (10-12°C) showed about 5% increase in basal rate of oxygen consumption, which increased to about 38% in 14-16°C and 40% in 16-18°C, but decreased by 84% in 20-22°C-acclimated worms. Temperature also increased the blood hemoglobin (Hb) concentration. Hemoglobin concentration and its oxygen affinity decreased slightly in 20-22°C-acclimated worms. The worms acclimated at 20-22°C showed their blood to be hypovolemic than that of 10-12°C worms indicating dehydration and osmotic stress at this elevated temperature.

TP139 Short-term water quality responses to storm events at two microtidal estuaries. J.J. Weston, Biology/ETRP, University of Mississippi, University, MS. Water properties (pH, salinity, etc.) in nearshore marine systems influence the bioavailability of anthropogenic compounds. This study evaluated natural factors that effect water properties and which might indirectly affect the bioavailability of anthropogenic compounds. In 2005, there were 3 heavy rain events, 1 tropical storm and 4 hurricanes, Hurricane Katrina being the largest, in the northern Gulf of Mexico. High resolution data, logged every 30 min, from three sites within Grand Bay National Estuarine Research Reserve (GBNERR), Mississippi, and four sites within Weeks Bay National Estuarine Research Reserve (WBNERR), Alabama, were used to assess water quality (depth, temperature, salinity, turbidity, pH and dissolve oxygen) responses to each of the eight storm events. Both estuaries are shallow microtidal systems but differ in surface freshwater input: WBNERR has two sources, Fish and Magnolia Rivers, while GBNERR has none. Water quality response data, during and after storms, were calculated based on

precipitation duration and tidal period then normalized to before conditions before analysis. Three storm characteristics (precipitation, wind speed and storm surge) were used to describe each storm event. Water quality responses were correlated to storm characteristics to determine if response magnitudes are proportional to storm strength. Water quality responses and correlation analyses at each estuary were compared. The resiliency of water quality measures could not be fully evaluated with these data, some parameters had return times longer than data evaluated.

TP141 Trophic Transfer, PCB and Mercury Accumulation and Effects on Bluefish, *Pomatomus saltatrix*, Consuming Contaminated Prey. A.C. Candelmo, Ecology and Evolution, Rutgers University, New Brunswick, NJ; J. Weis, Department of Biological Sciences, Rutgers University, Newark, NJ; A. Deshpande, James Howard Marine Sciences Laboratory at Sandy Hook, NOAA Fisheries, Highlands, NJ. Young-of-the-year bluefish, *Pomatomus saltatrix*, from Great Bay were fed daily for four months with menhaden and mummichog from Great Bay (control) or Hackensack River (contaminated). Hackensack-fed lab bluefish, field-collected bluefish, prey fish, and gut contents from Hackensack all had significantly elevated concentrations of PCBs and mercury. Hackensack-fed bluefish had reduced feeding, activity, and growth. There was no statistical difference in the condition index, but both the length and weight of the control fish were significantly larger. PCB concentrations in prey fish in the guts of bluefish from Hackensack River were higher than those in the field-caught specimens. As contaminants can exert adverse neurotoxic or endocrine effects, prey with higher body burdens may become slower and easier to capture. If bluefish are preferentially foraging on such prey, greater amounts of contaminants can be trophically transferred. PCB congeners are accumulated at different concentrations creating PCB fingerprints, which can be used to better understand the feeding ecology of the bluefish. PCB fingerprints in the exposed bluefish were nearly identical to each other and were closest to that of the mummichog, probably because they were the only prey used during the last month of the feeding experiment. PCB fingerprints of field caught bluefish can be compared to fingerprints of prey fish in the estuary to determine what types of prey they're consuming. Further research is investigating the physiological and biochemical changes resulting from contaminant exposure that may have affected bluefish behavior and growth in the present study. Decreased feeding, activity level and growth in the exposed YOY bluefish can have detrimental effects on migration fitness and recruitment success in wild populations exposed to similarly contaminated regimes.

TP142 Results of a Wildlife Toxicology Workshop held by the Smithsonian Institution – Identification and Prioritization of Problem Statements. K.C. Grim, OSCP, US EPA, Washington, DC; A. Fairbrother, ORD, US EPA, Corvallis, OR; K.C. Grim, S. Monfort, S. Tan, NZP/CRC, Smithsonian, Front Royal, VA; B. Rattner, Patuxent Wildlife Research Center, USGS, Patuxent, MD; S. Gerould, Contaminant Biology, USGS, Reston, VA; V. Beasley, School of Veterinary Medicine, University of Illinois, Urbana, IL; A. Aguirre, Conservation Medicine, Wildlife Trust, New York, NY; T. Rowles, National Marine Fisheries Service, NOAA, Silver Spring, MD. On March 13-15, 2007 nearly 50 scientists and administrators from the US and Canada participated in a Smithsonian-sponsored Wildlife Toxicology Workshop. Invitees were from academic, government, conservation and the private organizations and were selected to represent the diverse disciplines that encompass wildlife toxicology. The workshop addressed scientific and policy issues, strengths and weaknesses of current research strategies, interdisciplinary and science-based approaches in the study of complex contaminant issues, mechanisms for disseminating data to policy-makers, and the development of a partner network to meet the challenges facing wildlife toxicology over the next decade. Prior to the meeting, participants were asked to submit issues they deemed to be of highest concern which shaped four thematic groups for discussion: Wildlife Toxicology in Education, Risk Assessment, Multiple Stressors/Complex Mixtures, and Sub-Lethal to Population-Level Effects. From these discussion groups, 18 problem statements were developed and prioritized outlining what were deemed the most important issues to address now and into the future. Along with each problem statement participants developed potential solutions and action steps geared to move each issue forward. The workshop served as a stepping stone for action in the field of wildlife toxicology. These problem statements and the resulting action items are presented to the inter-disciplinary wildlife toxicology community for adoption, and future work and action items in these areas are encouraged. The workshop outcome looks to generate conversation and collaboration

that will lead to the development of innovative research, future mechanisms for funding, workshops, working groups, and listserves within the wildlife toxicology community.

TP143 The Ecological Footprint of SETAC NA Meetings: Making Meetings More Sustainable. H.M. Zahner, S.J. Klaine, Clemson University Institute of Environmental Toxicology, Pendleton, SC. Nature can restore renewable resources at a certain rate, yet humans are consistently consuming renewable resources faster than nature can restore them. The Society of Environmental Toxicology and Chemistry defines their mission as supporting the development of principles and practices for protection, enhancement, and management of sustainable environmental quality and ecosystem integrity. Each year, the geographic units that make up the society hold meetings to discuss the state of the science. The society meetings help to bring an economic boost to the hosting city, but also with these meetings comes travel by participants, increased use of utilities (i.e., water and electricity), and increased production of waste. An ecological footprint is a way to account for resources and examine sustainability by measuring how quickly resources are used in comparison to how quickly they can be regenerated. The objective of this study was to determine the ecological footprint our society meetings on our host cities each year. Results from the Baltimore 2005 and Montreal 2006 SETAC NA meetings concluded that each participant's footprint over the five-day meeting was slightly less than the ecological footprint of an individual in an undeveloped country for a year. These results, similar to ecological footprints for other meetings, found that the greatest impact came from travel to the meeting. Because transportation costs to meetings are difficult to moderate, the impact of the Montreal and Baltimore meetings were calculated without transportation to determine what parts of meeting planning could be improved. The ecological footprint of the 2005 SETAC NA meeting in Baltimore was compared to the 2006 SETAC NA meeting in Montreal. Participants from 2006 were given the option of purchasing carbon offsets to reduce the impact of their travel. The impact of this option on the ecological footprint of the meeting is also examined.

TP144 Effect of PBDE Exposure on Thyroid Hormone Homeostasis in Adult Sport Fish Consumers. M. Turyk, V. Persky, Epidemiology and Biostatistics, University of Illinois at Chicago, Chicago, IL; P. Imm, L. Knobeloch, H. Anderson, Wisconsin Division of Public Health, Bureau of Environmental Health, Madison, WI; R. Chatterton, Y. Lu, Departments of Ob/Gyn and Physiology, Feinberg School of Medicine, Northwestern University, Chicago, IL; J. Mathew, C. Buelow, Wisconsin State Laboratory of Hygiene, Madison, WI. Polybrominated biphenyl ethers (PBDE) are used as flame retardants in a variety of consumer products. They are persistent environmental chemicals that are increasing in prevalence in humans, particularly in North America. Health effects related to PBDE exposure have not been well studied, but animal investigations suggest that PBDEs decrease serum thyroxine levels through several potential mechanisms including induction of hepatic glucuronyl transferases and displacement of thyroxine from the binding protein transthyretin. We studied relationships of thyroid hormones with PBDE exposure in residents of the Great Lakes Basin who were infrequent and frequent sport fish consumers. The study participants were adults with mean age in the 50s. Geometric mean total PBDEs were approximately 26 ng/g lipid (range=not detected - 1359 ng/g lipid). In 257 men, total PBDEs and BDE 47 were negatively associated with thyroxine binding globulin (TBG), the major carrier protein for thyroxine in the blood; negatively associated with TBG-bound thyroxine; and positively associated with albumin-bound thyroxine. Positive associations were found for total PBDEs and BDE 47 with urinary total thyroxine. Thyroid stimulating hormone (TSH) was negatively associated with total PBDEs. These results suggest that exposure to PBDEs may result in increased bioavailability of thyroxine at the tissue level in men. BDE 47 was positively associated with TBG in 58 postmenopausal women, and positively associated with total thyroxine in 29 premenopausal women. Effects of total PBDEs and BDE 47 on thyroid hormones were independent of serum PCBs, serum DDE, and sport fish consumption. In conclusion, these results suggest that PBDEs may alter thyroid hormone homeostasis through effects on thyroid binding globulin. However, the effects of PBDEs on TBG vary by gender and in women by postmenopausal status. This research was funded by the US Environmental Protection Agency, Grant No RD-83025401-1. The research and researchers were supported in part by the Center for Disease Control and Prevention Training Program Grant #1 T01 CD000189-01.

TP145 Applications of an Integrated Framework for Environmental Assessment. S.M. Cormier, G.W. Suter, ORD, USEPA, Cincinnati, OH. We propose a new framework for environmental assessment that integrates different types of assessments to support environmental management to protect both human health and the environment (see the companion presentation). The framework is organized as a 2x2 matrix in terms of two dichotomies. One distinguishes problem detection from problem resolution. The other distinguishes environmental epidemiology from risk management. The framework includes not just risk assessment but the entire process of detecting an impairment, determining its cause, estimating risks and benefits from taking no action or taking remedial actions, choosing and implementing a management action, and assessing the results of the decision. Each of these types of environmental assessments consists of three steps: planning, analysis and synthesis. The potential utility of this framework is demonstrated by showing how it applies to three cases: (1) The restoration of the biologically impaired Cuyahoga River. (2) The remediation of the Fox River/Green Bay Superfund site. (3) The reregistration of carbofuran. We believe that this framework has the potential to improve the process of providing scientific support to environmental management by clarifying the relationships among the various sorts of assessment processes and their links to specific decisions.

TP146 Significance of Dietary Selenium in Prevention and Treatment of Mercury Toxicity. N.V. Ralston, L.J. Raymond, Energy & Environmental Research Center, University of North Dakota, Grand Forks, ND. High level mercury (Hg) exposure is harmful to fetal neurodevelopment, but consequences appear to depend upon molar ratios of Hg to selenium (Se). Selenium is an essential nutrient required for certain enzyme (Se-enzyme) activities that protect against oxidative damage in brain and other tissues. The extremely high binding affinities between Hg and Se (1045) result in sequestration of cellular Se as insoluble HgSe and thus prevent synthesis of Se-enzymes. Several of the 25-35 known Se-proteins are active in detoxification of oxygen radicals. Therefore, it is not surprising that oxidative damage is a major pathological finding of Hg toxicity. The protective effects of Se against Hg toxicity have been recognized for over 50 years. Supplemental Se replaces Se lost to Hg binding, thus maintaining Se-enzyme synthesis. Maternal consumption of foods that contain Hg in molar excess of Se is distinctly harmful, but consumption of similar amounts of Hg in foods with Se in molar excess of Hg has not been associated with harmful effects. Maternal consumption of pilot whale meat (Hg:Se ratio 4:1) harmed children in the Faroes, but consumption of ocean fish meats (average Hg:Se ratio 0.1:1) were not associated with adverse effects in the Seychelles, even though total Hg exposures appeared to be greater. Rat studies employing diets that reflect the range of methylmercury (MeHg) exposures from low to toxic in the presence of dietary Se at low, normal, or rich levels confirm the importance of the Hg:Se ratio in the Hg issue. Resistance to MeHg toxicity was directly proportional to dietary Se in the normal range of consumption. Levels of MeHg exposure that were lethal to animals fed low-Se diets were harmless to animals fed Se at levels slightly less than the average Se concentration present in ocean fish. These studies further indicate that although blood Hg reflects MeHg exposure, blood Hg:Se molar ratios provide better criteria for recognizing risk of MeHg toxicity ($r^2=0.96$, $p<0.00001$). Although ocean fish are rich in Se, it is important to note that environmental availability of Se results in dramatic variability in fresh water fish Se. As a result, Hg levels that are safe in fresh water fish from areas with normal or rich Se may constitute major Hg toxicity risks in areas where Se availability is poor, such as the in those that occur in 'Hg-hotspot' regions of the Northeastern U.S.

TP147 Recovery from mercury contamination in three North American lakes. J. Kubitz, ENTRIX, Inc., Barrington, IL. Fish mercury concentrations in Deer Lake (Michigan), Clay Lake (Ontario) and Ball Lake (Ontario) have decreased following remedial actions. Long-term monitoring data for northern pike, a piscivorous predator, are used to assess recovery from industrial mercury contamination in all three of these north-temperate reservoirs. Despite differences in mercury sources, loading rates, initial fish concentrations, and other factors, the recovery rates for these three water bodies are quite similar. The results from this study suggest that recovery from mercury contamination, as determined by methylmercury concentrations in predatory fish, can be forecasted.

TP148 Moving beyond a linear world: Development of a simplified modeling framework for mercury TMDLs. E.M. Sunderland, Office of Research and Development, US Environmental Protection Agency, Boston, MA; C.D. Knightes, Ecosystem Research Division, U.S. Environmental

Protection Agency, Athens, GA. A number of mechanistic research models have been developed in recent years that characterize the relationships between chemical and physical properties of different watershed and water bodies and Hg bioavailability and accumulation in organisms. However, recent regulatory activities in the United States, including statewide TMDLs in Minnesota and Massachusetts, have required a broad spatial assessment of expected changes in fish Hg concentration with declines in national and regional Hg releases. Here we review some of the challenges associated with coupling detailed mechanistic knowledge on factors controlling methylation, demethylation, oxidation, and reduction of mercury into transparent management models that can be applied at the state and Regional level. We present a summary of empirical research describing the most important factors driving methylmercury accumulation in freshwater ecosystems and explore uncertainties in both mechanistic and statistical representations of these findings in a simplified modeling framework. Key gaps in mechanistic research limiting the development of multimedia mercury cycling models are discussed as well as suggestions for developing management models of intermediate complexity that capture the important biogeochemical processes governing mercury bioaccumulation and exposure.

TP149 Effects of water chemistry and a point source on mercury biomagnification in streams. K.A. Kidd, T.D. Jardine, Biology Department, University of New Brunswick, Saint John, New Brunswick, Canada; P.A. Arp, Faculty of Forestry and Environmental Management, University of New Brunswick, Fredericton, New Brunswick, Canada; T.D. Jardine, R.A. Cunjak, Biology Department, University of New Brunswick, Fredericton, New Brunswick, Canada. Coal-fired power plants are known to be significant sources of mercury (Hg) to the surrounding region. However, the possibility of enhanced bioaccumulation of Hg through stream food webs due to this localized deposition has rarely been examined, despite the potential risks to nearby aquatic populations. In 2006 we examined deposition of Hg onto the terrestrial landscape and its bioaccumulation through stream food webs by collecting the lichen Old Man's Beard (*Usnea* sp.), benthic invertebrates, and fishes in a bulls-eye design at increasing distances away from a coal-fired power plant in New Brunswick, Canada. Samples were analyzed for total Hg and stable isotopes of nitrogen ($\delta^{15}\text{N}$) to determine trophic positioning. The terrestrial sentinel Old Man's Beard indicated enhanced mercury deposition within 10 km of the plant and significantly elevated concentrations as far away as 100 km. Biomagnification of Hg within streams, as measured by slopes of the Hg- $\delta^{15}\text{N}$ relationships for invertebrates and fishes, was higher at sites near the power plant, and differences in the biomagnification of this pollutant also depended on the fish species present. Blacknose dace had higher mercury concentrations than brook trout leading to greater Hg- $\delta^{15}\text{N}$ slopes in streams containing only the former species. Biomagnification of Hg was also linked to water chemistry; acidic streams with high organic matter content showed greater slopes of Hg versus $\delta^{15}\text{N}$. Future analyses will focus on separating the relative importance of water chemistry and the point source in the accumulation of Hg through these food webs to determine if the power plant may be negatively impacting aquatic populations and fish-eating consumers including humans.

TP150 Mercury bioaccumulation at the sub-habitat scale on a seasonally inundated floodplain. A. Lorenzi, R. Stewart, Water Resources, United States Geological Survey, Menlo Park, CA; C. Jeffres, Center for Watershed Sciences, University of California, Davis, Davis, CA. Seasonally inundated floodplains promote methylmercury (MeHg) production and initiate the biomagnification of mercury (Hg) through aquatic food chains, which could threaten wildlife that utilize floodplain habitat or consume fish reared on the floodplain. In the San Francisco Bay Delta, where mercury contamination is widespread due to historical mining practices, there are concerns that the creation of more floodplain habitat, which has been shown to be optimal rearing habitat for threatened Chinook salmon, could further exacerbate the problem. Evaluation of Hg dynamics and biogeochemical controls at the sub-habitat spatial scale could potentially aid managers in future restoration efforts. The Cosumnes River floodplain is a stable and more successful area for growth of juvenile Chinook salmon than areas within the river channel. Within the Cosumnes floodplain, sub-habitats can vary in temperature, dissolved oxygen concentrations, water circulation, or biological species, which might provide a reasonable starting point in determining factors that lead to differential Hg accumulation on the floodplain. To evaluate the potential differences in MeHg production and MeHg bioavailability among sub-habitats within a floodplain, we measured total mercury (THg) concentrations in the

skeletal tissue of hatchery juvenile Chinook salmon that had been caged on and off the floodplain throughout the spring flood season during 2004, 2005, and 2006. We also measured differences in growth rate and THg accumulation among subhabitats including vegetated sites and open water floodplain ponds, and compared these values to river channel sites. Growth rates were significantly different between the two sub-habitat types (pond = 0.006 ± 0.002 vs. vegetation = 0.019 ± 0.002 , growth/day for 2006 season). Average THg concentrations in fish tissue between the two sites for the 2006 flooding season differed significantly ($p < 0.05$; pond = 0.78 ± 0.05 vs. vegetation = 0.59 ± 0.06 $\mu\text{g/g}$). Comparison with the river channel site showed significant similarity compared to the vegetation site (river channel = 0.55 ± 0.07 $\mu\text{g/g}$) in THg accumulation with the sub-habitat in closest proximity suggesting a linkage likely due to hydrology and food web availability on the floodplain. Results for the 2004-2005 are pending and will be presented later.

TP151 Role of gas evasion from contaminated sediments as a mechanism of mercury transfer to aquatic biota. R. Razavi, L.M. Campbell, P.V. Hodson, Biology, Queen's University, Kingston, Ontario, Canada; L.M. Campbell, P.V. Hodson, School of Environmental Studies, Queen's University, Kingston, Ontario, Canada; J. Ridal, St. Lawrence River Institute of Environmental Sciences, Cornwall, Ontario, Canada. The St. Lawrence River near Cornwall, ON has been designated an Area of Concern (AOC) due to the past deposition of mercury (Hg) from several industries for nearly a century. Recent studies have demonstrated paradoxically high concentrations of Hg in yellow perch (*Perca flavescens*) from one contaminated zone. This is puzzling since average Hg concentrations in sediment are known to be higher at a contaminated site slightly further downstream. Studies of stomach content analyses of yellow perch show prey items exhibiting this same perplexing pattern. Extensive bubbling from contaminated sediments in the zone of interest may explain this discrepancy. The methane gas is likely produced by the decomposition of wood chips and other debris buried beneath recent sediments by methanogens and sulfate reducing bacteria. These bacteria can methylate Hg, thereby converting it to its toxic form, methylmercury (MeHg), which biomagnifies with trophic level. This study uses in situ exposure experiments with artificial substrates (rock baskets) and caging studies to determine if bubbling activity is enhancing Hg flux to biota in this zone. Artificial substrates were used to collect amphipods (Gammaridae) in high and low bubbling sites in the contaminated zone. Aufwuchs (biofilm) was collected in tandem, using tiles attached to the rock baskets. Preliminary results for both THg and MeHg indicate benthic invertebrates collected by artificial substrates show significant differences in Hg concentrations between areas of high bubbling in the contaminated site versus areas of low bubbling in the contaminated or a non-contaminated site.

TP152 Total Mercury and Methylmercury in Constructed Stormwater Wetlands. B.A. Monson, Minnesota Pollution Control Agency, St. Paul, MN. This study addressed the question: How do constructed stormwater wetlands compare to natural wetlands regarding methylmercury concentrations and loading? Water chemistry data was collected in 2005 and 2006 at 10 urban stormwater wetlands, nine of which discharge to lakes. In addition, 19 natural wetlands in agricultural, urban, and undisturbed areas were sampled for the same water chemistry analytes in 2006. The results indicate that stormwater wetlands have methylmercury concentrations similar to natural wetlands. Total mercury and methylmercury fluxes from an intensively monitored wetland treatment system was on the low end of the range reported for natural wetlands. Phosphorus and methylmercury concentrations were strongly correlated in the stormwater wetlands.

TP153 Mercury and Arsenic in the soil and water of Gorlovka, Ukraine. K.M. Conko, E.R. Landa, Water Resources Discipline, National Research Program, US Geological Survey, Reston, VA; A. Kolker, Eastern Energy Resources Team, US Geological Survey, Reston, VA; K. Kozlov, Ukraine Academy of Medical Sciences, Kyiv, Ukraine; H. Gibb, Sciences International, Alexandria, VA. The city of Gorlovka (population 320,000) in southeastern Ukraine includes the Nikitovka Mercury Mines, a series of open-pit mines surrounding an ore processing facility. For more than 50 years this industry extracted mercury ore and coal in one of the largest mercury production facilities in the former Soviet Union. Coals from these mines are elevated in both Hg and As (more than 10-times the average US coal). Commercial extraction and processing ended in 1995 but part of this facility has been used for mercury recycling from batteries and fluorescent light tubes since 2000. The local landscape contains numerous mine tailing piles and run-off ponds, as well as abandoned industrial structures. Access to the mine area is unrestricted;

some local residents collect coal for home use and consume fish caught in the run-off ponds. Three run-off ponds were sampled; the average concentrations of Hg and As in the water are $0.5 (\pm 0.23)$ and $95 (\pm 34) \mu\text{g/L}$; the concentrations of total Hg and As in the pond sediments are $7.1 (\pm 1.7)$ and $77 (\pm 32) \text{ mg/kg}$ respectively. A series of surface (0-10 cm) soil samples collected in transects (1-2 km) across the processing facility showed highs of 247 mg/kg Hg and 830 mg/kg As. Regional background levels, as reflected in the areas away from the central mining area, in these transects ranged from $2\text{--}63 \text{ mg/kg}$ for Hg and $45\text{--}290 \text{ mg/kg}$ for As. For comparison, the median concentrations in European top soil (0-25 cm) for total Hg and As are 0.04 and 7.03 mg/kg respectively. Hydroxylamine-HCl extraction was used to assess acid-labile and Fe/Mn-bound Hg and As in surface soils from playgrounds and public spaces in the city (within approximately 8 km of the processing plant). Extractable concentrations of Hg are $0.01\text{--}0.02$ and As are $5\text{--}44 \text{ mg/kg}$.

TP154 Development and Use of Benthic Flux Chambers in a Gravel-Bed River to Measure Mercury Fluxes. J.R. Flanders, URS Corp., Fort Washington, PA. Benthic flux chambers (BFC) have been developed and deployed to study the flux of filter-passing inorganic mercury (IHg) and methylmercury (MeHg) in the South River, VA, USA. The BFCs were specifically engineered to measure advective and total fluxes of IHg and MeHg; the materials of the BFC in contact with the internal sample volume are constructed of either Teflon or polycarbonate and go through an extensive cleaning process to remove trace levels of IHg. The influence of diurnal cycles was simulated through the simultaneous deployment of clear and opaque chambers. The chambers are initially equilibrated with the surface water environment via equilibration ports and an internal pump that exchanges the internal water volume of the BFC and the surface water via dedicated valves. After initial equilibration, the ports are closed and the valves are actuated; the pump continues to operate, preventing the formation of gradients within the chamber. The chambers were deployed in soft sediment deposits and cobble/gravel areas of the main channel to measure the potential contribution of common substrate types. In order to measure the potential contribution of gravel deposits, cobble sized rocks were collected from background locations, cleaned, and affixed to polycarbonate plates with aluminum wire. The plates were installed one month prior to sampling to allow them to acclimate with the surrounding environment, grow periphyton and trap particles. Samples were collected every hour for four hours via syringe, filtered with a syringe-tip $0.45 \mu\text{m}$ filter, and analyzed for filter-passing iron (Fe), manganese (Mn), total mercury, and MeHg. Dissolved oxygen (DO) was measured in the surface water and within the BFC via a dedicated port that accepts a YSI 550 DO meter. The fluxes of IHg and MeHg measured from both deposits and plates are generally similar to those calculated from surface water concentrations. In mud deposits, higher MeHg fluxes were observed in the opaque chambers than in the clear chambers, suggesting that diurnal effects may be present. Fluxes of IHg and MeHg were correlated with Mn fluxes in both clear and opaque chambers deployed on deposits, suggesting that dissolution of mineral phases may account for some portion of the total flux. Similar highly correlated relationships were not observed for Fe or for the rock plate installations.

TP155 Modeling Mercury Biomagnification in South River (Virginia USA). K.R. Tom, M.C. Newman, J.F. Carriger, E.L. Holloman, Environment and Aquatic Animal Health, Virginia Institute of Marine Science (W&M), Gloucester Point, VA. Mercury trophic transfer was modeled using stable nitrogen isotopes to quantify the biomagnification of mercury below a historic release along the South River in Waynesboro, Virginia. Nitrogen isotope shifts were consistent with peer-reviewed literature for similar systems. The $\delta^{15}\text{N}$ increased 3.4‰ with each unit change in trophic level. Using 4‰ as a gross estimate of the $\delta^{15}\text{N}$ for the primary producer level, approximately four trophic levels were identified. For a variable aquatic system such as South River, a trophic chain length of approximately 3.7‰ was anticipated. Total and methylmercury concentrations were modeled at three locations along the South River. To approximate biomagnification, a trophic level change of one unit toward the middle region of the trophic web ($\delta^{15}\text{N}$ from 8 to 11.4‰) was used. Total mercury and methylmercury concentrations increased an average of 2.33 and 2.58 fold, respectively. Modeling of mercury trophic transfer was expanded in the summer of 2007 by taking triplicates of sixteen biotic sample types at five locations along the South River. Prediction quality of these models was quantified with conventional cross-validation procedures. Additionally, efficiency of mercury movement into the trophic web was assessed relative to the proportion of the mercury present at lower trophic positions as methylmercury along the contaminated river reach.

TP156 Factors Controlling Total Mercury Distributions in Fine-Grained Sediment of the South River, VA USA. J.R. Flanders, T. Morrison, URS Corp., Fort Washington, PA; J. Pizzuto, K. Skalak, University of Delaware, Newark, DE; R. Turner, RT Geosciences, Squamish, British Columbia, Canada; D. Jensen, Unique Environmental Services, Wilmington, DE; N. Grosso, DuPont Corporate Remediation Group, Wilmington, DE. The factors that control the distribution of total mercury (THg) in the fine-grained sediments (FGS) of the South River, a gravel-bed river in central VA, USA, were evaluated along a 25-mile study area. The South River has concentrations of mercury in FGS that are elevated above background due to a historic, industrial point source of inorganic mercury that ceased in approximately 1950. Samples of FGS were collected from interstices of stream bed gravel and cobbles and from channel margin deposits (FGCM) and analyzed for total mercury (THg) and loss-on-ignition (LOI); samples for FGS were also analyzed for organo-complexed THg. In addition, THg concentrations were measured in eroding bank soils and on particles transported during both baseflow and storms. Concentrations of THg in FGS were highest in areas with the highest rates of observed bank erosion, which occurred between 3 and 9 miles downstream of the historic point source. Although organic matter comprised 10% of the sediment mass, over 60-100% of the THg was associated with organic matter. THg concentrations in FGS are similar to average concentrations of THg in eroding bank soils and FGCM deposits, and also to concentrations of THg on particles in surface water during baseflow. Concentrations of THg on particles during the highest storm discharges are up to a factor of 10 lower than concentrations in FGS, particularly in the upper half of the study area, probably due to transport of clean solids by storms from upstream. This effect is most pronounced in the upper half of the study area. At present, the working hypothesis is that the THg in FGS in the lower half of the study area is transported from upstream sources.

TP157 A comparison of mercury bioaccumulation rates in acidified versus circumneutral food webs. K.A. Kidd, B.J. Wyn, R.A. Curry, Biology, University of New Brunswick, Saint John, New Brunswick, Canada; N. Burgess, Environment Canada, Mt. Pearl, Newfoundland, Canada. Mercury (Hg) concentrations in fish from acidified lakes ($\text{pH} < 6.0$) are typically elevated above those from circumneutral systems. Concentrations of Hg in aquatic organisms are significantly related to their trophic position (as determined by stable nitrogen isotopes; $\delta^{15}\text{N}$), and the slopes of these Hg - $\delta^{15}\text{N}$ relationships are being contrasted to understand whether bioaccumulation rates differ across lakes and affect concentrations of this pollutant in top predators such as yellow perch. This study examined food web structure and biotic Hg accumulation rates in four acidified lakes ($\text{pH} 4.5\text{--}5.5$) in Kejimikujik National Park in Nova Scotia, Canada. Littoral, pelagic, and profundal invertebrates and yellow perch, golden shiner, banded killifish, and brown bullhead were captured in 2006 from each lake and analysed for MeHg (invertebrates) or total Hg (fish). $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ were also measured in all organisms to determine food source and trophic position, respectively, and to assess whether the structures of these acidified food webs differed from those in circumneutral systems. The top predators, yellow perch, had mean Hg concentrations ranging from 0.31 to $0.49 \mu\text{g/g}$ wet weight, but were at similar trophic levels (after adjusting for the baseline; mean TL of 3.59 to 4.06). Within each lake, the fish had comparable adjusted $\delta^{15}\text{N}$ ratios (less than 0.20 ppt difference among species), and although the Hg concentrations were not significantly different, the mean minnow Hg ranged from 0.16 to $0.35 \mu\text{g/g}$ wet weight. Mercury versus $\delta^{15}\text{N}$ regressions will be used to quantify bioaccumulation of Hg through these food webs, examine among-lake differences, and contrast data from acidified and circumneutral, temperate systems.

TP158 Accuracy of the National Descriptive Model of Mercury in Fish. S.P. Wentz, Formerly: US Geological Survey, Reston, VA; S.P. Wentz, Currently: US Environmental Protection Agency, Arlington, VA. The National Descriptive Model of Mercury in Fish (NDMMF) uses relationships derived from a national compilation of fish-tissue mercury (Hg_{fish}) concentration data to predict Hg_{fish} across a wide range of species, tissue types, and lengths of fish at many thousands of sampling events across the U.S. This research assesses NDMMF prediction accuracy for three scales at which analyses are commonly performed (individual site/sampling event, watershed, and national). NDMMF prediction accuracy at the site/sampling event and watershed scale is assessed using the fit of the NDMMF predictions (calibrated to the national data set) to 193 composite fish samples collected from 14 sites

in the St. Croix River Basin of Minnesota and Wisconsin in 2004. At each site, 14 samples were collected from a wide range of species, tissue types, and fish lengths. At many sites, observed Hg_{fish} concentrations varied by factors of more than 10 (range over all sites sampled is 7.3 to 830 $\mu g/kg$). At the site/sampling event scale, the NDMMF described between 75 and 96% ($r^2 = 0.75$ to 0.96) of the variability in observed Hg_{fish} concentrations at the 14 sites. Additionally, the lack-of-fit at two sites with high Hg_{fish} appears to be related to fish length with smaller, presumably less mobile, fish having higher than predicted Hg_{fish} concentrations and larger, more mobile, fish having lower (similar to nearby sites). The watershed scale assessment uses the NDMMF standardized Hg_{fish} concentrations from these sites to determine the minimum concentration difference necessary to detect inter-site differences within the St. Croix River Basin. At the national scale, accuracy is assessed for the NDMMF and several other empirically-based Hg_{fish} models using predictions of withheld observations. The variation in the accuracy of the NDMMF and other empirical models is shown to vary with the number of samples on which the specific prediction is based and the kind of prediction (within or between species). Results of this assessment indicate the NDMMF prediction accuracy equals or surpasses the prediction accuracy of the other empirical models. Lastly, using the Environmental Mercury Mapping, Modeling, and Analysis (EMMMA) website (<http://emmma.usgs.gov>) to assess NDMMF prediction accuracy is discussed.

TP159 Temporal Trends of Mercury Concentrations in Wisconsin Walleye (*Sander vitreus*), 1982-2005. C. Schrank, P.A. Campfield, Fisheries, Wisconsin DNR, Madison, WI; P.W. Rasmussen, Science Services, Wisconsin DNR, Madison, WI. The Wisconsin Department of Natural Resources has monitored mercury (Hg) in several species of fish since the early 1970s primarily for fish consumption advisory purposes. We selected skin-on fillets of walleye (*Sander vitreus*) from inland lakes collected over the years 1982 to 2005 to assess temporal trends of Hg concentrations. While individual lakes are of interest, sample sizes and unbalanced collections across fish lengths, seasons, or years prevent estimates of temporal trends of walleye Hg concentrations within most lakes. We evaluated temporal trends over all lakes using mixed effects models (3,024 records from 421 lakes). Relationships between Hg concentrations and a suite of lake chemistry, morphometry, and other variables were also explored. Mercury concentrations generally increased with walleye length but the relationship varied among lakes. The best-fitting mixed effects models suggested that the overall rate of change in walleye Hg across all lakes in the dataset varied with latitude over the period 1982 to 2005. Season of collection was also an important predictor variable. Hg concentrations were highest in walleye captured in the spring and lowest in the fall. Other variables such as gender, lake area, and total alkalinity were also important predictors.

TP160 Methodological Aspects of Fish Tissue Mercury Studies: (1) Holding Time Mercury Concentration Stability Beyond the Standard 28-Days. O. Pancorbo, J. Sullivan, C. Batdorf, Wall Experiment Station, Massachusetts Department of Environmental Protection, Lawrence, MA; M.S. Hutcheson, J. Rose, C. Smith, Office of Research and Standards, Massachusetts Department of Environmental Protection, Boston, MA. A maximum 28-day holding time prior to instrumental mercury analysis for frozen fish tissue samples is recommended by the US Environmental Protection Agency and widely followed. The effect of extended preservation times (up to 20 months) beyond 28-days on the reported concentrations of total mercury in frozen freshwater fish dorsal muscle fillets from largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*) was assessed. Mercury concentrations in both species from both a lake having generally low tissue levels of mercury and from a lake having high levels of mercury were determined on the same samples within the present recommended US EPA 28-day limit and 10 months later. Another group of yellow perch from a low mercury lake had their tissue mercury analyzed within the 28-day limit and 20 months later. Differences between mean mercury concentrations in the two species after 10 months were from $\pm 2.8 - 10.6\%$. There were no statistically significant changes in the tissue concentrations of total mercury expressed on a wet weight basis in yellow perch in samples held for up to 20 months after initial analysis. Concentrations in largemouth bass were greater (4.3 and 10.6 % in the low and high fish mercury lakes) after 10 months than in the samples analyzed within 28 days. These results will be contrasted with historical lab replicate variability.

TP161 Methodological Aspects of Fish Tissue Mercury Studies: (2) Edible Fillet Biopsy Plug-Based Mercury Concentrations Compared with

Fillet Sample-Based Mercury Concentrations. M.S. Hutcheson, J. Rose, C. Smith, Office of Research and Standards, Massachusetts Department of Environmental Protection, Boston, MA; O. Pancorbo, J. Sullivan, C. Batdorf, Wall Experiment Station, Massachusetts Department of Environmental Protection, Lawrence, MA; J. Strube, Normandeau Associates, Bedford, NH. Evaluations reported in the literature have reported that biopsy samples are reliable predictors of fish fillet mercury concentrations. Switching to a field biopsy sampling methodology is attractive over fillet based analysis because of: elimination of the need to sacrifice most of the fish; reduction of logistical requirements to handle larger samples; elimination of the need to process fish and prep fillet samples for eventual instrumental analysis for mercury; and direct introduction of weighed biopsy plugs into the analytical instrument, thereby reducing chance for sample contamination during lab processing. We have conducted an intercomparison study to determine the degree of agreement between tissue mercury concentrations determined on edible freshwater fish fillet subsamples and on 4 mm biopsy plug samples taken from the same fish. Two hundred individual fish (93 largemouth bass, *Micropterus salmoides*; 194 yellow perch, *Perca flavescens*) were used. Initial trials where fish were sacrificed in the laboratory and biopsy samples taken under controlled laboratory conditions provided excellent agreement between the two measures of mercury concentration (1-5% differences) with no significant differences between the measures. Biopsy samples taken on anaesthetized fish in the field (62 YP and 8 LMB) did not agree as well with fillet-based values being 11.5 - 14% greater than the biopsy plug samples. The differences will be contrasted with historical lab replicate variability and acceptability criteria and will be discussed in relation to use in a large, long-term fish tissue mercury monitoring program.

TP162 Selenomethionine reduces visual deficits due to developmental methylmercury exposures. D. Weber, J.A. Dellinger, M.J. Carvan, Marine & Freshwater Biomedical Sciences Center, University of Wisconsin-Milwaukee, Milwaukee, WI; V.P. Connaughton, Department of Biology, American University, Washington, DC; J.A. Dellinger, College of Health Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI; D.P. Klemmer, Department of Electrical Engineering, University of Wisconsin-Milwaukee, Milwaukee, WI; A. Udvadia, Department of Biological Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI; A. Udvadia, M.J. Carvan, Great lakes WATER Institute, University of Wisconsin-Milwaukee, Milwaukee, WI. Developmental exposures to methylmercury (MeHg) have life-long behavioral effects. Many micronutrients, including selenium, are involved in cellular defenses against oxidative stress and may reduce the severity of MeHg-induced deficits. Zebrafish embryos (<4 hours post fertilization, hpf) were exposed to combinations of 0.0-0.30 μM MeHg and/or selenomethionine (SeMet) until 24 hpf then placed in clean medium. Fish were tested as adults under low light conditions ($\sim 60 \mu W/m^2$) for visual responses to a rotating black bar. Dose-dependent responses to MeHg exposure were evident (ANOVA, $P < 0.001$) as evidenced by reduced responsiveness, whereas SeMet did not induce deficits except at 0.3 μM . Ratios of SeMet:MeHg of 1:1 or 1:3 resulted in responses that were indistinguishable from controls (ANOVA, $P < 0.001$). No gross histopathologies were observed (H&E stain) in the retina or optic tectum at any MeHg concentration. Whole-cell, voltage-gated, depolarization-elicited outward K^+ currents of bipolar cells in intact retina of slices adult zebrafish were recorded and outward K^+ current amplitude was larger in bipolar cells of MeHg-treated fish. This was due to the intense response of cells expressing the delayed rectifying IK current, cells expressing the transient IA current displayed a slight trend for smaller amplitude among MeHg-treated fish. Developmental co-exposure to SeMet reduced but did not eliminate the increase in the MeHg-induced IK response, however, IA responses increased significantly over MeHg-treated fish to match control levels. Electrophysiological deficits parallel behavioral patterns in MeHg-treated fish, i.e., initial reactions to the rotating bar were followed by periods of inactivity and then a resumption of responses.

TP163 Evaluation of potential for mercury volatilization from gypsum products using flux chamber tests. I.J. Noggle, Environmental Affairs, Georgia-Pacific LLC, Atlanta, GA; N.S. Bloom, Studio Geochimica, Seattle, WA; S.S. Shock, Health Sciences Practice, Exponent, Saint Paul, MN; L.J. Yost, Environmental, Exponent, Seattle, WA. Use of wallboard made from synthetic gypsum generated via flue gas desulfurization (FGD) by coal-fired power plants (FGD gypsum) has raised questions regarding metals concentrations in the gypsum, and the potential for exposure to these metals. Comparison of metals concentrations in natural and synthetic gypsum

with health protective screening values indicated that trace metals in the sources of natural and FGD gypsum do not appear to pose health concerns (see presentation by Yost et al.). However, mercury concentrations in FGD gypsum were higher than those in natural gypsum. While pathways associated with exposure to particulate dusts were ruled out in screening, no data were available to assess whether mercury in wallboard could volatilize into indoor air. Therefore, analyses of mercury volatilization were conducted using small-scale (5 L) glass and Teflon flux chambers, with samples collected using both iodated carbon and gold-coated sand traps. Mercury flux measurements made using iodated carbon traps ($n=6$) were below the detection limit of 11.5 ng/m²/day for all natural and synthetic gypsum wallboard samples. Mercury flux measurements made using gold-coated sand traps ($n=6$) were 0.92 $\pm$ 0.11 ng/m²/day for natural gypsum wallboard, and 5.94 $\pm$ 2.44 ng/m²/day for synthetic gypsum wallboard. Room air concentrations of 0.25 and 1.6 ng/m³ were estimated based on the flux rate data for natural and synthetic wallboard samples, respectively, and were derived assuming a 3 m x 4 m x 5 m room, and a 10th percentile air exchange rate of 0.18/hour. These concentration estimates are well below the EPA RfC of 300 ng/m³ and the ATSDR MRL of 200 ng/m³, and are also below the range of literature values for typical background mercury concentrations in indoor air.

TP164 Mercury Speciation in Dental-Unit Wastewater. P.K. Fu, M.E. Stone, M.E. Cohen, Applied Laboratory Science, Naval Institute for Dental and Biomedical Research, Great Lakes, IL. Wastewater from dental clinics contains mercury (Hg) as a consequence of the placement and removal of amalgam restorations. Removal of particulate amalgam waste from dental wastewater is easily accomplished in the clinic by using commercially available amalgam separation devices (sedimentation or filtration). Soluble and particulate forms of Hg that escape removal by local treatment will be discharged to the sewer system and transported along with domestic, commercial, and industrial wastewater to wastewater treatment plants (WWTPs). Municipal WWTPs are usually quite effective in removing particulate mercury from wastewater; however both the incineration and land application of the remaining biosolids results in the release of some Hg to the environment. Furthermore, dissolved Hg species have the potential to pass through wastewater treatment plants unimpeded and be released into receiving bodies of water. Minimizing the amount of Hg in dental wastewater discharged to the sewer system can minimize the potential for its ultimate release to the environment. Particle size distributions of Hg in dental wastewater are well characterized. Other studies have evaluated techniques for removing Hg from this waste stream. However, not much is known about the chemical speciation of Hg in dental wastewaters, particularly soluble species that may be present. Effective removal of soluble Hg species from the dental waste stream requires a better understanding of what species are typically present. We examined Hg speciation in dental wastewater samples collected chair-side and from a 250 gallon holding tank from a large 110 chair dental clinic in Great Lake, IL. Total, volatile, inorganic, and methyl mercury (THg, Hg₀, Hg₂₊, and MeHg) in filtered and unfiltered dental wastewater were determined for chair-side samples while THg and MeHg were determined in holding tank samples. Results suggest that Hg in dental wastewater is physically and chemically stable while in the amalgam form, however dramatically elevated concentrations of MeHg were seen in the large holding tank. Preserving samples with concentrated acids may mobilize Hg bound in amalgam into soluble, active species, but low acid concentrations favor methylation and volatilization. To lessen the environmental impact of amalgam and to develop effective treatment strategies, further studies need to be completed.

TP165 Mechanisms involved in BaP and ANF embryo toxicity. C.E. Thornton, W. Dong, C. Rogers, H. Freyaldenhoven, K.L. Willett, Pharmacology and Environmental Toxicology, University of Mississippi, University, MS. Previous studies have shown that when *Fundulus heteroclitus* embryos are exposed to a combination of α -naphthoflavone (ANF) and benzo(a)pyrene (BaP) there is a significant increase in developmental toxicity compared to either treatment alone. Our current research aims to understand the mechanisms associated with this increased toxicity of polycyclic aromatic hydrocarbon mixtures. Specifically, we are investigating the roles of CYPs 1A and 1C1, apoptosis, and oxidative stress. *Fundulus* embryos were exposed to DMSO, BaP (100 μ g/L), ANF (1, 10 or 100 μ g/L), or a combination of BaP and ANF from 4.5 hours post fertilization (pf) to 12 days pf. No significant physiological changes were seen in embryos exposed to either BaP alone or ANF alone. However, when embryos were exposed to BaP and ANF in

combination, major defects were seen including tube heart, pericardial edema, blood clots and heart rates and heart areas were significantly decreased at 8, 10, and 12 dpf. In embryos collected at either 120 or 240 hpf, CYP1A and CYP1C1 mRNA expression was significantly upregulated in BaP and ANF cotreatments compared to control or low doses of ANF. For example, embryos at 240 hpf, had CYP1A mRNA induction compared to control of 100-, 400- and 450- fold for 100 μ g/L ANF alone, 100 μ g/L BaP alone, and 100 μ g/L ANF + 100 μ g/L BaP, respectively while CYP1C1 mRNA induction was 55-, 50- and 105-fold for the same treatments. However, there was no significant difference in CYP1A protein expression between BaP treatment and BaP + ANF cotreatments. To study the contribution of apoptosis and/or oxidative stress, *Fundulus* embryos were exposed to BaP and ANF combined with the antioxidant Vitamin E (250 μ g/L). By TUNEL staining, BaP + ANF significantly increased apoptosis in the heart compared to either the control or BaP + ANF + Vitamin E groups. Also, when the embryos were exposed to BaP + ANF + Vitamin E, the heart rates and areas were similar to controls suggesting a role of oxidative stress in the mechanism of action. Supported by NIEHS R01ES012710.

TP166 Thyroid Peroxidase Inhibition as a Tool to Select Chemicals for Testing in Amphibian-based Thyroid Toxicity Assays. M.W. Horning, J.T. Haselman, J.E. Tietge, S.E. Degitz, NHEERL, MED, US EPA, Duluth, MN; L.M. Korte, Student Contractor Services, Duluth, MN. Within the context of developing an amphibian-based hypothalamic-pituitary-thyroid axis systems model to predict the potential for chemicals to produce thyroid toxicity, there was a need to develop an initial screening tool to select chemicals for testing. One mechanism by which chemicals can affect this axis is via direct inhibition of enzymes responsible for thyroid hormone production. In the thyroid gland, thyroid peroxidase (TPO) catalyzes the iodination of tyrosines of thyroglobulin protein. TPO also catalyzes the coupling of iodinated tyrosines to form tri- and tetra-iodothyronines. These iodo-thyronines are cleaved from thyroglobulin by proteolytic enzymes in the thyroid follicular cells to release thyroid hormones to the circulation. Thyroid peroxidase activity can be measured spectrophotometrically following the activation and coupling of two guaiacol molecules in the presence of hydrogen peroxide. Microsomes prepared from porcine thyroid glands were incubated in the presence of guaiacol and test chemical to determine the inhibitory potency of chemicals on this enzyme. The reaction was initiated with hydrogen peroxide and the change in absorbance at 470 nm was measured. Methimazole and propylthiouracil, two model inhibitors of TPO, produced dose-related inhibition of TPO activity. Methimazole was more potent than propylthiouracil by an order of magnitude. The concentration that inhibited enzyme activity by 50% (IC₅₀) was 1.3 μ M and 11 μ M, for methimazole and PTU, respectively. Perchlorate, which inhibits thyroid hormone production by inhibition of iodine uptake into the thyroid gland, was negative in this assay when tested at concentrations up to 100 μ M. A series of six alkylphenols were tested ranging from phenol with no alkyl chain through octylphenol. None of these alkylphenols inhibited TPO when tested at concentrations from 0.36 to 3600 μ M. Further development and testing with this assay to screen more chemicals and to determine their relative potency compared to methimazole is being conducted. These results represent the initial stages of an effort to determine structure activity relationships for TPO inhibition by xenobiotic chemicals and to select candidate chemicals to test in an amphibian thyroid gland explant culture system and in a tadpole metamorphosis assay. This abstract does not necessarily reflect EPA policy.

TP167 Use of a marine hydroid model organism as surrogate for corals in early-life stage toxicity tests. M. Nipper, Center for Coastal Studies, Texas A&M University-Corpus Christi, Corpus Christi, TX; R. Carr, Marine Ecotoxicology Research Station, CERC, USGS, Corpus Christi, TX; K. Strychar, Department of Life Sciences, Texas A&M University, Corpus Christi, TX. The worldwide decline of coral reefs as a result of disease, pollution and excessive nutrients has become the focus of attention in recent years. While the effects of contaminants on the early-life stages of corals are poorly understood, mostly because laboratory research is limited due to slow coral growth, infrequent spawning and difficulty of laboratory maintenance, hydrozoans have been successfully used in toxicological research for decades. The class Anthozoa and the sessile phase of the life cycle of the class Hydrozoa, both representatives of the phylum Cnidaria, exhibit similar morphological structure. The body has radial symmetry, a mouth encircled by tentacles at the center of one end of the body, and a gastrovascular cavity. The embryo endoderm produces a layer of digestive cells, the gastrodermis,

and the embryo ectoderm produces the epidermis and a net of nervous cells. Between the ectoderm and the endoderm there is a non-cellular mesoglea. The homologous nature of the body structure and systems of these two classes of the phylum Cnidaria suggests that studies with colonial hydroids could be used as surrogates for reef forming hermatypic corals. Therefore, a model hydrozoan, *Hydractinia echinata* (Hydrozoa, Hydractiniidae) has been selected for early-life stage toxicity tests analyzing the effects of contaminants on larval development and metamorphosis. *Hydractinia echinata* eggs are shed and fertilized overnight and were harvested in the morning. The larval development of fertilized eggs was observed under control conditions over seven days and metamorphosis was induced with larvae of different ages, by exposure to cesium chloride for three hours. The highest rate of metamorphosis was achieved with 3-day old larvae. Therefore, 72 hours has been selected as the exposure period for toxicity tests analyzing larval development and metamorphosis. Results of toxicity tests with a variety of pesticides, PAHs and metals will be analyzed in view of realistic concentrations observed in coral reef environments.

TP168 Development of fluorescence in situ hybridization (ISH) techniques to detect and quantify expression profiles of genes along the HPG-axis in Japanese medaka. J. Park, A. Tompsett, X. Zhang, M. Hecker, P. Jones, NFSTC, Michigan State University, East Lansing, MI; M. Hecker, P. Jones, J. Newsted, J. Giesy, ENTRIX Inc., Okemos, MI; J. Giesy, Biomedical Sciences and Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Novel genomic and proteomic techniques have been developed to identify mechanisms of toxic action in organisms exposed to environmental contaminants. Most of the methods that have been developed to meet these objectives such as RT-PCR, Northern blotting, and RNase protection assays etc., typically rely on high yields of RNA extracted from bulk tissues. However, the limitations of these techniques are that they often fail to detect gene expression of low-abundance mRNA in small tissues, and they do not allow localizing changes within a tissue. Therefore, the aim of this study was to develop an ISH methodology that allows for both the evaluation of gene expression profiles simultaneously in multiple target tissues, as well as determination of subtle effects on multiple genes in multiple tissues. Common ISH approaches utilize probes labeled with radioactive or enzymatic (DIG or biotin) visualization systems. While these systems hold some promises in regards to the detection of gene expression in tissues, they are limited to some degree by sensitivity and resolution (see Tompsett et al.). More recently, the application of fluorescent labeling of probes directly (FISH) has considerably improved ISH. This improvement is not only due to the fact that FISH is highly reliable, sensitive and economic but also provides the option of using different fluorescent tags to simultaneously detect different genes in the same section. However, one of the major issues involved with FISH is the high levels of autofluorescence limiting in paraffin-embedded tissues that has limited the application of this method. Hence, in this study we optimized a FISH method using a confocal microscopy to reduce the autofluorescence signal. To validate the developed protocol, we applied the FISH system to detect CYP19a (aromatase) gene expression in four month old medaka that were exposed to aromatase inhibitor fadrozole (1, 10, and 100 µg/L for 7 days). We demonstrated that the advanced FISH method allowed for the determination and localization of specific tissue and cell type effects of fadrozole on CYP19a expression with high sensitivity and reliability. These results indicate that the method has the potential to serve as a powerful tool to further understanding of the specific modes of action of environmental contaminants.

TP169 Effects of Water Hardness on Skeletal Development and Growth in Larval Fathead Minnows. H.L. Schoenfuss, C.D. Houdek, B.A. Rosty, Biological Sciences, St. Cloud State University, St. Cloud, MN. Skeletal growth in vertebrates is frequently limited by the availability of basic nutrients and minerals. In particular, calcium, the primary component of the calcified collagen matrix forming the bony skeleton of most vertebrates, is essential to adequate growth and development. The correlation between aquatic calcium content and fish skeletal growth is especially important as calcium absorption from water is an essential route by which teleost fishes acquire calcium for skeletal development. Even if calcium is given to developing fishes as dietary supplements, calcium acquisition via gills from the surrounding water remains the primary source of calcium. In this study, we tested the hypothesis that a calcium-rich aquatic environment will expedite larval skeletal development while a calcium poor environment will inhibit the development of skeletal elements in larval fishes. We adapted enzyme clearing and histological differential staining techniques that allow for the simultaneous visualization of

cartilage and bone in developing larvae. Based on a range-finding experiment, we determined that 60-70 days rearing time provides the most opportune window to determine different ossification patterns for the subsequent experiment. Subsequently, we divided three batches of fathead minnow eggs from a fathead minnow colony supplied with calcium rich water and one with low calcium content, exchanged one half of each egg batch and reared fish to 60 days post-hatch in the two colonies. All fish were then sacrificed, cleared and stained and ossification patterns were quantified using NIH Image software. Results of this study have implications for the rearing conditions of many fish species used as model organisms in toxicological laboratories.

TP170 Development of Ecotoxicity Safety Factors for Pharmaceuticals in Wastewater Effluent Using Population Modeling. L. Trumbull, C.J. Kriegner, P. Sinha, W. Schew, Eco-Sciences, O'Brien & Gere, Blue Bell, PA; D. Cragin, Occupational & Environmental Health Sciences, Merck & Co., Whitehouse Station, NJ. Establishment of a no effects concentration (NOEC) to protect ecological receptors from adverse effects traditionally has been based on acute toxicity tests and application of a safety factor. This methodology may not be appropriate, because while protection of sensitive individuals is appropriate for the protection of human health, ecological assessment endpoints are often directed toward the protection of populations or communities rather than protection of the individual organism. Therefore, once a chronic toxicity NOEC is established for individuals in a test species, population modeling should be conducted to determine a population level chronic toxicity NOEC. The ratio between the individual-based NOEC and the population NOEC may form the basis of an ecotoxicity safety factor. In this study, a population model is constructed for an ecotoxicity test species and the adverse effects of a selected pharmaceutical compound on a population parameter (e.g., intrinsic population growth rate) is incorporated. The population model is run to obtain steady state population densities for the test species for a range of chemical concentrations. Beginning with a value of zero, the chemical concentration (x) is increased until the steady state population density begins to decline, indicating the lowest effects concentration (LOEC) for the test species population. The corresponding population NOEC is selected as the concentration just below the population LOEC for which the steady state population density is unaffected by the chemical. After completion of a Monte Carlo uncertainty analysis for developing a range of population NOECs, statistical methods may also be used to obtain confidence intervals for individual-based NOECs from toxicity tests. The ratio between the range of individual-based NOECs to the range of population NOECs can form the basis of a range of acceptable safety factors.

TP171 Transgenic Zebrafish as Indicators of Oxidative Stress. B.W. Kusik, M.J. Carvan, A.J. Udvadia, Biological Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI; B.W. Kusik, M.J. Carvan, A.J. Udvadia, Great Lakes WATER Institute, University of Wisconsin-Milwaukee, Milwaukee, WI. The goal of this project is to create a biosensor to detect low levels of chemical contaminants that cause oxidative stress in aquatic environments, such as heavy metals or pesticides. To achieve this goal we have developed two different reporter constructs that when introduced into zebrafish embryos produce easily assayable proteins under conditions of oxidative stress. The reporter gene expression in these constructs is driven by the electrophile responsive element (EPRE), which activates gene expression in response to oxidative stressors. One construct contains a reporter gene that encodes a luciferase-GFP fusion protein (LUC-GFP). The GFP component of this fusion protein allows us to visually detect reporter gene activity and to determine if activity is localized to a particular tissue. The luciferase component is capable of returning a quantitative assessment of reporter gene activity that allows us to determine if reporter gene activity is directly correlated to the concentration of the chemical inducer. The second reporter contains a reporter gene that encodes the *mitfa* transcription factor, which is essential for pigment formation in melanocytes. Expression of the *mitfa* transgene can rescue pigment production in *nacre* mutant fish, which have a point mutation in the *mitfa* gene and lack dark pigmentation found in the stripes. Transgenic fish bearing this construct have the potential for providing a simple +/- assay for the presence of oxidative stressors. We have tested these reporter constructs in both transient and stable transgenic fish after exposure to a range of HgCl₂ concentrations. We observed inducible luciferase expression from the EPRE-LUC-GFP construct in both transient assays and in stable lines. GFP expression was inducible in transient assays, but was below the limit of detection in stable lines. We did not detect inducible *mitfa* activity in either transient assays or in stable lines after induction. We conclude that

the EPRE is capable of driving reporter gene expression under conditions of oxidative stress, however modifications to the reporter system will be required to amplify the induced signal in order to increase the sensitivity of the system.

TP172 Using STELLA to Model Population-level Ecological Risk. L. Trumbull, C.J. Kriegner, P. Sinha, W. Schew, Eco-Sciences, O'Brien & Gere, Blue Bell, PA. Because the goal of ecological risk assessment is the protection of populations and not individuals, risk management decisions based on the results of traditional risk assessment procedures may be supplemented by modeling the population-level response to constituents of potential ecological concern. In this poster, we present two case studies where STELLA is used to evaluate population-level risk. In the first study, we examine the response of a hypothetical population of *Peromyscus maniculatus* exposed to five different concentrations of lead in surface soil, with and without the inclusion of predators. While both factors (lead and predators) decreased population density when modeled individually, an increase in the density of predators had a greater detrimental effect on population growth than did an increase in soil lead concentrations. In the second case study, we use STELLA to develop no effects concentration (NOEC) safety factors for pharmaceuticals in wastewater effluent. A population model was run to obtain steady state population densities for the test species for a range of chemical concentrations. The chemical concentration is increased until the steady state population density begins to decline, indicating the lowest effects concentration (LOEC) for the test species population. The corresponding population NOEC is selected as the concentration just below the population LOEC for which the steady state population density is unaffected by the chemical. The ratio between the range of individual-based NOECs to the range of population NOECs can form the basis of a range of acceptable safety factors.

TP173 Quantitation of xenoestrogen-dependent interaction of the human estrogen receptor with its estrogen response element using surface plasmon resonance spectroscopy. J.C. Clark, L. Ferguson, Chemistry and Biochemistry, University of South Carolina, Columbia, SC. The occurrence of endocrine disrupting compounds (EDCs) in the aquatic environment has raised considerable scientific and regulatory concern over the past decade. These compounds have the potential to disrupt normal endocrine system functions, resulting in reproductive and developmental abnormalities in organisms. Of particular interest are the xenoestrogens, a large class of structurally-diverse compounds that mimic or block the actions of the endogenous hormone, 17 β -estradiol, by binding to the estrogen receptor (ER), a ligand-inducible transcription factor. Upon ligand binding, the ER dimerizes and translocates to the nucleus where it then binds to a promoter DNA sequence, the estrogen response element (ERE) to form a transcriptional protein complex. Xenoestrogens can act through this same mechanism to activate or repress gene transcription. This differential modulation is thought to occur in part by ligand-dependent changes in the affinity of ER binding to the ERE promoter site. In order to study the mechanism by which xenoestrogens modulate ER transcriptional activity, we have used surface plasmon resonance (SPR) spectroscopy to probe the binding affinity and kinetics of xenoestrogen-bound ER to a consensus ERE sequence. Our objective in this work was to study the ligand-dependence of this process across classes of estrogenic pharmaceuticals, pesticides, and industrial products including nonylphenol, methoxychlor, and bisphenol-A, for example. Initial results confirm homo- and heterodimerization of the estrogen receptor in the presence of estradiol as well as ER-ERE binding in a ligand-dependent fashion. Further studies are being conducted using an ER-positive MCF-7 breast cancer cell line to examine ligand-dependent recruitment of ER from a complex nuclear extract mixture to immobilized ERE.

TP174 Investigation of reversible chemical neurotoxicity in *Eisenia fetida* using a custom-designed 15,000 oligo probe array. P. Gong, X. Guan, SpecPro Inc., Vicksburg, MS; Y. Deng, M. Pirooznia, University of Southern Mississippi, Hattiesburg, MS; C. Liang, Miami University, Oxford, OH; E. Perkins, US Army Engineer Research and Development Center, Vicksburg, MS. The earthworm *Eisenia fetida* is one of the most used species in standardized soil ecotoxicity tests. Endpoints such as survival, growth and reproduction are ecologically relevant but provide little mechanistic insight into the toxicity pathways, especially at the molecular level. To better understand toxicological modes of action and to facilitate the development of molecular biomarkers, we have obtained 34,000 EST sequences from *E. fetida* and have designed a novel microarray with 15,000 60-mer oligonucleotide probes. These probes target the unique non-redundant EST sequences identified in *E. fetida*. Using this array we have profiled gene expression of *E.*

fetida after exposure to CL-20, a cubic, nitroheterocyclic energetic compound previously found exhibiting reversible neurotoxicity to worms. Worms were exposed for 6 days to CL-20. Half of the exposed worms were allowed to recover in a clean environment for 7 days. Electrophysiological analysis showed that the conduction velocity of worm medial giant nerve fiber was significantly decreased after 6-d exposure to CL-20, and that giant nerve fiber function was restored at the end of the 7-d recovery period. Total RNA samples isolated from four treatment groups (6 replicates per group), i.e., 6-d control, 6-d exposed, 13-d control and 6-d exposed with 7-d recovery, were analyzed using the new 15K oligo array. Bioinformatics and statistical analyses have identified specific neurological pathways affected by CL-20 and recovery of these pathways after CL-20 removal. These results provide significant insights on the CL-20 toxic mode of action and how earthworms can recover from toxic chemical stressors.

TP175 Interpreting WET Data from *Arbacia punctulata* Using Wastewater Treatment Plant Effluent in Puerto Rico. A.B. Chartrand, D. Holmes, T. Hamaker, S. Costa, Aquatic Sciences, CH2M Hill, Bellevue, WA; M. Rivera, Puerto Rico Aqueduct & Sewer Authority, San Juan, PR. The sea urchin *A. punctulata* (*Arbacia*) chronic fertilization test is currently used to conduct Whole Effluent Testing (WET) bioassays in response to Puerto Rico NPDES permit requirements, in part to replace a formerly recommended chronic test species (*Champia* sp.). The hypothesis testing method currently being used by EPA Region 2 for evaluating the *Arbacia* data relies on No Observed Effects Concentrations (NOECs) based solely on statistically-derived differences in variance between control and test organisms. Variance may be exceedingly low between control replicates, thus leading to NOEC estimates that are prone to "false positive" or Type I error. When these results are compared with a commonly used and widely accepted point estimate technique (IC25, the concentration of a test effluent resulting in 25% inhibition of fertilization success of *Arbacia* eggs), test results yield very different estimated levels of chronic response endpoints. For example, using 2006 and 2007 WET data generated from Puerto Rico WWTPs, 11 out of 14 test NOECs indicated unacceptable chronic toxicity based on statistically-based NOECs alone, while using a more biologically meaningful data evaluation method (e.g. IC25 point estimates), no unacceptable toxicity was identified at the specified compliance level of 142 chronic toxic units (TUC). Use of point estimates such as IC25 values in lieu of statistical hypothesis testing is consistent with current USEPA guidance on WET data interpretation. For example, USEPA 2002 (Third Edition) suggests that these point estimation techniques are generally preferable for regulatory compliance evaluations as they more comprehensively estimate the level at which a sublethal biological response (in this case, reproductive inhibition) may occur. Point estimates employ the entire toxicological data set to define the estimate, and are thus both more reliable and biologically significant. Our presentation will help to clarify more effective and appropriate methods to use for interpreting future *Arbacia* WET test results. When point estimates such as IC25s are combined with biologically-based NOECs or other more relevant data evaluation techniques, *Arbacia* WET data will yield much more meaningful toxicity evaluations.

TP176 Effect of Perfluorooctanesulfonate (PFOS) Exposure on Steroidogenesis in Juvenile *Xenopus (Silurana) tropicalis*. D.J. Fort, R.L. Rogers, Fort Environmental Labs, Stillwater, OK; P.D. Guiney, J.A. Weeks, S.C. Johnson & Son, Racine, WI. The impact of the perfluorochemical, perfluorooctanesulfonate (PFOS), on gonadal steroidogenesis during sexual differentiation in *Xenopus tropicalis* was examined because of its ubiquity in the environment, bioaccumulative nature, and potential to disturb endocrine activity. PFOS was previously found to inhibit androgen-induced oocyte maturation in vitro in *Xenopus*. A partial lifecycle study exposing *X. (Silurana) tropicalis* to varying concentrations PFOS (<0.03, 0.05, 0.12, 0.29, 0.62, and 1.1 mg/L) was also conducted. A concentration-dependent increase in whole body PFOS residues was measured ranging from 29.6 mg/Kg to 163.5 mg/Kg in the 0.05 mg/L and 1.1 mg/L PFOS treatments. Gender ratios were similar to controls in the 0.05, 0.12, and 0.29 mg/L PFOS exposure treatments; however an increase in males was noted in the 0.62 and 1.1 mg/L PFOS treatments. Abnormal ovary development characterized by size asymmetry, necrosis and formation of excessive fibrous connective tissue was identified in females exposed to 0.29 mg/L PFOS. Asymmetrically misshapen testes were found at 1.1 mg/L PFOS. To further examine the effect of PFOS exposure on gonadal differentiation, aromatase and 5 α -reductase activities were measured, in addition to plasma estradiol (E2), testosterone (T), and dihydrotestosterone

(DHT) levels. Gonad and plasma samples were collected from juvenile control specimens and organisms exposed to PFOS from early embryo through metamorphosis. Increased mean plasma DHT and T, and decreased mean E2 levels were found in PFOS-treated juvenile *X. tropicalis* compared to controls. *X. tropicalis* exposed to PFOS exhibited a concentration-related decrease in mean gonadal aromatase activity, but an increase in mean 5 α -reductase activity compared to control frogs. Additional confirmatory studies with cultured undifferentiated *X. tropicalis* gonad explants suggested that PFOS was capable of decreasing gonadal aromatase activity while increasing 5 α -reductase activity in vitro. These results are consistent with similar studies conducted in fish, and suggest that the decreased aromatase activity and increased 5 α -reductase activities may have resulted in the increase in plasma T and DHT levels found in PFOS treated *X. tropicalis*. Further, the increase in the proportion of phenotypic male frogs may be the result of increased gonadal androgen levels induced by PFOS exposure.

TP177 In Vitro Metabolism of 8-2Fluorotelomer Alcohol in Multiple Species. R.C. Buck, W.J. Fasano, D.L. Nabb, B. Szostek, S.H. Korzeniowski, M.P. Mawn, E. I. duPont de Nemours & Co., Inc., Wilmington, DE; M. Gargas, The Sapphire Group, Beavercreek, OH. The detection of perfluorinated organic compounds in the environment has generated interest in their biological fate. 8-2 Fluorotelomer alcohol (8-2 FTOH, C₇F₁₅CF₂CH₂CH₂OH), a raw material used in the manufacture of fluorotelomer-based products, has been identified in the environment, and has been implicated as a potential source for PFOA in the environment. In this study, the in vitro metabolism of [3-14C] 8-2 FTOH and selected acid metabolites by rat, mouse, trout, and human hepatocytes and by rat, mouse, and human liver microsomes was investigated. Clearance rates of 8-2 FTOH in hepatocytes indicated that rat > mouse > human $\geq$ trout. The major 8-2 FTOH metabolic pathway was conjugation. A number of metabolites not previously reported were identified adding further understanding to the pathways for 8-2 FTOH metabolism. They included 7-3 aldehyde, 7-3 α - β unsaturated aldehyde, 7-2 ketone, 7-3 β -keto aldehyde, and the taurine conjugate of 7-3 acid. Additionally, perfluoropentanoate, perfluorohexanoate, perfluoroheptanoate, perfluorooctanoate, and perfluorononanoate were minor metabolites representing in total less than 0.1% of 8-2 FTOH dosed. Neither perfluorooctanoate nor perfluorononanoate were detected from incubations with human microsomes. To further elucidate the steps in the metabolic pathway, hepatocytes were incubated with known metabolites: 8-2 fluorotelomer acid, 8-2 fluorotelomer unsaturated acid, 7-3 acid, 7-3 unsaturated acid, and 7-2 secondary fluorotelomer alcohol. Although all of the 8-2 and 7-3 acids were metabolized, shorter chain perfluorinated acids were only observed in hepatocyte and microsome incubations of the 8-2 acids but not from the 7-3 acids. Overall, the results indicate that 8-2 FTOH is extensively metabolized in rats and mice and to a lesser extent in humans and trout. Metabolism of 8-2 FTOH to perfluorinated acids was extremely small and likely mediated by enzymes in the microsomal fraction. These results suggest that human exposure to 8-2 FTOH is not expected to be a significant source of PFOA or any other perfluorocarboxylic acids.

TP178 Modelling the long-range transport of PFOA as a multispecies chemical. L.K. Reid, D.A. Ellis, D. Mackay, Canadian Environmental Modelling Centre, Trent University, Peterborough, Ontario, Canada; D.A. Ellis, C.J. McMurdo, Department of Chemistry, Trent University, Peterborough, Ontario, Canada. Perfluorinated octanoic acid (PFOA) has been identified as a potential global contaminant. PFOA is an acid with a pK_a $\approx$ 3.4 and at environmental pHs, exists in both the protonated and deprotonated forms in aqueous solution. In the atmosphere it exists nearly entirely as the protonated form. Due to this ionization and the other unique physical-chemical properties of the chemical (e.g. surface activity), there are challenges in simulating its environmental fate using conventional models. Previous studies of environmental fate have almost exclusively examined the deprotonated form and largely ignored the protonated one. This study proposes that the multispecies approach outlined by Toose and Mackay (2004), which accommodates chemicals that exist in various forms that exhibit differing physical-chemical properties, be used. For an ionizing chemical such as PFOA, this approach has the ability to address both the volatility of the protonated species and the solubility of the deprotonated form, while accounting for the presence and transport of each form throughout the environment. Long range transport of PFOA can be shown to occur in the protonated form via the atmosphere in the gaseous and particulate phases as well as in the deprotonated form by slower oceanic pathways. The relative

importance of these pathways can be shown. A global mass balance of total PFOA can be achieved using the BETR-World model; major global sources and sinks for the chemical can be deduced.

TP179 Mass balance analysis and pathways of perfluorinated acids in multimedia environment: contributions from airborne deposition/ gaseous exchange, rainfall, snow, and surface runoff. S. Kim, NeoEnBiz, Co., Institute of Environmental Protection and Safety, Seoul, South Korea; S. Kim, K. Kannan, New York State Health of Dept., Wadsworth Center, Albany, NY. In order to elucidate the pathways of perfluorinated acids (PFAs), inland lake waters with no known direct anthropogenic sources were collected longitudinally representing urban to rural areas. PFOA concentration showed a source-dependent distribution with a 2-fold higher concentration in lakes than in the river traversing the study area. To identify the pathways and sources, we collected and analyzed rainwater, snow, and surface runoff water (SRW) in the urban area. These data, along with the concentrations in air were used to establish the mass balance of PFOA in lakes. Of 12 PFAs measured, PFOA was the dominant compound found in all samples. Concentration of PFOA in lake water, rainwater, snow, and SRW ranged from 3.27 to 15.8 (median=7.20 ng/L), from <LOQ to 7.27 (2.15 ng/L), <LOQ to 19.6 (2.72 ng/L), and 0.51-29.3 (3.80 ng/L), respectively. SRW contained a greater concentrations of PFOA, and was suspected as a dominant contributor to contamination of lake water. This is also supported by the similar relative composition of PFAs and the detection of FtS in both SRW and lake water. Mass balance analysis suggested that an unknown source(s) was estimated to be a major contributor, ~60% of total PFOA under a steady-state assumption. Fluorotelomer alcohol (FTOH)-related sources in aqueous matrices can be considered as a possible source. Concentration of FTOHs in lake water was estimated to be ~30 ng/L. Urban release and surface runoff are important source and pathway, respectively, of PFOA in the environment.

TP180 Bioaccumulation of Perfluorinated Compounds in Recycled Water: Assessing the Biological Effects of Water Reuse for Urban Ecosystem Restoration. H. Bischel, M. Plumlee, P. McLeod, M. Reinhard, R.G. Luthy, Civil and Environmental Engineering, Stanford University, Stanford, CA. As a result of human population growth and increasing water demands, environmental stores of fresh water supporting aquatic habitat are dwindling. The problem is particularly acute for urban streams, which also often receive urban drainage and sewer overflow leading to a consistent pattern of ecological degradation. Recognizing the potential for tertiary treated wastewater, or recycled water, to restore local aquatic habitat, the Santa Clara Valley Water District plans to use tertiary-treated wastewater from the City of San Jose, CA to augment Coyote Creek during a short-term research demonstration in the summer of 2007. Such projects are complicated by considerable uncertainty regarding the risk of emerging contaminants in reclaimed wastewater. Effluent sampling efforts conducted at Coyote Creek in 2005 indicate recycled water total perfluorochemical (PFC) concentrations range from 200 ng/L to greater than 500 ng/L. To investigate the biological impact of PFCs on Silver/Coyote Creeks, we will characterize PFC bio-uptake by freshwater bivalves. Because PFCs are known to accumulate in animal and human tissues, a bioaccumulation test is an appropriate bioassay for the analysis of these contaminants in recycled wastewater and receiving waters. In the planned work, filter-feeders at the base of the aquatic food web will be used for 28-56 day laboratory and field bioaccumulation studies. A biodynamic model previously used to describe uptake of other persistent organic compounds by two bivalve species will be applied for the interpretation of the bioaccumulation results. This work-in-progress will be presented as part of an interdisciplinary project on the use of recycled water for urban stream restoration.

TP181 A stochastic population model for narrow mouthed toads: effects of multiple stressors on population projections. C.J. Salice, EFED, US EPA, OPP, Washington, DC; C.L. Rowe, Chesapeake Biological Laboratory, University of Maryland, Solomons, MD; W.A. Hopkins, Department of Fisheries and Wildlife Science, Virginia Polytechnic Institute and State University, Blacksburg, VA. An important challenge for ecotoxicologists is evaluating the potential effects of toxicants in an ecological context. Importantly, environmental variability combined with toxicant-induced effects can result in changes in populations that may not be understood from toxicity tests alone. Here, an approach is described for linking laboratory- and field-derived data to population-level processes while incorporating some elements of environmental variability. The method entails using exposure-effect relationships combined with life history information to generate population

projections for narrow-mouthed toads (*Gastrophryne carolinensis*). Aquatic and terrestrial phases are considered explicitly. A matrix population model is used as the basis for population projections. Environmental stochasticity is introduced using distributions to describe life history variability and catastrophic environmental events. Twenty-year projections are simulated multiple times to yield a probability of certain outcomes such as extinction and threshold population size. Although there are uncertainties associated with the current model, baseline projection results show toad population sizes similar to what have been observed in the field. Simulation results indicate that for narrow-mouthed toads, the population is able to withstand a certain degree of catastrophic reproductive failure. However, additional stresses, such as toxicant-induced reductions in reproductive output and reduction in upland habitat reduce the ability of toad populations to withstand random catastrophic events. Results also highlight the importance of survival in upland habitats for this species suggesting that further research to better define upland habitat use is warranted. Future efforts are aimed at further model refinements to include more sophisticated density dependent functions and to explore the implications of certain key assumptions related to vital rates.

TP182 Action Area Definition for a Pesticide Endangered Species Assessment Using Exposure Factors Based on Flow Accumulation. D.A. Howes, J.M. Giddings, B.D. McGaughey, Compliance Services International, Lakewood, WA. The area in which threatened or endangered species may potentially be impacted due to the use of a pesticide product is known as the 'action area', which refers to the federal action of pesticide registration by U.S. EPA. In a screening level assessment, the spatial definition of the action area begins with the identification of the potential use area for the pesticide. If a refined species-specific assessment is necessary, the action area can be defined more precisely to account for spray drift and runoff. A grid-based method for estimating the action area for a pesticide product is presented using the California Red-Legged Frog as an example and involving analysis of information from the California Department of Pesticide Regulation Pesticide Use Reporting program, the U.S. Geological Survey 2001 National Landcover Dataset, and the U.S. EPA National Hydrography Dataset Plus dataset. The potential risk to a species due to the use of a product is evaluated for observation locations using a newly developed algorithm that computes an exposure factor (EF) value for each cell in an analysis grid. The EF for a location is based on the proportion of the area draining to the location that lies within the area in which the product may be used or spray drift may occur. Any cell for which the EF is greater than a threshold value (based on the toxicity of the pesticide, the screening-level exposure estimate, and a pre-established Level of Concern) is considered to be part of the action area for the product.

TP183 Refining Action Area in the Context of Pesticide Runoff for Protecting Endangered Species Habitats. T.S. Ramanarayanan, J. Tang, Environmental Research, Bayer CropScience, Stilwell, KS; A. Hall, Ecotoxicology, Bayer CropScience, Research Triangle Park, NC; R. Vamshi, C. Holmes, Waterborne Environmental, Leesburg, VA. Action area for endangered species effects determination may be defined as all the areas that could potentially be affected directly or indirectly by a federal action (pesticide application). It is not merely the area of application. Pesticide movement from the application area through runoff is governed by the landscape hydrography. The extent of the action area downstream of the pesticide application area would depend on composition of the landscape – i.e. the proportion of the land where the pesticide can be applied to the rest of the area. By defining the landscape hydrography (delineating watersheds and streams), the action area of aquatic habitat protection can be determined. NHD-Plus is a suite of dataset and tools compiled by USEPA and USGS. It consists of detailed stream layers, catchments, catchment land use summaries and other related hydrographic and geographic datasets, designed to work within Geographic Information Systems (GIS). Stream navigation tools are a part of the NHD-Plus suite that can be used to delineate watersheds. Using NHD-Plus dataset we delineated watersheds for all known locations of the California Red-Legged Frog. Locations and defined the action area for protecting against potential adverse effects from pesticide use. This concept may be adopted for defining action areas for aquatic habitat protection elsewhere.

TP184 Effects of chronic dietary pesticide or pharmaceutical exposure on zebrafish serotonin and dopamine transporters. G.G. Gould, A. Frazer, Pharmacology, University of Texas Health Science Center at San Antonio, San Antonio, TX; G.G. Gould, Biology, William Paterson University, Wayne, NJ. Mechanistic studies of the neurotoxicological effects of exposures to pesticides during critical life stages are needed to understand their relationship

to neurodegenerative disorders. Use of zebrafish embryos, larvae and adults to examine this link has advantages over rodent models, including the potential to efficiently examine effects of early pesticide exposures on later biogenic amine system development. Despite evolutionary divergence, dopamine (DA) and serotonin (5-HT) systems are largely conserved between zebrafish and mammals. The aim of this study was to determine if chronic exposure to pesticides would alter the central biogenic amine systems of zebrafish adults. Pesticide exposures were compared to pharmaceutical positive controls: the selective 5-HT reuptake inhibitor, sertraline, for which chronic treatment produces loss of 5-HT transporter (SERT) binding sites, and the selective DA reuptake inhibitor, GBR 12909, for which chronic treatment produces loss of DA transporter (DAT) binding sites in rats. Zebrafish were administered 1 or 10 ug/day sertraline, 10 ug/day of the organophosphate chlorpyrifos, 10 ug/day GBR 12909, or 10 ug/day of the organochloride dieldrin via a gelatin fish food diet for 21 days. Fish brains were assayed for SERT or DAT binding site density by homogenate binding, using [³H] citalopram or [125I] RTI-55 with SERT binding blocked by 50 nM cold citalopram. Samples were pooled from the brains of 2-3 zebrafish. After 21-day dietary exposure to sertraline or chlorpyrifos, SERT binding was significantly reduced by 50% or more relative to controls (N = 3-6, control = 103 ± 15 fmol/mg protein, sertraline-exposed = 51 ± 9 or 39 ± 13 fmol/mg protein, chlorpyrifos-exposed = 51 ± 14 fmol/mg protein, p<0.05). After exposure to GBR 12909 or dieldrin for 21 days DAT binding increased in dieldrin-exposed fish (6.5 ± 0.2 fmol/mg protein) and decreased in GBR 12909-exposed fish (3.2 ± 0.3 fmol/mg protein) relative to controls (4.6 ± 0.2 fmol/mg protein, N = 2, p<0.05). Thus, chronic exposure to pesticides can affect zebrafish biogenic amine systems and alter SERT and DAT binding site densities. Quantitative autoradiography studies are underway to confirm these results, and measurement of acetylcholinesterase inhibition will determine if these doses produced overt neurotoxic effects.

TP185 The Long-Term Behavioral Effects of Exposure to the Endocrine Disrupting Compound, Ethinyl Estradiol, on Four-Spined Stickleback (*Apeltes quadracus*). K. Kuroiwa, J. Basil, The Graduate School & University Center, CUNY, New York, NY; K. Kuroiwa, J. Basil, Brooklyn College, CUNY, Brooklyn, NY. Some environmental pollutants, called endocrine disrupting compounds (EDCs), have the potential to affect the behavior of living organisms. Synthetic estrogen, in the form of birth control and hormone replacement therapy, is a common and potent EDC pollutant in the aquatic environment. The active ingredient in most of these therapies is ethinyl estradiol (EE2). In this study, *A. quadracus*, the four-spined stickleback, was exposed to three environmentally relevant levels of EE2 (10, 70 and 100 ng/L) for 60 days. The fish were evaluated for behavioral changes in activity, aggression and predator avoidance at two points in time: 1) right after EE2 exposure, and 2) after a 100 day depuration in clean water. Preliminary evidence suggests that exposed fish differ in these behavioral measures from the controls. These behavioral changes that persist long after exposure suggest that EE2 has the potential to influence the fitness of four-spined sticklebacks.

TP186 Maternal dietary exposure to methylmercury induces developmental abnormalities in early life stage zebrafish. Q. Liu, M.L. Rise, M.J. Carvan, Great Lakes WATER Institute, University of Wisconsin-Milwaukee, Milwaukee, WI; Q. Liu, Department of Biological Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI; M.L. Rise, Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, Newfoundland, Canada; D. Weber, J. Dellinger, M.J. Carvan, Marine& Freshwater Biomedical Sciences Center, University of Wisconsin-Milwaukee, Milwaukee, WI; M. Dellinger, J. Dellinger, Department of Health Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI; S.L. Gerstenberger, Department of Environmental and Occupational Health, University of Nevada Las Vegas, Las Vegas, NV. Methylmercury (MeHg) exposure affects the developing nervous system in fishes and other vertebrates, including humans. The goal of this project is to identify neural and molecular biomarkers as predictors of MeHg exposure and deficits in specific neurobehavioral endpoints. Specifically, we are investigating the effects of sublethal MeHg exposure on developing zebrafish by analyzing early lifestage (ELS) toxicity, changes in global gene expression by microarray analysis and quantitative real-time PCR (QPCR), and neurobehavioral dysfunction. We also exposed zebrafish embryos to varying concentrations of MeHg via maternal diet using freeze-dried wild-caught walleye fillets grouped as low, medium and high Hg content representing 1.0, 2.0 and 3.5 ppm dry weight, respectively. Maternal walleye diet resulted in an increase in embryo Hg content and

an increase in ELS toxicity. Neurobehavioral deficits were also apparent in startle reflex response to a visual stimulus. Gene expression analysis in exposed embryos was performed using an 8,000 element custom zebrafish cDNA microarray. Microarray results were validated using QPCR. A number of the early life stage zebrafish genes found to be dysregulated by maternal MeHg have functional annotations involving cell division, cell cycle progression, neurodevelopment, liver development, ion-binding, transcriptional regulation and endopeptidase activity. These results show that maternal exposure to moderate levels of MeHg can have dramatic developmental and behavioral effects in their offspring by disrupting numerous molecular pathways involved in the growth and development of multiple organ systems. These results suggest that low-level environmental MeHg in food chains can have significant impacts on the early life stage fitness of fish without signs of overt toxicity.

TP187 Pharmaceutical Plasma Concentrations in Fish as a Prediction Tool For Toxicity: Case Studies With 17 α -Ethinyl Estradiol and Propranolol. M. Moen, L.A. Constantine, Pfizer Global Research and Development, Groton Laboratories, Groton, CT; S.F. Owen, J.P. Sumpter, Institute for the Environment, Brunel University, Uxbridge, Middlesex, United Kingdom; S.F. Owen, T.H. Hutchinson, M.J. Hetheridge, Global Safety Health and Environment, AstraZeneca, Brixham Environmental Laboratory, Freshwater Quarry, Brixham, Devon, United Kingdom; D.B. Huggett, Department of Biological Sciences, University of North Texas, Denton, TX. The environmental risk assessment (ERA) guidelines for pharmaceutical ingredients require chronic testing of fish to assess early life stage toxicity. Testing of every pharmaceutical requiring a Phase II assessment would result in the use of many vertebrate animals, as well as being costly and labor intensive. Pharmaceutical plasma concentrations have been proposed as one method by which the need for fish testing can be better assessed. In mammalian models, a given pharmacological/toxicological effect can be linked to the circulating plasma drug concentration. As these effect-exposure data are readily available, it has been proposed that the mammalian therapeutic or no-observable effect level (NOEL) be utilized as a benchmark concentration in fish. To determine the applicability of this approach, rainbow trout were exposed to two model pharmaceuticals with different mechanisms of action (e.g. 17 α -ethinyl estradiol (EE2) and propranolol). EE2 was found to accumulate in the plasma in a dose-dependent fashion with measured plasma values above the 100 ng/L mammalian therapeutic benchmark level. In all treatment groups, there was an induction of the egg-yolk precursor vitellogenin (i.e. mRNA and circulating protein), as well as an increase in the hepatic-somatic index. These data, as well as the propranolol data, will be presented to demonstrate the applicability of using mammalian benchmark levels to better guide chronic fish testing.

TP188 Hypoxia alters gene expression in the gonads of zebrafish. D. Martinovic, D.L. Villeneuve, M.D. Kahl, J.D. Brodin, L.S. Blake, G.T. Ankley, Mid-Continent Ecology Division, U.S. EPA, Duluth, MN. The objectives of this study were to characterize gene expression responses to hypoxia in gonads of mature zebrafish (*Danio rerio*), and to determine how the duration of exposure affects gene expression. Adult male and female zebrafish were maintained under normoxia (7 mg O₂/L), moderate hypoxia (3 mg O₂/L) and severe hypoxia (1 mg O₂/L) for 4 and 14 days (n = 5 per treatment) and changes in gene expression in gonadal tissues were evaluated using a commercial 21,000 gene zebrafish oligonucleotide microarray. Differentially expressed genes were determined using ANOVA (p < 0.01) and enriched gene ontology (GO) categories (p < 0.05) were identified using GeneSpring GX software (Agilent, USA). As hypothesized, gene expression patterns differed with duration of exposure. In both sexes, there were only two hypoxia-affected genes that were differentially expressed in both the 4 d and 14 d treatments. Short-term (4 d) hypoxia affected expression of genes associated with the initial adaptive responses such as: metabolism of carbohydrates and proteins, nucleotide metabolism, hemoglobin synthesis, reactive oxygen species metabolism and locomotion. More prolonged (14 d) hypoxia affected genes belonging to following GO categories: lipid metabolism, reproduction (e.g., steroid hormone synthesis), growth (growth factor signaling pathway) and immune responses (cytokine synthesis). Our findings suggest that long-term exposures could impact several processes that affect population dynamics (e.g., reproduction and growth) of fish living in hypoxic habitats. Overall, the microarrays proved useful for identifying potential processes that might be affected, but it remains to be seen whether the observed gene expression changes reflect alterations in broader physiological processes. Although this work was reviewed by U.S. EPA and approved for publication, it may

not necessarily reflect official Agency policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

TP189 GSK-3 β Inhibitors and Environmental Chemicals Disrupt Axis Determination in Zebrafish and Herring Embryos Via Nuclear β -Catenin Accumulation. E. Fairbairn, G. Cherr, University of California Davis, Bodega Marine Lab, Bodega Bay, CA; J. Bonthuis, University of California Davis, Davis, CA. The canonical Wnt/ β -catenin signaling pathway is critical during early development for establishing the dorsal-ventral axis in teleosts. Within this pathway, GSK-3 β regulates β -catenin degradation and thus β -catenin's ability to enter nuclei, where it can activate expression of dorsal-related genes. In this study, we linked the morphological abnormalities that result when axis determination is disrupted by commercially available GSK-3 β inhibitors or common environmental contaminants with aberrant nuclear localization of β -catenin. Zebrafish embryos were exposed to commercially available GSK-3 inhibitors (GSK-3 Inhibitor IX and 1-azakenpaulone), or common environmental contaminants (dibutyl phthalate or the polycyclic aromatic hydrocarbon (PAH) phenanthrene) from the 2-4-cell stage through the mid-blastula transition (MBT). These embryos displayed morphological abnormalities at 12.5 hours post-fertilization that were identical to embryos exposed to LiCl (300mM LiCl for 10 minutes, prior to the MBT), a classic disruptor of axis determination. We used whole-mount immunolabeling and scanning laser confocal microscopy to localize β -catenin in treatments. The commercially available GSK-3 inhibitors, LiCl, and dibutyl phthalate all resulted in increased levels of nuclear β -catenin throughout the embryo and/or in the yolk syncytial layer, suggesting that the morphological abnormalities are a result of disruption of Wnt/ β -catenin signaling during dorsal-ventral axis specification. These results with zebrafish have been translated to the estuarine Pacific herring, *Clupea pallasii*, an important commercial species. Since phenanthrene and other PAHs can disrupt axial development in teleosts as well as sea urchin embryos, and since axis determination and the Wnt/ β -catenin signaling pathway are highly conserved across phyla, environmental contaminants such as phthalates and PAHs may pose a serious hazard to early embryos across phyla.

TP190 Site fidelity of golden shiners (*Notemigonus crysoleucas*) and their use in effects-based assessments of pesticides by DFO's Center for Environmental Research on Pesticides (CERP). V.P. Palace, S. Mittermuller, C.L. Baron, Fisheries and Oceans, Freshwater Institute, Winnipeg, Manitoba, Canada; V.P. Palace, A.T. Goodmanson, J. Hare, K.G. Wautier, Zoology, University of Manitoba, Winnipeg, Manitoba, Canada; J. Struger, Water Quality and Surveillance Division, Environment Canada, Burlington, Ontario, Canada; L.E. Peters, Department of Environment, University of Manitoba, Winnipeg, Manitoba, Canada. The Canadian Department of Fisheries and Oceans (DFO), Center for Environmental Research on Pesticides (CERP), has adopted the use of small-bodied fish in an Environmental Effects Monitoring (EEM) framework for assessing the potential effects of pesticide use in southern Ontario. Specifically, golden shiners (*Notemigonus crysoleucas*) have been captured and assessed from several locations of Twenty Mile Creek, an intermittent flow creek in southern Ontario that often has multiple pesticide inputs from adjacent vineyards, orchards, a recreational golf course and urban runoff. While results suggest that pesticides may be affecting gonadal steroidogenic capacity and recruitment, uncertainty regarding mobility of the fish between study sites precludes the ability to link these effects with exposures to pesticides at each specific site. To address this knowledge gap, resident golden shiners at six sites on Twenty Mile Creek were marked using site-specific colours of visible implant elastomer (VIE). Recapture records at three periods throughout the summer provide a measure of site fidelity and pesticide exposure regimes.

TP191 Enhanced Bioaccumulation Of Ivermectin And Benzo(A) Pyrene In Catfish By Exposure To The Surfactant Linear Alkylbenzene Sulfonate. K. Kleinow, X. Tan, S. Yim, P. Uppu, Comparative Biomedical Sciences, Louisiana State University, Baton Rouge, LA. Linear alkylbenzene sulfonates (LAS), a widely used group of household and industrial surfactants, are high production volume and 'down-the-drain' chemicals. Surfactants as used in drug formulations have been shown to increase intestinal absorption and decrease the elimination of drugs through alteration of membrane permeability and ABC transporter function. The present study investigated in the catfish the effect of environmentally relevant concentrations of LAS (CH₃(CH₂)₁₁ C₆H₄SO₃ Na) on the in vivo bioaccumulation of the pharmaceutical drug ivermectin (IVM) and the pro-carcinogen benzo(a)pyrene (BaP).

To assess the contribution of membrane fluidity and the function of the ABC transporter P-glycoprotein (Pgp) to the observed effect, anisotropy measurements and transport studies were performed with the in situ prepared isolated perfused liver (IPIPL). For the bioaccumulation studies, groups of catfish were exposed 12 days to LAS in water at 0, 100 or 300 µg/L. Starting on day seven of LAS exposure, catfish were sequentially administered by gavage 6 daily doses of ³H-IVM (10 µg/day/kg body weight) or ³H-BaP (40 µg/day/kg body weight). ³H-IVM and ³H-BaP molar equivalents (parent and metabolites) in blood and all organs were elevated in a dose response fashion with increasing LAS concentrations. Mass balance studies indicated that LAS treatments of 100 and 300 µg/L increased the dose remaining in fish after exposure by 39% and 78% for ³H-IVM and 50% and 157% for ³H-BaP, respectively. Following LAS exposure at 300 µg/L, ³H-IVM and ³H-BaP equivalent concentrations increased 1.6-fold and 3.8-fold in liver, 3.2-fold and 3.9-fold in brain, 1.8-fold and 3.1-fold in muscle, respectively. LAS at 1, 5 and 20 µM in the IPIPL, significantly decreased the transport of the prototypic Pgp substrate Rhodamine-123 (1 µM) into bile by 18.6, 38.1 and 66.7%, respectively. Fluorescence anisotropy measurements of corresponding hepatic plasma membranes demonstrated a 29.7% decrease (indicating a reciprocal increase in membrane fluidity) at the 1 µM LAS concentration, with little additional change evident at the 5 and 20 µM concentrations. These results suggest that LAS at environmentally relevant concentrations increased bioaccumulation of ³H-IVM and ³H-BaP equivalents through modulation of transporter activity and membrane permeability.

TP192 Completion of a short-term reproduction test for identifying endocrine-disrupting chemicals. K.M. Jensen, L.S. Blake, J.D. Brodin, E.J. Durhan, M.W. Hornung, M.D. Kahl, J.J. Korte, E.A. Makynen, D. Martinović, D.L. Villeneuve, G.T. Ankley, Mid-Continent Ecology Division, U.S. Environmental Protection Agency, Duluth, MN. In 1996 the US Environmental Protection Agency (EPA) received a mandate from the US Congress to develop a screening and testing program for endocrine-disrupting chemicals (EDCs), including those with the potential to affect reproduction and development through alterations in the vertebrate hypothalamic-pituitary-gonadal (HPG) axis. To address this regulatory need, we developed a short-term reproduction test with the fathead minnow (*Pimephales promelas*) that not only identifies chemicals with the potential to disrupt normal endocrine function, but also provides diagnostic information regarding mechanism(s) of action (MOA) and an assessment of whole-organism responses relevant for risk assessment (e.g., reproduction). During a 21-d chemical exposure, survival, reproductive behavior, fecundity, fertility, and embryo development are evaluated. At conclusion of the test, a number of endpoints specific to endocrine function are evaluated including gonadosomatic index, gonad histology, secondary sex characteristics and plasma concentrations of vitellogenin and sex steroids. The test has been evaluated using EDCs with known or suspected MOA including strong and weak estrogens (estradiol, methoxychlor), androgens (methyltestosterone, trenbolone), anti-androgens (vinclizolin, flutamide), and inhibitors of steroid metabolism (fadrozole, prochloraz, fenarimol, ketoconazole, and trilostane). The test consistently detects the reproductive toxicity of the chemicals, and the observed responses are generally consistent with the presumed MOA. The EPA program office responsible for implementing an EDC testing program has taken a number of steps to support final validation of the test including peer review and independent evaluation of the assay by the EPA Science Advisory Panel. Following this, the EPA plans to use this assay along with others to fulfill screening and testing requirements associated with the current EDC regulatory program. This presentation will provide an overview of the assay, supporting data, and final implementation steps. *This abstract does not necessarily reflect EPA policy.*

TP193 Evaluation of a Novel Mechanism of Endocrine Disruption in the Fathead Minnow. M.D. Kahl, L. Blake, J. Brodin, E. Durhan, K. Jensen, D. Villeneuve, G. Ankley, Mid-Continent Ecology Division, US-EPA, ORD, NHEERL, Duluth, MN; D. Bencic, Ecological Exposure Research Division, US-EPA, ORD, NERL, Cincinnati, OH. The majority of studies with chemicals that disrupt endocrine function controlled by the hypothalamic-pituitary-gonadal (HPG) axis have focused on those that act as agonists or antagonists of the estrogen and androgen receptors. However, there is the potential for chemicals to affect the HPG axis in other fashions. Fipronil is a pesticide that acts as an antagonist of γ-aminobutyric acid (GABA) receptors in invertebrates. GABA has been shown to stimulate luteinizing hormone (gonadotropin II) release in a number of fish species, including goldfish, via

interaction with GABAA receptors, and treatment with GABAA receptor antagonists which inhibit that stimulation. The purpose of these studies was to evaluate the effects of fipronil on endocrine function and reproductive success in a model small fish species, the fathead minnow (*Pimephales promelas*). Adult fathead minnows were exposed to 0, 0.05, 0.5 and 5 µg/L of fipronil in a flow-through system for 21 d, and effects on reproduction, gonadal histology, sex steroids and expression of key HPG axis genes were evaluated. Fipronil decreased egg production in the fish at a water concentration of 5 µg/L. The pesticide did not affect ex vivo steroid production in testis tissue, but did reduce ex vivo testosterone production by ovary tissue collected from females exposed to 5 µg/L. Ovarian expression of cathepsin B, a gene whose expression was altered in invertebrates exposed to fipronil, was not affected in the exposed fish. Additional transcript measurements are being used to evaluate the impacts of the chemical on the HPG axis. At present, our results indicate that fipronil can cause reproductive toxicity in the fathead minnow, but the mechanistic basis for these effects remains to be established. This abstract does not necessarily reflect EPA policy.

TP194 Dose and Period dependent influences in reproduction of Japanese medaka *Oryzias latipes* exposed to 17α-ethinylestradiol during the phase of 'Point of no return' on formation of testis-ova. N. Hirai, A. Nanba, M. Koshio, N. Tatarazako, National Institute for Environmental Studies, Tsukuba, Japan. Fish early life stages include developmental period, and the exogenous estrogens in those stages are significantly effective in sex differentiation. In our previous study, we demonstrated the point of no return on formation of testis-ova as 18 days after fertilization (daf) when medaka is exposed to 17β-estradiol (E2) at 133 ng/L (SETAC-NA, 2005), and fish exposed to E2 until PNR on formation of testis-ova indicated the significant increase in male vitellogenin induction and the proportion of intersex and sex-transformation (SETAC-NA, 2006). The results suggest the exposure until the PNR on formation of testis-ova is significantly effective in sexual maturation, but there is no information on the relationship of estrogen effect between chemical dose and exposure period. Therefore we examined the reproductive influences in medaka exposed to 17α-ethinylestradiol (EE2) with different concentrations (10, 20, 40, 80, 160 ng/L, nominal concentration) and different exposure period (fertilization to 17daf, 24daf, 31daf). Each test group is set up to 30 eggs with a single replicate, and is returned to clear filtered fresh water after each exposure period and is cultured until 80daf. Thereafter, 8 males are paired with normal female in control, and are conducted the reproduction test for 30days. As results, the exposure until 17daf did not indicate the significant different in external sex character, fecundity, no. fertilized eggs, and fertility. The significant decrease of fecundity, no. fertilized eggs is found in group exposed to over 80ng/L, and proportion of external male character fish is significantly low in 160 ng/L when fish are exposed to EE2 until 24daf. In group exposed to EE2 until 31daf, the significant decrease of external male character fish, no. fertilized eggs, and fertility was found in 40ng/L, and all fish was female external sex character in 80ng/L and 160ng/L. No significant effects were found in any exposure period when fish are exposed to less than 20ng/L EE2. The results suggest that estrogen effect is found exposure period dependently in lower concentration, and the results is summarized that the PNR on reproduction is 24daf in over 80ng/L EE2, and that is 31daf in 40ng/L EE2.

TP195 Toxicity of pharmaceuticals and personal care products (PPCPs) and its related chemicals in fish embryo and larva – angiogenesis related toxicity in Japanese medaka *Oryzias latipes* and zebra fish *Danio rerio*. N. Hirai, A. Nanba, N. Tatarazako, National Institute for Environmental Studies, Tsukuba, Japan; Y. Takao, Nagasaki University, Nagasaki, Japan. This study examined the developmental toxicity of pharmaceuticals and personal care products (PPCPs) in fish embryo and larva. The embryos of Japanese medaka *Oryzias latipes* and zebrafish *Danio rerio* are used for toxicity test of bactericide (triclosan (TCS)) and its related chlorophenols (pentachlorophenols (PCP) and 2, 4-dichlorophenol (DCP)), antibiotics (neomycin sulfate (NMS)) and hypotensive drugs (amiloride hydrochloride (AMC) and captopril (CPP)). The embryos are aqueous-exposed to five concentrations for PCP, DCP and TCS with including the LC50 value of medaka adults (43-1000µg/L: TCS, 17-400µg/L: PCP, 260-6000µg/L: DCP) from fertilization to first feeding phase (17 days for medaka, 10 days for zebrafish). For NMS, AMC, CPP, 3 concentrations are prepared as 0.1-100 mg/L. As results, lethal toxicity was found in tested chemicals except AMC, CPP. The mortality is different by species and chemicals during embryo period, but any chemicals indicate the lethal toxicity in larval period. In the symptoms during exposure, angiogenetic

influences such as vascular occlusion and/or disturbance in cardiovascular system was observed in more than half of the dead individuals in TCS, PCP, and DCP. In TCS, zebrafish is more sensitive in vascular occlusion (94 μ g/L) than that in medaka (207 μ g/L), but in DCP, medaka is more sensitive in vascular occlusion (1240 μ g/L) than in zebrafish (6000 μ g/L), and in PCP, significant number of vascular occlusion is not found in medaka, but it is found in zebrafish at 180 μ g/L, suggesting that the chemical sensitivity of each species is different by substances. NMS indicates the lethal toxicity in 100 mg/L in zebrafish after hatching. From these results, fish embryo and larva toxicity test is available to examine the toxicity of PPCPs, and the angiogenetic inhibition can be one of the endpoint related to the toxicity of PPCPs in fish embryo and larvae in chemical toxicity.

TP196 Toxicity of Adverse Water Quality Conditions to the endangered Rio Grande Silvery Minnow. K.J. Buhl, Biological Resources Discipline, U.S. Geological Survey, Yankton, SD. Acute (96 h) laboratory studies were conducted to determine the relative tolerance of the endangered Rio Grande silvery minnow (*Hybognathus amarus*) to adverse water quality conditions in the Middle Rio Grande, NM. One set of tests was conducted to determine the upper lethal levels (LL50s) of water temperature and the lower lethal concentrations (LC50s) of dissolved oxygen (DO, hypoxic conditions) to four age groups of silvery minnow. The four age groups tested were 3-4 day posthatch (dph) larvae, 32-33 dph juveniles, 93-95 dph juveniles, and 11-month old subadults. A second set of tests was conducted to determine the effects of pulsed exposures to ammonia on larvae and juveniles. The tests were conducted in reconstituted water that simulated that in the Middle Rio Grande. Preliminary results of the temperature tests indicated that subadults were less tolerant of high temperatures (LL50s, 32-33°C) and hypoxic water (LC50s, 0.9-1.1 mg DO/L) than larvae and juveniles (LL50s, 35-37°C; LC50s, 0.6-0.8 mg DO/L). Fish that had access to the surface generally succumbed at lower DO levels than those denied access to the surface, indicating the importance of aquatic surface respiration. In the pulsed ammonia tests, exposures to high ammonia concentrations for only 1.5 hours were nearly as toxic as exposures to the same concentrations for 96 hours. Based on nominal total ammonia concentrations, larvae (96-h LC50s for all pulses, 16-23 mg/L as N) were about twice as sensitive as both juvenile age groups (96-h LC50s for all pulses, 39-70 mg/L as N). These data will be useful in predicting the effects of brief exposures to elevated ammonia concentrations that may occur in the Middle Rio Grande resulting from accidental discharges at wastewater treatment plants and runoff from livestock operations.

TP197 Olfactory Performance in Salmonids Exposed to Aquatic Herbicides. C.A. Curran, J.M. Grassley, C.E. Grue, Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle, WA; C.A. Curran, Nautilus Environmental, Tacoma, WA; L.L. Conquest, Aquatic and Fishery Sciences, University of Washington, Seattle, WA. Herbicides are frequently used to control exotic or nuisance aquatic plants and their use has been hampered by concerns directed at the non-target toxicity of active ingredients. Unfortunately, adequate data on the non-target toxicity of aquatic herbicides are lacking, threatening the permitting process. In the Pacific Northwest, population declines of several species/stocks of salmon and efforts to restore these populations heighten concerns. The effects of aquatic herbicides on the olfactory system have not been studied, despite altered olfaction by exposure to other pesticides (e.g. organophosphates). Olfaction is important for fish influencing their ability to find a mate, detect prey, and avoid predators. It is additionally important in salmonids as part of imprinting during out-migration and smoltification, allowing them to return to their native streams to reproduce. Our objective was to determine if the aquatic herbicides DMA[®] 4 IVM (ai=2,4-D), Renovate[®] 3 (triclopyr), Reward[®] (diquat), and Sonar[®] AS (fluridone) affect the olfactory ability of juvenile rainbow trout (*Oncorhynchus mykiss*) when exposed to the maximum application rate for 96 hours. We used five replicate exposure and behavioral assays to determine effects. Water samples from each concentration were chemically analyzed. Juvenile rainbow trout were only affected by the maximum rate of Reward. Results of additional studies with the maximum rate on the current (new) label for Reward will be presented.

TP198 Effects of a Progestin, 19-Norethindrone, on Japanese Medaka, *Oryzias latipes*, and Fathead Minnow, *Pimephales promelas*. P.M. Paulos, T.W. LaPoint, D.B. Huggett, Institute of Applied Science, University of North Texas, Denton, TX. Norethindrone (NET), a commonly prescribed progestin, is the principal active component in contraceptives. It is representative of a class of chemicals commonly used in contraception. Given the persistent use

of this chemical, it may be expected that progestins are present in aquatic environments, and that NET would be a primary contributor. A synthetic progestin, NET plays an important role in ovulation regulation. NET also has a key function in spermatogenesis. It is this dual role, essential to male and female gamete maturation that presents an intriguing potential for environmental effect. To date, ecotoxicological studies of progestin effect are lacking. Due to the metabolic role of NET, effects of exposure may be expected to be androgenic and estrogenic. Indeed, NET is known to undergo metabolic transformation to low concentrations of estrogen, thereby allowing the viability of vitellogenin induction as a biomarker of exposure. Our research includes a comprehensive examination of NET effect on the fathead minnow, *Pimephales promelas*, and Japanese medaka, *Oryzias latipes*. Testing will incorporate partial life-cycle exposure, 0-150 dph for fathead minnow, 0-100 dph for medaka, though foci of the study are short-term partial life cycle tests, generally 14-28 days duration, exposing pre-adult test species to environmentally relevant concentrations of NET. A critical component of these tests is the sexual dimorphism of test species, allowing for endpoints of maturation and differentiation of external sexual characteristics and internal development. Preliminary testing indicates that, though NET is not especially acutely toxic (LC50 > 1.0 mg/L, NOEC > 250 μ g/L), this compound may readily be available for uptake in the aquatic environment and we may expect affects to be probable at low μ g/L concentrations.

TP199 Characterization of Growth, Development, and Gene Expression Patterns in the Fathead Minnow (*Pimephales promelas*). S.M. Johns, M.S. Sepúlveda, Purdue University, Lafayette, IN; M.D. Kane, Department of Computer and Information Technology, Purdue University, West Lafayette, IN; N.D. Denslow, Department of Physiological Sciences and Center for Environmental and Human Toxicology, University of Florida, Gainesville, FL; K.H. Watanabe, Oregon Health & Science University, Beaverton, OR; E.F. Orlando, Florida Atlantic University, Boca Raton, FL. Exposure of early life-stages of fish to endocrine disrupting compounds can result in a variety of negative effects, including abnormal growth, development, and altered sex differentiation. These changes could be tractable to changes in gene expression. However, little is known about the baseline changes in gene expression of reproductive and developmental genes in early life-stages of fish and on the relationship between gene expression and physiological changes. The objectives of this study were to describe ontogenetic changes in gene expression in a commonly used ecotoxicological model, the fathead minnow (*Pimephales promelas*), and to relate changes at the gene level with growth and development. From days 0 to 28 post-fertilization, and at weekly intervals, we measured growth (total length), general development, and expression of 10 genes important for growth and sex differentiation, including growth hormone, thyroid and sex steroid hormone receptors, vitellogenin, and different cytochrome P450s, among others. Gene expression was quantified using quantitative polymerase chain reaction (q-PCR). Our results indicate gene-specific ontogenic changes. For instance, the expression of ER β decreased from days 0 to 28 post-fertilization, whereas CYP1A increased up to day 21 and then was back to baseline levels by day 28. Other genes (StAr, IGF, and β HSB) did not change significantly over the first month post-fertilization. Results from these studies will be used to further validate the use of fathead minnow early-life stages in ecotoxicological studies.

TP200 Effect of Wastewater Treatment Plant Effluent on Female Fathead Minnow, *Pimphales promelas*, Reproductive Success and Behavior. C. Lavelle, P. Sorensen, Fisheries and Wildlife, University of Minnesota, Saint Paul, MN. Wastewater sewage effluents release endocrine disruptors into aquatic environments and their effects on aquatic organisms are largely unknown. One goal of this research is to determine if compounds in a wastewater treatment plant effluent reduces the reproductive success of female fathead minnows, *Pimphales promelas*. Previous experiments reported that male fathead minnows exposed to the St Paul (MN) wastewater treatment plant (MWTP) effluent exhibit a delay in mating in the absence of competing males and expressed a substantial reduction in competitive fitness when paired with control males. Our experiment revealed that while some female behaviors were suppressed, reproductive success of female minnow was not affected by a 3-weeks long exposure to MWTP effluent. According to our knowledge, this is the first female fathead minnow exposure to MWTP to be conducted. This along with results of an additional male competition experiment, and a female estradiol exposure, provides evidence that this phenomenon is sex-specific and estrogenically driven.

TP201 Transgenerational Adult and Offspring Response to Poultry Litter Exposure in the Fathead Minnow (*Pimephales promelas*). S. Pollack, W. Lamp, Department of Entomology, University of Maryland, College Park, College Park, MD. Poultry litter may be a significant source of endocrine disrupting contaminants (EDCs) in the Chesapeake Bay region through run-off from agricultural fields. Fish populations have been shown to respond to EDCs in and around areas of agricultural run-off. Of particular concern are sub-lethal effects during early development in larval fish or during the breeding season in adults where exposure to the natural steroid hormones and other contaminants found in poultry litter may lead to altered development or altered reproductive function. As a result, individuals in a population may no longer maintain reproductive fitness and individuals exposed during critical growth stages may not develop sufficiently to reproduce. The objective of this study was to investigate the transgenerational sub-lethal response of endocrine disrupting agents on the reproductive capacity in adult exposed fish as well as the developmental response to EDCs in the exposed offspring of these exposed adult fish. We treated adult breeding groups of fathead minnow for a total of 21 days with a poultry litter mixture known to contain both environmentally relevant and biologically active levels of estrogenic and androgenic active compounds. The four treatments were; a poultry litter leachate prepared by diluting a 2.5 g/L neat mixture four-fold or eight-fold, or either a negative control containing no poultry litter and 0.001% ethanol (vehicle), or a positive control containing 100 ng/L 17 β -estradiol. After 11 days of exposure, eggs produced from the parental or P1 (adult breeding groups) generation were then removed from the parental tank and placed into either one of two exposures depending on the parental exposure. These eggs were then hatched and the larvae grown to 6 months of age. Adult fish were analyzed for body weight, gonadosomatic index, hepatosomatic index and reproductive fitness by measuring gametogenic output and fertilization capacity. Percent hatch and survival of offspring were also evaluated to determine the P1 reproductive performance. Circulating plasma steroid hormones, estradiol and testosterone were also analyzed to determine reproductive readiness in the P1 fathead minnow. Male P1 fathead minnow were also assessed in terms of secondary sex characteristics (breeding tubercle count and epithelial pad thickness) both prior to and after the study and plasma was also analyzed for vitellogenin.

TP203 Exposure of Salmonids to Carbaryl Following Applications to Control Burrowing Shrimp in Willapa Bay, Washington: Channel Habitats and Enzyme Recovery. C. Grue, J. Grassley, K. King, N. Overman, R. Fisk, R. Lebrand, University of Washington, Seattle, WA. Efforts to restrict the use of carbaryl to control burrowing shrimp in Willapa Bay, Washington have been in part driven by concerns over potential effects on salmonids. Previously, we studied the use of treated oyster beds in the Bay by salmonids in an effort to quantify their actual exposure to carbaryl. The only salmonid captured above the beds before or after treatment were juvenile Chinook (*Oncorhynchus tshawytscha*). Brain AChE was inhibited in Chinook above 2 of 6 treated oyster beds (means = 12-18%) during the first tide post treatment with recovery to pre-spray levels of AChE by the second or third tide post-treatment, respectively. In 2006, we studied the use of channel habitats adjacent to treated oyster beds by fishes, quantified their exposure to carbaryl, and exposed Chinook smolts to carbaryl in the laboratory to determine time to recovery of brain acetylcholinesterase (AChE) activity, the target enzyme of the pesticide. Floating and sinking gill nets (272 net hours, daylight high tides) and beach seines (daylight low tides) were used to capture fish within five channels across two spray events before and after pesticide applications. Chinook, primarily smolts, were the only salmonid captured; maximum AChE inhibition was 11-12% and differed from controls at only two sites/times post spray. In most cases, concentrations of carbaryl in the water column at high tide (6-h postspray) were <0.2 ppb, maximum = 29.1 ppb. Concentrations at low tides (12 or 24 h postspray) were greater, 0.6-38 ppb. AChE activity in Chinook smolts exposed to 1,520 ppb carbaryl (Sevin® 80 WSP) in seawater for 6 h (> 80% enzyme inhibition) reached normal levels within 48 h. Results will be discussed within the context of concerns over non-target effects of the pesticide on salmonids in the Bay.

TP204 Endocrine disruption effects in rainbow trout due to different pulp and paper mill effluent treatments. R. Orrego, J. Guchardi, L. Roti, R. Krause, D. Holdway, Faculty of Science, University of Ontario Institute of Technology, Oshawa, Ontario, Canada; V. Hernandez, University of Concepcion, Concepcion, Biobio, Chile. Endocrine disruption effects due to pulp and paper mill effluents involving different industrial procedures and effluent treatments (SPE specific extracts obtained from non-treated,

primary and secondary treated pulp and paper mill effluents) were evaluated using a fish (hatchery-reared immature triploid rainbow trout *Oncorhynchus mykiss*) pulse-exposure toxicity experiment. The protocol involved the use of intra-peritoneal injection, corrected for individual fish weight and utilizing previously determined dose information, and also included several laboratory standards (steroidal hormones and phytosterols). Multiple biomarkers at different levels of biological organization (molecular, cellular, tissue and individual organism level) were analyzed. Previous results indicated that non significant changes were observed in the individual physiological indices represented by condition factor and liver somatic index during different sampling times. Significant induction of the cytochrome P4501A1 was observed between different effluent treatments and experimental controls. Significant endocrine disrupting effects (reproductive level) were observed in all effluent treatments involving significant increments in gonadal somatic index and plasma vitellogenin (Vtg) levels. Untreated effluent exposed fish had significantly higher Vtg levels compared to fish exposed to primary and secondary treatment effluents, indicating a decrease of the endocrine effect due to the effluent treatment. These results will be confirmed by immunohistochemical analysis of Vtg in the fish gonads. Key words: Endocrine disruption, pulp mill effluent, treatments

TP205 Evaluation of Polychlorinated Biphenyl and Metal Contamination in Fish from Two Waterways in the Eastern European Country of Moldova. K.L. Richardson, H. DeHaro, D. Schlenk, Department of Environmental Sciences, University of California-Riverside, Riverside, CA; N. Zubcov, E. Zubcov, Department of Hydrobiology and Ecotoxicology, Institute of Zoology, Academy of Sciences of Moldova, Chisinau, Moldova. In order to evaluate the impact of anthropogenic inputs to the waterways of the Republic of Moldova in Eastern Europe, accumulation of polychlorinated biphenyls (PCBs) and metals (Fe, Mn, Al, Zn, Co, Cu, V, Mo, Ni, Pb, Cd) in tissue samples from fish (*Cyprinus carpio*, *Carasius auratus gibelio*, *Aristichthys nobilis*, *Hypophthalmichthys molitrix*, *Abramis brama*, and *Rutilus rutilus* hecheli) collected from Dubăsari reservoir and Faleshti fish farm have been evaluated. Between 13 and 22 of the 27 PCBs analyzed were detected in muscle tissue and the most commonly detected congeners included PCB 8, 44, 66, 153, and 187. Both *H. molitrix* and *C. carpio* collected from the fish farm demonstrated accumulation of PCBs in concentrations exceeding 40 ng/g on a wet weight basis. Concentration of metals in fish collected from Dubăsari reservoir were higher than in fish from the fish farm, indicating anthropogenic influence on this important reservoir. Its important to note that the concentration of metals in fish gonads increased 9-25 times during pre-spawning periods, indicating the importance of considering physiological changes during tissue residue analysis. It was also observed that the gonads of younger females and phytophagous fish species showed concentrations of biologically important trace elements higher than in mature females, while levels of toxic elements were lower. These results indicate accumulation of metals and PCBs in two waterways in the Republic of Moldova.

TP206 Response of Juvenile Chinook to Herbicide Tank Mixes Used to Control *Spartina* in Willapa Bay, Washington. K. King, C. Grue, J. Grassley, J. Kim, R. Fisk, University of Washington, Seattle, WA. To address continuing concerns over the potential non-target toxicity of herbicides used to control smooth cordgrass (*Spartina alterniflora*) in Willapa Bay to salmonids, we exposed Chinook (*Oncorhynchus tshawytscha*) smolts to one of five herbicide tank mixes used operationally in the Bay in 2006. Tank mixes included one or two active ingredients (glyphosate [AquaNeat® or GlyPro®] and/or imazapyr [Habitat®]), one of two surfactants (Agri-Dex® or Competitor®), and one of two marker dyes (Blazon® or Hilit®) at concentrations used in the Bay. Tank mixes included those used with hand-held sprayers, broadcast (aerial application), and high precision ground application. Smolts (n=10, three replicates) were exposed to each tank mix in seawater at a concentration equal to that if the herbicides were applied directly to 10 mm of surface water (worse case scenario) three times for 6 h over a 72-h period. This cycle mimicked fish exposed to the tank mixes during the first tidal inundation following each of three consecutive spray events followed by 18 h of clean seawater. Behavior and survival were monitored and plasma samples collected at the end of the test to assess osmoregulatory function (plasma sodium and chloride concentrations). All but one treated fish survived and no behavioral abnormalities were detected in the remaining fish. No differences in plasma sodium or chloride analyses were detected. Results will be discussed relative to predictions based on the results of median lethal toxicity tests, progress in controlling *Spartina*

in Willapa Bay, and growing concerns over the spread of smooth cordgrasses in Puget Sound.

TP207 Toxicity of Imidacloprid to Salmonids. K. King, T. Stringer, K. Adams, J. Banfill, E. Holm, N. Jander, A. Ryznar, M. Smith, J. Grassley, C. Grue, University of Washington, Seattle, WA. Carbaryl has been used to control burrowing shrimp within oyster beds in Willapa Bay and Gray's Harbor, Washington for 5 decades. These shrimp destabilize the sediments onto which young Pacific oysters are seeded. A legal settlement requires growers to reduce the annual use of carbaryl such that use of the pesticide is discontinued by 2012, and to seek alternatives. Imidacloprid has been shown to be effective in controlling burrowing shrimp and its toxicity to non-target fishes appears to be less than that of carbaryl. The static 96-h LC50 for juvenile rainbow trout (*Oncorhynchus mykiss*) exposed to technical grade imidacloprid is 211 ppm, ca. 2 orders of magnitude less toxic than carbaryl to juvenile trout and Chinook (*Oncorhynchus tshawytscha*). The toxicity of imidacloprid as formulated products to salmonids, particularly juvenile Chinook that occupy waters above the treated beds and adjacent channels, is not known. In an initial effort to determine the relative toxicity of a widely used formulation of imidacloprid (Admire® 2F, Bayer CropScience), we exposed juvenile trout (ca. 0.3 and 20 g) to 15-305 ppm AI for 96 h (static) and quantified behavior and mortality; a previous study indicated concentrations <15 ppm did not result in overt toxicity. All fish exposed to <66 ppm survived, no overt effects were observed in fish exposed to <32 ppm. The LC50s were 163 ppm (95% CI=148-177 ppm) for the 20 g trout and 170 ppm (159-181) for the 0.3 g trout. Results were comparable to those reported previously for the AI and 1.3 g trout. Under a worse case scenario, i.e. application at 0.2 lbs AI/ac to a mudflat with 10 mm of water prior to tidal inundation, the maximum concentration of imidacloprid would be 0.5 ppm, suggesting a significant margin of safety. Future studies will quantify effects of formulated products on behavior, osmoregulatory function, and survival in seawater adapted Chinook smolts and olfactory-mediated behavior in juvenile rainbow trout.

TP208 Expression and regulation of retinoids in zebrafish ovarian development. C. Simpson, A. Lister, G. Van Der Kraak, Integrative Biology, University of Guelph, Guelph, Ontario, Canada. Retinoids, derivatives of retinoic acid (RA), are essential for reproduction in healthy organisms. Previous studies have shown that retinoid status is negatively impacted by exposure to compounds that interact with the aryl hydrocarbon receptor (AhR) such as planar halogenated aromatic hydrocarbons (PHAHs) and polychlorinated biphenyls (PCBs). The expression of retinoic acid receptors (RARs) and retinoid X receptors (RXRs) has been well characterized in embryogenesis but little is known regarding their expression patterns during reproduction in adult teleosts or how this is affected by chemicals found in the environment including estradiol (E2), polycyclic aromatic hydrocarbons (PAHs) and pulp and paper mill effluent (PME). The primary objective of this study was to characterize the expression of RA receptor isoforms in zebrafish ovarian follicles at the primary, pre-vitellogenic and vitellogenic follicular stages. A secondary objective was to examine the effects of various compounds in vivo such as estradiol, 17 α 20 β -dihydroxy-4-pregnen-3-one (MIS) and β -naphthoflavone (bNF) on RA receptor isoform expression. Using quantitative Real-Time PCR RA receptor isoforms (RXR α , β , γ and δ and RAR γ) showed expression in all ovarian follicular stages however no differences in expression occurred between stages. E2 and MIS decreased RXR δ and RAR γ expression in whole ovary. Exposure to bNF had no effect on RAR γ expression but caused a slight decrease in RXR δ . This study has demonstrated RA receptor isoforms are present in zebrafish ovarian development and are potentially regulated by E2 and MIS. Further study is required to determine if all RXR and RAR isoforms are impacted in similar manners and if regulation exists between ovarian follicular stages.

TP209 Toxicity of dispersed MESA crude oil to early life stages of herring (*Clupea harengus*). S. McIntosh, K. McAlindon, P. Hodson, School of Environmental Studies, Queen's University, Kingston, Ontario, Canada; S. Courtenay, Biology, Fisheries and Oceans Canada at the Canadian Rivers Institute, Fredericton, New Brunswick, Canada. Crude oil is transported across several herring fishing zones along the Atlantic coastlines of Canada and USA. In the event of a spill, efforts to minimize ecological damage may include chemical dispersion of oil into the underlying water to protect shorelines and wildlife from floating oil. While such action may be appropriate in some instances, its potential risks and benefits depend on the aquatic species living in the contaminated area. For larval herring, the toxicity of dispersed crude oil is about 100 times greater than that of water-accommodated (mechanically-

dispersed) crude oil fractions. Furthermore, dispersed oil may be differentially toxic during certain stages of embryonic herring development. It is therefore important to improve our understanding of dispersed oil's toxicity to herring to ensure that the current guidelines for dispersant use are applicable to spills in herring habitats. By identifying the stages of herring development that are most sensitive to dispersed oil, we aim to determine the times of year when exposure to dispersed oil would be most detrimental to herring recruitment. The lowest dispersed oil concentration that elicits a negative response during herring development will then be compared to time and concentration-dependent models of oil dispersion. This comparison will help to characterize the spatial conditions in which developing herring would most likely encounter harmful concentrations of dispersed oil, thereby summing the temporal and spatial information that is necessary to make sound decisions on dispersant use in herring habitats and fishing zones.

TP210 Altered HIF-1A gene expression profiles by semi-quantitative RT-PCR of *Colossoma macropomum* CUVIER, 1818 in response to waste effluent. F.M. Casanova, V. Val, A. Val, Instituto Nacional de Pesquisas da Amazônia - INPA, Manaus, Brazil; R. Honda, M. Nozawa, S. Nozawa, Centro Universitário Nilton Lins, Manaus, Brazil. The hypoxia-inducible factor 1 α (HIF-1A) is an evolutionarily conserved transcription factor that up regulates the expression of several genes involved in oxygen transport and anaerobic energy metabolism. Previously it has been thought that HIF-1 α is activated only in response to low oxygen, not in other cell stresses. Using semi-quantitative RT-PCR as gene expression profiling may be useful in identifying new mechanisms in the pollutant effects. We have compared animals exposed (n=6) to urban waste effluent CL50 (2.06% v:v) in a) 15 min., b) 30 min, and c) 1 h. Total RNA of liver of *Colossoma macropomum* (tambaqui) was extracted and the RT-PCR showed different level of expression: 1- fold to 15 min of exposition, 4- fold at 30 min. and 10- fold in 1 h as compared to the control. Based on these results, we can suggest that this gene may be involved in different mechanisms of fish stress response. These results suggest that in addition to stress adaptation, HIF-1 α has a role in hypoxia, results of aerobic microorganisms in the urban waste effluent that decrease the level of oxygen. Supported by FAPEAM, CNPq, INPA

TP211 Effect of organochlorine pesticides on ex vivo gonadal testosterone synthesis in largemouth bass (*Micropterus salmoides*). D.S. Barber, W.J. Rees, M. Prucha, N. Denslow, Center for Environmental and Human Toxicology, University of Florida, Gainesville, FL. Previous work has shown that largemouth bass living in sites with high levels of organochlorine pesticides exhibit poor reproduction that is linked with changes in circulating steroid levels. These effects have been reproduced in laboratory experiments, suggesting that OCPs are responsible for altered steroid levels, but the mechanism underlying this effect is unknown. To determine if OCPs have the capacity to directly alter steroid synthesis by gonadal tissue, testosterone (T) production by minced testis and ovary of recrudescant largemouth bass was examined. Basal and hCG stimulated T synthesis was monitored during a 20 hour exposure to OCPs. In testes, exposure to 100 μ M toxaphene, methoxychlor (MXC), dieldrin and p,p'-DDE reduced hCG stimulated T synthesis by 29, 28, 32 and 54%, respectively. None of the compounds significantly altered basal synthesis. In ovary, exposure to 100 μ M toxaphene and MXC reduced hCG stimulated T synthesis by 74 and 92%, respectively. MXC reduced basal ovarian T synthesis by 83% while dieldrin increased basal synthesis by 73%. Analysis of steroidogenic acute regulatory protein (StAR) mRNA levels in these samples demonstrates that treatment with hCG stimulates StAR mRNA when compared to basal controls in both male and female tissues. However, the hCG-induced stimulation of StAR message is diminished in both male and female tissues exposed to toxaphene or MXC. These results demonstrate that toxaphene and MXC are capable of directly inhibiting gonadotropin signaling in gonadal tissue.

TP212 Exposure to the gasoline Additive Methyl tert-butyl ether Results in Abnormal Embryonic Vascular Development in Zebrafish (*Danio rerio*). J.A. Bonventre, Joint Graduate Program in Toxicology, Rutgers University, Piscataway, NJ; S.M. Bugel, Department of Environmental Science, Rutgers University, New Brunswick, NJ; L.A. White, K.R. Cooper, Biochemistry & Microbiology, Rutgers University, New Brunswick, NJ. Methyl tert-butyl ether (MTBE) is an anti-knocking agent and oxygenate introduced into gasoline in the 1980s in an effort to increase burning efficiency and decrease polluting emissions. MTBE is an organic solvent that is both highly volatile and relatively soluble (42 μ g/L) in water. Ground water and surface water contamination is a primary concern of MTBE containing gasoline. Previous

work from our laboratory demonstrated that MTBE inhibited vascular development in Japanese Medaka (*Oryzias latipes*). To further examine the effect of MTBE on vascular development, a transgenic zebrafish model (fli1-EGFP) that expresses enhanced green fluorescent protein (EGFP) in vascular endothelial cells was used. Fli1-EGFP embryos were exposed to varying concentrations of MTBE (5, 10, 20 and 40mM), and monitored for gross lesions, vascular effects, and mortality during early embryogenesis, up until hatching. At the doses studied, the highest concentration resulted in 100% mortality by 48 hours post fertilization (hpf). Mortality decreased to 10%, 5% and 25% with decreasing MTBE concentration and 5% mortality in controls. Normal development was impaired in all treatments, showing a dose related decrease in growth, angiogenesis, blood circulation, and an increase in brain hemorrhages, pericardial edema, and atypical vasculature. Furthermore, mRNA expression of vascular endothelial growth factor (VEGF), a mitogen implicated in zebrafish vasculogenesis and angiogenesis, was quantified. Higher doses (20mM) had significantly altered expression at 48hpf (fold increase = 1.32) and 72hpf (fold decrease = 0.41). Inappropriate early expression of VEGF in the treatment may have led to the prevalent vascular aberrations and subsequent decrease in VEGF. Therefore, acute low dose exposure to MTBE can alter normal vascular formation that can result in subsequent damage in organ systems which require sufficient blood supply.

TP213 The effects of oil sands constituents on the reproductive physiology of fathead minnows (*Pimephales promelas*). R.J. Kavanagh, G. Van Der Kraak, Integrative Biology, University of Guelph, Guelph, Ontario, Canada; R. Frank, K. Solomon, Environmental Biology, University of Guelph, Guelph, Ontario, Canada; A. Farwell, G. Dixon, Biology, University of Waterloo, Waterloo, Ontario, Canada. In the process of extracting bitumen from oil sand, large volumes of fluid tailings are produced. Developers plan to eventually transfer these tailings to mined-out pits and cap them with clean water to create a self-contained aquatic environment. Earlier studies have suggested that oil sand constituents may alter the reproductive physiology of fish. In order to determine if fluid tailings would impair reproduction, 21 day fathead minnow reproduction assays were conducted in Northern Alberta. Fathead minnows were held in Gregoire Lake water (reference site) for 14 –21 days to gather baseline data on fecundity, fertility, and hatching success. Fathead minnows were then held in oil sands process-affected waters (OSPW) or Gregoire Lake water (reference) for 21 days. Spawning was reduced in fish that had been held in OSPW and male fish had tubercles that were reduced both in size and number. Follow-up experiments were conducted to identify the oil sands constituents responsible for the reproductive impairment observed in these fish. Collectively, these studies show that oil sands tailings have the potential to affect the reproductive physiology of fish.

TP214 Pilot Study of Sublethal Effects on Fish of Pesticides Currently Used and Proposed for Use on Maine Blueberries. C. Straub, A.A. Elskus, Biological Sciences, University of Maine, Orono, ME; C. Robinson, School of Marine Sciences, University of Maine, Orono, ME; A.A. Elskus, US Geological Survey, University of Maine, Orono, ME. Blueberry pesticides are found at detectable levels in Down East Maine Rivers. The pesticides used include an herbicide, Velpar™ (active ingredient hexazinone), and an insecticide, Imidan™ (active ingredient phosmet). Although the pesticides are present in the rivers, there has not been extensive research on the sublethal effects of these formulations on riverine fishes. In addition, both Velpar™ and Imidan™ are proposed to be replaced by Callisto™ (active ingredient mesotrione) and SpinTor™ (active ingredient spinosad), respectively. Our goal was to determine how the current use and proposed alternatives affect fish early life stages. To determine sublethal effects, early life stage zebrafish (*Danio rerio*) (embryo through 3 days post-hatch) were exposed to low (0.2-0.75 ppb) and high pesticide (3 - 30 ppb) concentrations both singly and in binary combinations. The zebrafish were examined to determine the effects of these pesticides on fitness parameters. The fitness parameters include innate immunity, prey capture, and spontaneous swimming. Results indicate that at environmentally realistic concentrations, these pesticides may have no significant effect on innate immunity, development rate or behavior. We are currently conducting parallel studies with larval Atlantic salmon to determine (1) how these pesticides affect these endpoints in salmon, and (2) to investigate how zebrafish and Atlantic salmon early life stages compare in their relative response to these pesticides. Support provided by the Maine Dept of Environmental Protection, the Maine Water Resource Research Institute, and the U.S. Geological Survey.

TP215 EPA's National Study of Chemical Residues in Lake Fish Tissue Report. L.L. Stahl, Office of Water, U.S. EPA, Mail Code 4305T, Washington, DC. The National Study of Chemical Residues in Lake Fish Tissue (or National Lake Fish Tissue Study) is one of a series of statistically-based national environmental surveys conducted by EPA since the late 1990s. It is a national screening-level survey of chemical residues in fish tissue from lakes and reservoirs in the contiguous United States, excluding the Laurentian Great Lakes and Great Salt Lake. Two features make this study unique. It is the first national freshwater fish contamination survey with sampling sites selected according to a statistical design, and it includes the largest set of chemicals studied in fish. From October 1999 through November 2003, EPA and a large network of state, tribal, and other federal partners collected fish composite samples from 500 lakes and reservoirs in the lower 48 states. Sampling teams collected two 5-fish composites at each site: a predator (e.g., bass or trout) and a bottom-dweller (e.g., carp or catfish). Predator filets and bottom-dweller whole bodies were analyzed for 268 persistent, bioaccumulative, and toxic (PBT) chemicals, including mercury, arsenic, dioxins and furans, all 209 PCB congeners, 46 pesticides, and 40 semivolatile organic compounds. Results from the National Lake Fish Tissue Study indicate that mercury, PCBs, and dioxins and furans are widely distributed in lakes and reservoirs in the lower 48 states. Mercury and PCBs were detected in 100% of the fish samples collected from the 500 sampling sites over a period of four years. Dioxins and furans were detected in 81% of the predator fillet and 99% of the bottom-dweller whole-body samples. The five most commonly-detected chemicals occurred in this order of decreasing prevalence: mercury, PCBs, dioxins and furans, DDT, and chlordane. Forty-three of the target chemicals were not detected in any samples, including 9 organophosphate pesticides and 33 semivolatile organic chemicals. The National Lake Fish Tissue Study final report will be ready for release in Fall 2007. It contains national estimates of the median concentrations for the full suite of target chemicals in lake fish and statistically-derived estimates of the percentage of lakes and reservoirs with fish tissue concentrations that exceed EPA's tissue-based water quality criterion for mercury and risk-based human health screening values for the other four commonly-detected chemicals.

TP216 Risks of Contaminants to White Sturgeon and Their Human Consumers. C.W. Thompson, Environment International, Ltd., Seattle, WA. Objective: Document how concentrations of various organic and inorganic contaminants vary in fillet (muscle) samples of white sturgeon in relation to their body size. Assess implications of these results for development of a non-lethal program to monitor contaminant burdens that pose risk to sturgeon and to humans who eat them. White sturgeon, *Acipenser transmontanus*, are declining in the Pacific Northwest causing great concern to many state, federal, tribal and non-governmental entities to which to species is culturally and biologically important. Both inorganic and organic pollutants are suspected of contributing significantly to these population declines. In many fish, contaminants continue to accumulate in individuals throughout their lives. New analyses of data collected by the Columbia River InterTribal Fish Commission (CRITFC) and the U.S. Environmental Protection Agency indicate that contaminant concentration increases in sturgeon filets (muscle) with increasing body size among prereproductive harvestable (42-60 in) and older sturgeon. These results indicate that: 1. Larger (older) sturgeon are at greater risk of harm from contaminants than are smaller (younger) sturgeon. 2. Human health risk assessment must consider consumption of contaminants from harvestable-size sturgeon, not younger ones. 3. It is not appropriate to use other fish species as "surrogates" to assess risk of pollutants to sturgeon and their human consumers. 4. Additional work is needed to develop a non-lethal and minimally invasive method for monitoring contaminant burden in, and assessing risk to, adult sturgeon and their human consumers.

WP1 Hanford Site Central Plateau Ecological Risk Assessment.

R. Rytty, J. Markwiese, Neptune & Co, Los Alamos, NM; R. Bauer, Fluor Hanford, Richland, WA; M. Miller, Environmental Quality Management, Richland, WA; N. Lane, Lane Environmental, North Bend, WA; B. Tiller, Environmental Assessment Services, Richland, WA. The ecological risk assessment for the Hanford Central Plateau terrestrial ecosystem has two main objectives: it provides information to support waste site decision-making, and it evaluates the health or condition of the ecosystem across habitats. The area considered in this report is larger than 6,000 hectares and includes waste sites and shrub steppe habitat. The ecological risk assessment evaluates upland terrestrial sites (nine assessment end points evaluated using seven types of measures) and an alkali lake (six assessment end points evaluated using seven types of measures). Data were collected in phases to help focus studies to resolve uncertainties for assessing ecological risks. The phased approach also permitted the project to efficiently assess varied ecological settings and provided some time-series data for comparison to other previous investigations of the Hanford Site. Final conclusions and reporting for the project are still under way but many interesting findings have already been obtained. Some of the key uncertainties addressed in this assessment were the nature and extent of radionuclides on non-waste site areas in the Central Plateau, and the nature and sources of PCBs detected in the initial sampling of tissues from small mammals and lizards at waste site investigation areas.

WP2 Use of Guided Interactive Statistical Decision Tools for Hanford Site Risk.

J.T. Markwiese, T. Stockton, W. Houghteling, B. Doug, J. Linville, Neptune and Company, Los Alamos, NM. The present-day mission of the Hanford Site, a former nuclear fuel production facility near Richland, Washington, is to clean up the radioactive and hazardous wastes generated during previous years. As final Records of Decision are being developed for Hanford waste sites, risk assessments are being performed utilizing newly-collected and historic analytical data to determine residual risks to human health and the environment. Accessibility and consolidation of data from various sources are integral pieces in the performance of a concise, defensible, and transparent assessment of risk to human health and the environment. The Guided Interactive Statistical Decision Tool (GiSdT) is a user-friendly web-based interface for assembly, query, and analysis of data relevant to risk assessment efforts at the Hanford Site. The user interface promotes transparency of project activities by offering a repository of analytical data, project documentation, and data analysis tools that are equally available to clients, state and Federal agencies, stakeholders, and the interested public. The centralized database version control system provides a measure of quality assurance and ensures that all project members have access to the most current information. The GiSdT interface uses open-source programming languages (R, SQL, and XML) to assemble and normalize data from multiple sources into a single, universally available, cross-platform, queryable interface. GiSdT's library of statistical and graphical analysis tools provide resources for individuals and organizations desiring real-time calculations and graphical analyses

WP3 The Yakama Nation Traditional Lifestyle Exposure Scenario.

K.L. Cunningham, M.D. Calac, P. Cirone, RIDOLFI Inc., Seattle, WA. An exposure scenario for risk assessment was developed for the Confederated Tribes and Bands of the Yakama Nation to describe their traditional subsistence lifestyle, including dietary patterns and seasonal activities that may result in disproportionate exposure to radioactive and hazardous chemical contamination at the Hanford Nuclear Reservation in southeastern Washington. This scenario describes the maximum exposure reasonably expected to occur in the Yakama population, who currently subsist on natural resources in the vicinity of Hanford and who, upon adequate cleanup, hope to regain access to the site that was formerly part of their usual and accustomed use areas. Without compromising confidential information, details of this scenario will be used by the U.S. Department of Energy to complete an exposure assessment to evaluate potential risks to the Yakama Nation from Hanford Site contamination now and in the future. Using ethnographic interview methods, adult Yakama members provided information on traditional fishing, hunting, and gathering practices, sweathouse use and ceremonies, all of which remain critical aspects of their subsistence and culture. These data were compiled to provide a qualitative description of the current and anticipated future Yakama lifestyle and to evaluate potential exposure parameters. This study resulted in a conceptual site model that was developed to illustrate potential exposure pathways from Hanford Site contaminant releases to soil, water, plants, fish and other animals, which may

ultimately impact the Yakama people. Surveys found that the Yakama depend heavily on the harvest and consumption of fish from local rivers, including the Columbia River, which passes through the Hanford Site, as well as wild game and an abundance of local native plants, including shoots, roots, leafy material, and berries. These resources provide not only foods and medicines, but also material for tools, shelter, and accessories. Federal guidance documents currently do not include adequate exposure information pertinent to a Native American subsistence lifestyle. This exposure scenario describes the traditional Yakama Nation lifestyle, which must be considered when evaluating potential risk from Hanford Site contamination and to facilitate appropriate cleanup decisions.

WP4 A New Method to Define Fish Embryo vs Eleutheroembryo Stages of Development and the Importance in Embryonic Toxicity Testing.

S. Belanger, J. Rawlings, Central Product Safety, Procter & Gamble, Cincinnati, OH. Determination of the time (age) of first feeding in fish is important and has regulatory implications. The UK Act on Operation of the Animals defines a "protected animal" as any living vertebrate, other than man, and extends the protection status to the stages of fish development from the time at which they become capable of independent feeding (UK Act 1986). The EU Dir 86/609/EEC defines as "animal" as any live non-human vertebrates including free-living larval forms. With this in mind we developed a method to define the age at first feeding for fish. Several species of protozoa were labelled with fluorescent beads and fed to post hatch (eleutheroembryos) Zebrafish, Fathead minnows and Medaka. The onset of exogenous (independent) feeding was determined by the presence of fluorescent microspheres in the digestive tract. Exogenous feeding for Zebrafish, the most common species used in embryo tests, began between 4-5 days post fertilization (approximately 24-48 hours post hatch, 25 C). Acute toxicity tests in Zebrafish across life stages show eggs (embryos) and eleutheroembryos (yolk sac present, non-feeding) are somewhat less sensitive than juveniles. Limited toxicity data covering the critical hatching period is promising and may provide a valid alternative animal replacement method. The methods and implications will be discussed.

WP6 Influence of short-term and long-term exposure to chemical toxicants on oxygen consumption of fathead minnows.

D.H. Pistole, Department of Biology, Indiana University of Pennsylvania, Indiana, PA; J.D. Peles, Penn State University, McKeesport, PA. Understanding the effects of chemical toxicants on energetic processes is an important aspect of ecotoxicology. However, the influence of toxicant concentration and time of exposure on oxygen consumption (VO₂) in aquatic organisms is still poorly understood. The purpose of this investigation was to examine the influence of short-term and long-term exposure to sublethal concentrations of salt (NaCl), copper (Cu) or cadmium (Cd) on VO₂ of fathead minnows (*Pimephales promelas*). In each exposure regime, VO₂ was determined for minnows (N = 15 per concentration) in aquaria representing a control or one of five increasing sublethal concentrations of a toxicant. Short-term exposures were conducted for 24 hr and long-term exposures for 168 hr. In all short-term exposures, there existed a threshold concentration, above which VO₂ decreased significantly compared to the control and lower concentrations. In contrast, VO₂ of fish exposed for 168 hr increased significantly in all concentrations compared to fish from the control. We suggest that the length of exposure is an important consideration when assessing the influence of chemical toxicants on the energetics of exposed organisms.

WP7 Influence of protein heterozygosity on oxygen consumption in fathead minnows exposed to copper.

J.D. Peles, Penn State University, McKeesport, PA; D.H. Pistole, Department of Biology, Indiana University of Pennsylvania, Indiana, PA. Although protein heterozygosity has been shown to be associated with metabolic efficiency in many aquatic organisms, few investigations have examined this association in the context of ecotoxicology. An investigation currently being conducted in our laboratory is designed to examine the influence of single (h) and multilocus (H) protein heterozygosity on VO₂ of fathead minnows (*Pimephales promelas*) exposed to Cu. The experimental protocol consists of the determination of VO₂ prior to, and immediately following, a 96-hr exposure to 240 µg/L copper sulfate. Preliminary results demonstrate a significant increase in VO₂ following exposure. Following completion of VO₂ determinations, genetic variation will be determined for each individual at six enzymatic loci and the influence of h and H on change in VO₂ will be evaluated. Our findings will address the importance of protein heterozygosity for response of organisms to sublethal concentrations of toxicants in the environment.

WP8 Enzymatic Method for the Determination of Zinc Chloride from Environmental Samples. C.M. Goparaju Venkata, Zoology, Kakatiya University, Warangal, Andhra Pradesh, India; Y.F. Zimering, Columbia University, New York, NY; P. Yalavarty, Zoology, Kakatiya University, Warangal, Andhra Pradesh, India. A simple, rapid, low cost determination method is developed for heavy metals from the environmental samples which is very useful in under-developed and developing countries. This method will help in the determination of the heavy metals like zinc chloride even in remote places with parascientific personnel, and helps to conduct tests on the spot where the instrumental facilities are inadequate or lacking. The main principle is dependent on the biochemical reaction between the pollutant and its inhibition caused on succinate dehydrogenase enzyme. The method involves the use of two separate tablets, A and B for the determination of the metal quantity present in the environmental samples. In this method, these two tablets are added to the sample from which the metal is to be determined. Tablet A which consists of an enzyme, is to be added to the sample in the test tube and is mixed thoroughly with glass rod, and has to be kept for 5 minutes. Then tablet B, which consists of the necessary reactants for specific enzyme is to be added and mixed thoroughly and kept for half-an-hour at 37°C. Then a color is developed. The color that is developed is to be matched with the standard chart colors that are provided. The chart colors are developed after standardized procedure. Standard chart is developed for zinc chloride of 10-70 µg concentration ranges showing 20-95% inhibitions. The minimum detection limit is 10 µg. The analytical technique thus developed can be employed by the local monitoring laboratories, public health laboratories, forensic laboratories, and others. This technique is useful for the determination of environmental pollutants like effluents, residues in food, raw agricultural commodities, clinical samples and in sabotage.

WP9 Ionic Stress to Invertebrates in Appalachian Headwater Streams. G.J. Pond, M.E. Passmore, USEPA, Region 3, Wheeling, WV; T.J. Norberg-King, USEPA, Mid-Continent Ecology Division, Duluth, MN. In the Appalachian coal fields where alkaline coal mine drainage is common, total dissolved solids (TDS) and/or elevated conductivity have been identified as a potential primary stressor to aquatic life in many biologically-impaired streams. Macroinvertebrates are the most widely used indicator of the aquatic life used by many states and several streams have been listed on the 303(d) list as biologically impaired with TDS or conductivity as the primary stressor. These streams are naturally very dilute with conductivities measured at < 40 µS/cm while alkaline coal mine drainage routinely increases conductivity to 500 to 2000 µS/cm due to increased mineralization of the mine overburden on the mined areas and in associated valley fills. At these conductivity levels, ionic changes may interfere with normal osmoregulation in invertebrates. When the TDS and the associated elevated conductivity is high, the empirical macroinvertebrate assemblage data shows that sensitive mayflies are affected/absent and these mayflies are an important component of the aquatic life the CWA is meant to protect. Empirical data from some West Virginia and Kentucky coalfields suggest that the macroinvertebrate IBI score is often below established aquatic life use impairment thresholds (based on the reference condition) when conductivity is greater than 500 µS/cm. In this poster, we will present the analysis and summary of available empirical datasets to develop empirical relationships and compare these results to toxicity testing data from various literature sources. *This abstract does not necessarily reflect EPA policy.*

WP10 Effects of in ovo exposure to Zinc on western fence lizards. A.E. Delecki, L.G. Talent, Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK. Zinc is a soil contaminant in some areas, particularly near former zinc mines. However, little is known about the effects of zinc on native lizards. Because most lizards bury their eggs in moist soil where they absorb water from the surrounding substrate, zinc may enter the eggs and affect the development of embryos. We evaluated the effects of incubating western fence lizard (*Sceloporus occidentalis*) eggs on zinc-spiked substrate. Eggs were obtained from a captive population of western fence lizards that originated from animals captured in the San Joaquin Valley in California. Forty-eight hours after oviposition, fertile lizard eggs were placed in six concentrations of Zn-spiked perlite and a control, incubated at 26°C, and weighed weekly. Eggs were examined daily for mortality. There was a dose-related response for both increase in egg mass during incubation, and hatching success. Therefore, it appears that lizard eggs may be useful for evaluating the effects of soil contaminants on reptiles.

WP11 Aquatic Toxicity of Amical™ 48 Antifungal Agent to Freshwater Fish, Daphnids, and Green Algae. T.A. Marino, A.M. Yaroch, H.D. Kirk,

E.L. McClymont, Toxicology & Environmental Research and Consulting, The Dow Chemical Company, Midland, MI. AMICAL™ 48 Antifungal Agent (1-((Diiodomethyl)sulfonyl)-4-methyl-benzene), hereafter referred to as AMICAL™ 48, is an in-can and dry-film fungicide used in adhesives, construction products, leather, paint, plastics, pulp and paper and wood applications. For product stewardship and regulatory compliance, a freshwater ecotoxicology profile was developed for AMICAL™ 48. The test species used to evaluate the ecotoxicity profile of this product were a freshwater fish (rainbow trout, *Oncorhynchus mykiss*), a freshwater invertebrate (*Daphnia magna* or daphnid), and a freshwater green alga (*Pseudokirchneriella subcapitata*). Studies were conducted according to OECD and USEPA testing guidelines. Exposures periods were 96 hours (flow-through), 48 hours (flow-through), and 96 hours (static) for the fish, daphnid, and algal tests, respectively. Analytical verification of test exposure concentrations were conducted on each test. The green alga was the most sensitive species tested resulting in 72- and 96-hour E_bC_{50} values of 42.8 and 43.1 µg/L, respectively. The daphnid was the least sensitive of the species tested with a 48-hour EC_{50} value of 279 µg/L; the 96-hour LC_{50} value for rainbow trout was 66.7 µg/L. These data will constitute a critical part of any tier 1 environmental risk assessment regarding application or disposal issues with AMICAL™ 48. ™ Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow

WP12 Comparative Responses of *Lepomis macrochirus*, *Pimephales promelas*, *Hyalella azteca*, *Ceriodaphnia dubia*, and *Daphnia magna* to Laboratory Exposures of Two Copper Algaecides. B.M. Johnson, M.M. Chao, O.R. Tedrow, J.H. Rodgers, Clemson University, Clemson, SC. Responses of sentinel non-target species to laboratory exposures of algaecides (Algimycin® PWF and copper sulfate pentahydrate) can provide useful data for first order assessments of potential risks to these species due to treatments of problematic algae growths in aquatic systems. The objective of this research was to compare the toxicity of Algimycin® PWF and copper sulfate pentahydrate to freshwater fish *Lepomis macrochirus* Rafinesque and *Pimephales promelas* Rafinesque as well invertebrates *Hyalella azteca* Saussure, *Ceriodaphnia dubia* Richard, and *Daphnia magna* Straus. Survival was measured after 96 hours of static exposure to a range of copper concentrations in moderately hard water using USEPA testing protocols. LOEC and LC_{50} values were estimated from the nominal copper concentrations. The LOEC and LC_{50} values (µg Cu/L) for Algimycin® PWF were 29,360 and 67,000 for *L. macrochirus*, 10 and 250 for *P. promelas*, 100 and 390 for *H. azteca*, 15 and 48 for *C. dubia*, and 0.7 and 4.6 for *D. magna*, respectively. The LOEC and LC_{50} values (µg Cu/L) for copper sulfate pentahydrate were 363 and 2,640 for *L. macrochirus*, 10 and 230 for *P. promelas*, 100 and 400 for *H. azteca*, 14 and 42 for *C. dubia*, and 1.0 and 5.0 for *D. magna*, respectively. Four of the five species (excluding *L. macrochirus*) showed no significant differences in their responses to exposures between Algimycin® PWF and copper sulfate pentahydrate. In terms of relative sensitivity to these algaecides: *D. magna* > *C. dubia* > *P. promelas* > *H. azteca* > *L. macrochirus*.

WP13 Proteomic Investigation of Atrazine Exposure in *Drosophila melanogaster*. B. Thornton, Union College, Lincoln, NE; B. Thornton, T. Elthon, R. Cerny, B. Siegfried, University of Nebraska, Lincoln, NE. Two-dimensional gel electrophoresis was used to investigate differential regulation of protein expression in *Drosophila melanogaster* exposed to atrazine. Three day-old, sexed adults were exposed to 1000 ppm atrazine incorporated into their rearing diet for 72 hr. Total protein was extracted from whole bodies and subjected to two-dimensional gel electrophoresis. The first dimension involved 11 cm immobilized pH gradient (IPG) strips (pH ampholytes 3-10). The second dimension involved SDS-PAGE under denaturing conditions to separate proteins based on molecular mass. Differences between the normalized protein volume of exposed and control groups for each of three trials were averaged and the standard error calculated. Protein spots of interest with > ±1.2 average fold difference in normalized protein volume and a standard error of < 0.50 were excised from the gels and analyzed by ms/ms. Functions of the biochemical pathways these proteins are associated with include: glycolysis and ATP production, stress responses including detoxification of xenobiotics and scavenging of free radicals, and forming of chaperone complexes. The significance of alterations in these and other affected biochemical pathways in non-target species should not be underestimated. Further proteomic investigations using subcellular fractions will further elucidate the effects of atrazine on biochemical pathways in non-target species.

WP14 Identifying Controllable Test Parameters that Impact the Variability of Responses by *Leptocheirus plumulosus* in the Sediment Toxicity Bioassay of Synthetic-based Drilling Muds. R. MacGregor, H.E. Morris, K.S. Wolfe, K. Kovar, S. Stone, Baroid Bioassay Lab, Halliburton, Houston, TX. The primary objective of this study was to identify controllable test parameters that have a significant affect on the variability of the 96-hr sediment toxicity bioassay of synthetic-based drilling muds (SBMs) as required for offshore discharge of drill cuttings to the Gulf of Mexico. Test parameters that may affect the survival/ LC50 results include, but are not limited to, the SBM-sediment preparation and blending, physical/chemical characteristics of artificial sediments, formulations of test and reference materials, and test organism health, size and weight. This study examined the relationships between the test results and 1) selected test organism sizes, 2) water content of the test sediments, 3) test organism origin by culture batch and/or culture media and 4) different reference and test material preparations. The test results measured were percent survival, LC50 and dose-response of *L. plumulosus* in the 96-hr sediment toxicity bioassays. These bioassay responses were evaluated by multi-variant analyses for correlations with the controlled parameters. The observed correlations can be used to reduce variability and improve reliability of this test in its current regulatory environment.

WP15 Responses of *Ceriodaphnia dubia* Richard And *Pimephales Promelas* Rafinesque to Aqueous Boron Exposures. B. Damiri, J.H. Rodgers, Forestry and Natural Resources, Clemson University, Clemson, SC; J.H. Rodgers, Forestry and Natural Resources, Clemson University, Clemson, SC. Boron in industrial effluents can be found at concentrations that adversely affects to aquatic animals. The objectives of this research were to measure responses (potency, median lethal effect concentrations (LC50s), lowest observed effect concentrations (LOECs), no observed effect concentrations (NOECs) of *Ceriodaphnia dubia* Richard and *Pimephales promelas* Rafinesque to aqueous boron exposures (in the form of boric acid). Boron toxicity tests were conducted in 7-d static /renewal tests following U.S.EPA testing protocols for *C. dubia* and *P. promelas* (USEPA, 2002). Each test concentration was replicated three times with 30 organisms per treatment and controls. The estimated 7-d aqueous LC50 for *C. dubia* was 75.97 mg B/L with a 95% confidence interval of 74.91-77.04 mg B/L while the LC50 for *P. promelas* was 81.57 mg B/L with a 95% confidence interval of 77.82-83.65 mg B/L. NOEC and LOEC values for *C. dubia* reproduction were 17.22 and 18.26 mg B/L, respectively. No *C. dubia* reproduction was observed at boron concentrations ≥ 38.41 mg B/L. Similar to most elements, aqueous boron exposures elicited different responses (sensitivity) for *C. dubia* and *P. promelas* with potency slopes of 0.86 and 0.57, respectively concluding that *C. dubia* survival is mores sensitive than *P. promelas* to boron (Figure 1 and Figure 2).

WP16 Antioxidant enzyme activities and lipid peroxidation in the *Daphnia magna* co-exposed to photo-toxicants and ultraviolet B light. J. Kim, K. Choi, Seoul national university, Seoul, South Korea. Ultraviolet-B-enhanced oxidative stresses in the freshwater *Daphnia magna* co-exposed to phototoxicants, such as sulfathiazole (pharmaceutical; STZ), fluoranthene (PAHs) and copper (metal) were investigated. Activities of various antioxidant enzymes including catalase (CAT), glutathione S-transferase (GST), superoxide dismutase (SOD) and levels of lipid peroxidation measured as thiobarbituric acid reactive substances (TBARS) were determined in *D. magna* juveniles after the exposure to both environmental level UV-B light and sublethal levels of phototoxicants. Antioxidant enzyme responses varied among test toxicants having different defense mechanisms against oxidative stress. Without UV-B, CAT activities showed an increase compared to control animals under exposure to STZ, and then return to control level. Co-exposure to UV-B significantly increased the levels of CAT at 9.5 mg/L STZ ($p < 0.05$). GST activities showed similar pattern. For fluoranthene and copper, the CAT activity increased in *D. magna* co-exposed to UV-B as the concentration of exposure increased (p for trend < 0.05), whereas low responses of GST for fluoranthene (p for trend < 0.1) and CAT for copper (p for trend < 0.1), coupled with negligible increase in SOD for both chemicals were found. UV-B irradiation did not influence significantly the level of antioxidant enzyme activities in *D. magna* exposed to phototoxic chemicals. In previous study, UV-B light enhanced the acute 48 h *Daphnia* toxicities of STZ, fluoranthene and copper by 2.2, 8.7 and 1.6 fold respectively. Antioxidant enzyme activities were obviously different from lethal responses, potentially indicating sublethal damages to the receptor. Antioxidant enzymes such as CAT and GST have reliabilities as sensitive biomarker for oxidative stresses induced by several environmental contaminants and UV-B light.

WP17 Using WET Test Methods to Detect Phototoxic Effects in Pah-Contaminated Groundwater. J. Fortner, R. Harper, Environmental Sciences, Western Washington University, Bellingham, WA; D. Sternberg, Toxics Cleanup Program, Washington State Department of Ecology, Olympia, WA. In this study, the acute toxicity of PAH-contaminated groundwater to *Daphnia magna* and *Americamysis bahia* are characterized under both standard laboratory fluorescent light and ultraviolet light (UV) test conditions using USEPA WET test methods. Studies using a variety of methods have demonstrated the potential of UV light and natural sunlight to increase the toxicity of PAHs to many aquatic organisms. Based on these studies, the discharge of PAH-contaminated groundwater to adjacent surface waters may result in increased acute groundwater toxicity due to the effect of photoenhanced toxicity of PAHs under natural sunlight. Though photoenhanced toxicity testing of PAH-contaminated groundwater is not typically conducted using acute USEPA WET test methods, WET test methods may represent a means to characterize the toxicity of PAH-contaminated waters. Under standard WET test protocol, USEPA recommends the use of ambient laboratory lighting during WET toxicity tests (10-20 $\mu\text{E}/\text{m}^2/\text{s}$ or 50-100 ft-c). No recommendations are made for the specific spectral distribution or relative wavelength irradiance of these ambient lighting conditions. This lack of specific recommendation for laboratory lighting may result in inaccurate toxicity estimates when photoactive PAHs are present. In this study, we characterize acute groundwater toxicity under the following two lighting treatments: 1) ambient laboratory lighting and 2) ambient laboratory lighting plus UVA (320-400nm) and UVB (290-320nm). In the second treatment, cool white fluorescent (CWF) and ultraviolet bulbs are combined to create a light source that produces UVA and UVB light with a spectral distribution similar to that of natural sunlight and produces ecologically-relevant irradiance levels of UVA and UVB. Total UVA, total UVB, and total PAR (400-700nm) are described in terms of light dose over time, spectral distribution, and irradiance for both light treatments.

WP19 Using Non-invasive Techniques to Monitor Environmental Pollutants in Coastal River Otters of the Puget Sound-Georgia Basin. D. Guertin, A. Harestad, Simon Fraser University, Burnaby, British Columbia, Canada; M. Ben-David, University of Wyoming, Laramie, WY; J. Gaydos, The SeaDoc Society, Eastsound, WA; J. Elliott, Environment Canada, Delta, British Columbia, Canada. The North American river otter (*Lontra canadensis*) is a semi-aquatic apex predator that inhabits freshwater and marine systems throughout North America. Pollution of aquatic ecosystems is a significant threat to river otter populations, yet little effort has been made to monitor environmental contaminant levels in wild otters. Because of their elusive nature, river otters are difficult to study in their natural surroundings, however, advances in non-invasive sampling has opened opportunities for gathering information on the species. In a pilot project, fecal samples analyzed from marine-foraging river otters near the city of Victoria, British Columbia in the transboundary Puget Sound-Georgia Basin (PS-GB) region of Canada and the United States had elevated levels of industry produced polychlorinated biphenyls (PCBs). Based on these results, we have undertaken a novel approach to examine the significance of PCBs on the region's coastal river otter population. We identified 165 river otter latrine sites spanning 87.5 km of coastline on southern Vancouver Island, BC. A total of 893 fresh fecal samples were collected from Dec 13 – 18, 2005 and June 1 – Aug 22, 2006. Fecal DNA genotyping will be used to determine the abundance and distribution of river otters in the study area. Hard prey remains will be removed from all fecal samples and used for dietary analysis. River otters in which genetic profiles are obtained will have their feces analyzed for contaminant levels. Our goal is to combine these techniques to examine the effect of spatial and temporal landscape use on the exposure of individual otters to contaminants. Results are pending. Due to their high trophic status in the nearshore environment and high site fidelity, river otters are an ideal species to monitor localized environmental contaminants in marine ecosystems.

WP20 The Effects of Functionalized Carbon Nanotubes on Development of Fathead Minnow (*Pimephales promelas*) Embryos. G. Laban, M. Sepulveda, J. Bickham, Forestry and Natural Resources, Purdue University, West Lafayette, IN; L. Nies, M. Sepulveda, School of Civil Engineering, Purdue University, West Lafayette, IN; R. Turco, Department of Agronomy, Purdue University, West Lafayette, IN; J. Bickham, Center for the Environment, Purdue University, West Lafayette, IN. Nanomaterials are part of an industrial revolution that has resulted in an explosion of hundreds

of novel products due to their malleable properties, thus enabling usage in a wide range of innovative applications. Assessing the environmental impact of such a great variety of products is of prime importance; however, there is little published information in this regard. Therefore, we investigated the toxicity of carbon nanotubes (CNTs) by exposing developing fathead minnow (*Pimephales promelas*) embryos to functionalized CNTs (0-160 ppm). The LD50 for polyaminobenzene sulfonic acid functionalized CNTs was 40 ppm. Chronic values (ChVs) for mortality were determined as the geometric mean of the no observed effect concentration and lowest observed effect concentration based on analysis of variance. In addition, a hatching delay was observed starting at doses of 2 ppm. Further analyses are currently being performed to determine genotoxic effects caused by CNTs using Laser Scanning Cytometry. This data provides a basis for future risk assessment, dose response relationships and hazard identification in an important model, the fathead minnow, commonly used as a standard sentinel organism in aquatic environmental toxicity analyses.

WP21 Campus Parking Lot Stormwater Runoff: Toxicological and Physiochemical Analyses. A.D. McQueen, Environmental Toxicology, Clemson University, Clemson, SC; J.H. Rodgers, Forestry and Natural Resources, Clemson University, Clemson, SC. Parking lot stormwater runoff mobilizes a variety of constituents from vehicular and atmospheric deposition that may pose risks to receiving aquatic systems. Constituents and consequent risks may be site specific; therefore, comprehensive characterization of parking lot stormwater is needed to assess these risks. The objective of this study was to conduct physiochemical and toxicological analyses of campus parking lot stormwater (CPLSW) from diverse storm events. Over a 7 month period aqueous samples were collected from selected parking lots at Clemson University using both automated and grab sampling techniques. Factors that might influence CPLSW such as storm durations, intensities, and seasons were analyzed along with the intrinsic characteristics of the parking lots (i.e. surface type, use intensity, and size). Physiochemical analyses included elemental (Al, Cd, Cr, Cu, Fe, Pb, Mn, Ni, Zn), organic (oil and grease), chemical oxygen demand, total suspended solids, total dissolved solids, and other common water characteristics. *Ceriodaphnia dubia* Richard and *Pimephales promelas* Rafinesque were used in 7-day static /renewal toxicity tests with CPLSW runoff following U.S. EPA testing protocols. Endpoints of interest include survival and reproduction of *C. dubia*, and survival of *P. promelas*. Initial runoff samples from storm events elicited greater responses for both species than did samples from later in the storm events.

WP22 Review of toxicological endpoints for arbuscular mycorrhizal fungi in culture and soil columns. D.G. Hillis, P.K. Sibley, K.R. Solomon, Environmental Biology, University of Guelph, Guelph, Ontario, Canada; P. Antunes, J.N. Klironomos, Integrative Biology, University of Guelph, Guelph, Ontario, Canada. Most plants, including the majority of crop species, form a beneficial symbiosis with arbuscular mycorrhizal fungi (AMF), which improves plant nutrient uptake, tolerance to drought, pathogenic and toxic stressors as well as improved seedling establishment and soil stability. A suite of pharmaceuticals have been screened for toxicological effects on the AMF, *Glomus intraradices*, using a *Daucus carota* root organ culture bioassay. A few compounds elicited fungicidal effects at concentrations well below the concentration needed to produce phytotoxic responses in culture. One such compound was the bacteriostatic antimicrobial compound, doxycycline, which was selected for soil column experiments. As anticipated, the soil column experiment did not produce a phytotoxic response in *Daucus carota* at soil concentrations up to 10 000 µg/kg. Both functional and structural mycorrhizal endpoints are currently being evaluated from the soil column experiment. As the use of mycorrhiza in ecological risk assessment is still within its infancy, a review of AMF toxicological endpoints will be evaluated. This review will be based on the experimental results and will evaluate which endpoints are most sensitive and whether functional endpoints can be predicted based on structural responses or vice versa. The temporal requirements to efficiently but accurately evaluate AMF in culture and columns will be discussed. Extrapolation between culture and whole plant systems as well as an exploration as to whether mycotoxic responses in AMF may change based on the associated plant species will also be discussed.

WP23 The influence of population density and stand establishment on the toxicity of the herbicide diuron to the aquatic macrophyte *Elodea canadensis*. N.C. Rentz, M. Hanson, Environment and Geography, University of Manitoba, Winnipeg, Manitoba, Canada; K. Solomon, Environmental Biology, University of Guelph, Guelph, Ontario, Canada. The current use

of toxicity tests in risk assessment has shortfalls regarding the relevance and accuracy of the results in predicting effects. This is certainly true with tests designed for the protection of non-target aquatic macrophyte species, in part due to the dependence on individual based laboratory assays that do not consider the influence of population density and stand establishment on toxicity under natural environmental conditions. A field study was conducted in summer 2007 at the University of Guelph Microcosm Facility to characterize the effects of the herbicide diuron on the non-target aquatic macrophyte *Elodea canadensis*. The six week study analyzed the toxicity of diuron to both individual plants as well as populations of varying densities. Individual plants were grown in plastic 'cone-tainers', while model populations of 9, 18 and 27 plants were grown in plastic trays filled with an organic sediment. A range of diuron concentrations and controls were applied to the microcosms (n=3). An additional 3 trays, planted at a density of 18 plants per tray, were included in each microcosm. These plants were allowed to grow for several weeks before the study in order to become a well-established population. In order to obtain comparative sensitivity data for a standardized test species, toxicity to *Lemna gibba* in each microcosm was assessed. Endpoints measured for *E. canadensis* were biomass, chlorophyll, root/shoot mass, and root number. Endpoints measured for *L. gibba* were biomass, chlorophyll, frond number and plant number. The study aims to determine to influence of macrophyte stand density and population establishment on observed toxicity. It is hypothesized that populations of *E. canadensis* will be more sensitive to diuron than individually grown plants due to higher relative growth rates under the exposure conditions relative to individual plants. Established cultures will be less sensitive than non-established cultures due to the increased amount of roots and shoots that can act as a reservoir for new growth after impact compared to recently established communities.

WP24 Toxicological Ramifications of Flocculent Accumulation Around Two Remediated Chemical Holding Ponds in the North Fork Holston River, Virginia during Drought Conditions. B.S. Echols, D.S. Cherry, Biological Sciences, Virginia Tech, Blacksburg, VA; R.J. Currie, Toxicology & Environmental Research & Consulting, The Dow Chemical Company, Midland, MI. The degradation of the North Fork Holston River (NFHR), below Saltville, VA and the extirpation of many freshwater mussel species (Bivalvia: Unionidae) due to historical mercury contamination, has led to many research efforts aimed at understanding the current ecological state of the river. Studies conducted in the NFHR attribute the lack of unionid diversity to historical and remnant mercury; however, a reconnaissance effort focused on the river section directly below the original contamination source revealed continued inputs from two former holding ponds, now US EPA Superfund sites. A preliminary evaluation revealed a thick flocculent accumulating in the river below these two sites. Analysis of the flocculent indicated high levels of aluminum (1.9-38 mg Al/L), iron (2.0-51 mg Fe/L) and trace levels of mercury (0.00018-0.0076 mg Hg/L). The origin of the flocculent is still under investigation; however, dyke cuts on the surface of the remediated area which discharges surface runoff into the river at the site of flocculent accumulation, are the probable source. Toxicity tests with *Ceriodaphnia dubia* and juveniles of *Villosa iris* were conducted on each of the dyke cut discharges. Forty-eight hour lethal concentration (LC₅₀) values for *C. dubia* ranged from 12.07-15.95 %. Juvenile *Villosa* were slightly more tolerant, with LC₅₀ values of 18.95 and 17.36 %. Timed toxicity tests with daphnids were conducted due to the extremely alkaline pH of these discharges (11.50-12.25) and low LC₅₀ values from the acute tests. In 15 min, 100 % mortality occurred in the East and West diversion discharges of Pond 6. Although the evaluation of the flocculent and dyke cut discharges is being continued, preliminary results indicate that contamination from the remediated holding ponds continues to be a source of concern in the river.

WP25 Use of Weibull Function for Non-Linear Analysis of Effects of Low Levels of Simulated Herbicide Drift on Plants. D. Olszyk, E. Lee, T. Pfleeger, NHEERL, Western Ecology Division, US EPA, Corvallis, OR. We compared two regression models, which are based on the Weibull and probit functions, for the analysis of pesticide toxicity data from laboratory studies on Illinois crop and native plant species. Both mathematical models are continuous, differentiable, strictly positive, and monotonically decreasing to zero with increasing rates of pesticide application on a log scale. The Weibull model was reparametrized so that one of its parameters was equal to EC₂₅ (effective concentration producing a 25% reduction in dry weight response). Similarly, the probit model was reparametrized so that its inflection point corresponds to log(EC₂₅). Unlike the Weibull model, the probit model is

derived from the cumulative normal distribution and assumes that the absolute difference in plant response is the same for a unit increase or decrease in the pesticide application rate about $\log(EC_{25})$. We compared EC_{25} values for dry weight for a variety of plant species treated with herbicides at below field application rates (f.a.r.) using both the Weibull and probit models. In cases where there were significant reductions in dry weight at the lowest level of herbicide used ($0.001 \times$ f.a.r.), the probit model would either not fit the data or would result in a poorer fit. The probit model did not fit the data as well as the Weibull model because its constraint of symmetry about the inflection point was not a feature of the data. Thus, the Weibull model provides a better alternative function to evaluate the risks associated with new pesticides prior to their release into the environment.

WP26 Bimodal Effects of Cadmium on Growth, Development and Thyroid Condition of Tadpoles. B. Sharma, Natural Resource Management, Texas Tech University, Lubbock, TX; R. Patino, USGS Texas Cooperative Fish and Wildlife Research Unit, Texas Tech University, Lubbock, TX. The objectives of this study were to determine the effects of Cd on tadpole growth, development and thyroid condition. African clawed frogs (*Xenopus laevis*) were exposed to 0, 0.1, 1, 8, 84 and 855 $\mu\text{g Cd/L}$ (measured concentrations) from fertilization to 47 days post fertilization to cover the period of embryogenesis, larval development and onset of metamorphosis. Endpoints measured included cumulative survival, stage of development, snout vent length, tail length, total length, hind limb length, weight, and percent metamorphosis (animals with fore limb emergence). Survival was not affected at any of the Cd concentrations tested. Reduced tail length and total length were observed at 0.1, 1, 8 and 855 $\mu\text{g/L}$; and reduced snout vent length, hind limb length and weight were observed at 0.1, 1 and 855 $\mu\text{g/L}$. Mean stage of development and percent metamorphosis were not affected at Cd concentrations of 0 - 84 $\mu\text{g/L}$, but development was inhibited and metamorphosis was blocked at 855 $\mu\text{g/L}$. Histological analysis of thyroid glands showed no significant effects on follicle cell height in tadpoles exposed to Cd at 0.1 - 84 $\mu\text{g/L}$, but follicle cell height was reduced at 855 $\mu\text{g/L}$. In conclusion, (1) Cd inhibited tadpole growth in a bimodal manner with the first and second modes occurring at concentrations below and above 84 $\mu\text{g/L}$, respectively; and (2) development and metamorphosis were inhibited only at 855 $\mu\text{g/L}$ possibly via thyroid-dependent mechanisms.

WP27 Latent Effects Due to Zinc Toxicity May Not Be Characterized in Acute Toxicity Tests. M. Bowersox, J. Diamond, H. Latimer, Tetra Tech, Inc., Owings Mills, MD. Latent effects, or effects that continue after the end of the method-defined exposure period, may result in significant effects to organisms routinely used for WET testing. Typical acute toxicity testing may not accurately characterize toxicity of some contaminants due to latent effects. Mysid shrimp, larval fathead minnows, and *Daphnia* neonates exhibited latent mortality after pulsed exposures to zinc. Exposure of *Americanysis bahia* to zinc bromide resulted in latent mortality at 48-96 hours that was equal to or greater than mortality observed during the exposure (1-10 hours). Exposures of larval fathead minnows or *Daphnia magna* to zinc chloride resulted in significant effects on organisms survival that continued up to 5 days after the conclusion of the test exposure. Zinc effects typically continued beyond the internal chemical half-life reported for aquatic organisms (1.5 days), which suggests that zinc imparts irreversible physiological damage to the organism once a threshold amount of zinc has been accumulated. Thus, zinc effects are a function of zinc concentration as well as time over which zinc exposure and organism accumulation occurs. Latent responses to zinc observed in multiple test species suggests two-compartment rather than first-order kinetics for this metal and the need to consider longer-term mortality effects in testing if zinc is a contaminant of concern.

WP28 Screening endocrine disruption capacity of several pharmaceuticals using a yeast-based reporter gene assay, and gene expression and reproductive characteristics of Japanese medaka (*Oryzias latipes*). Y. Park, J. Kim, Y. Kim, K. Choi, School of Public Health, Seoul National University, Seoul, 110799, South Korea; S. Park, National Institute of Environmental Research, Incheon, South Korea; C. Park, Research Institute of Public Health and Environment, Seoul, South Korea. Pharmaceuticals are of growing importance as environmental contaminants due to their widespread occurrence in the environment and potential ecological consequences. These compounds are manufactured for specific biological functions which lead to concerns for potential adverse effects on non-target species in aquatic ecosystems. Endocrine disruption is one of the recent concerns related to this group of chemicals. In this study, we used

yeast based reporter gene assay and a reverse transcription-polymerase chain reaction (RT-PCR) system for screening of estrogenic compounds among 38 frequently using pharmaceuticals in Korea. For a few pharmaceuticals that were shown potential estrogenicity, longer term individual level toxicity tests were conducted with medaka fish, *Oryzias latipes*. None of the test pharmaceuticals were identified estrogenic by the yeast assay. However, an RT-PCR system showed expression of vitellogenin in male fish that were exposed to sulfamethoxazole, sulfadimethoxine, sulfamethazine, tetracycline, acetaminophen, carbamazepine, diltiazem, and oxytetracycline, among test chemicals. Fish were then exposed to acetaminophen and diltiazem for 90 d and observed for various reproduction-related endpoints. Female juveniles exposed to diltiazem showed dose dependent increase of gonadosomatic index. However fecundity, hatchability and hatching time were not affected at the test concentrations. Our study shows a link between gene expression level and histological endpoint of endocrine disruption due to some common pharmaceuticals.

WP29 Effects of EDCs and Mouthpart Deformity of Larval Development in chironomids. I. Kwak, Faculty of Marine Technology, Chonnam National University, Yeosu, South Korea; W. Lee, Department of Life Science, Hanyang University, Seoul, South Korea. The effects of EDCs on larvae of *Chironomus riparius* were tested in the laboratory. In the most treatments it reached a statistically significant difference from the control condition. In terms of development, the effects of tebufenozide and DEHP were delayed growth stage in relatively lower concentration such as 10 $\mu\text{g/L}$ treatments. The morphological effects showed that the first and second segments of body of exposed larvae with tebufenozide expanded slowly and not made a complete cephalothorax of pupae during long times or days. Due to the different emergence periods of male/female in low insecticide concentrations, mating chances or opportunities of insects should be decreased. Accordingly, ecological strategies for keeping of sustainable populations should be disrupted. The female biomass was increased after DEHP treatments while male biomass was not clearly appeared in these tendencies. Also, the biomass along the male/female was obscure after tebufenozide treatments. The type of deformity observed in the mouthpart mentum is depicted: The deformities noted following exposure to tebufenozide typically involved smooth/round tooth, the loss of ≥ 1 tooth, and reduced median lateral teeth (MLT). The incidence of mentum deformity was associated with tebufenozide exposure. Chemical treatments cause the appearance of a light color and round shape in the mentum that was dose-dependent. Also, the incidence of the smooth teeth was observed more frequently in the median lateral teeth (MLT) than in the lateral teeth (LT).

WP30 A Residue-Effects Database for Polychlorinated Biphenyls, Polychlorinated Dibenzofurans, and Polychlorinated Dibenzo-p-dioxins. L.P. Burkhard, C.L. Russom, D.J. Hoff, NHEERL, Mid-continent Ecology Division, US-Environmental Protection Agency, Duluth, MN. In the last decade, our understanding of appropriate dose measures and effects endpoints for persistent, bioaccumulative, toxic substances (PBTs) has increased greatly; and it is now recognized that for PBTs, the chemical residue in the organism (or one of its tissues) is the best measure of dose for predicting chronic toxicity. A residue-effects database has been assembled, which builds upon previous efforts, for fish, bird, and non-primate and non-domestic mammal species for polychlorinated biphenyls (PCBs), e.g., commercial mixtures like Aroclors as well as individual congener data, polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and any combination of the three chemical classes. The database encodes numerous facets associated with the laboratory toxicological tests including exposure timing and dosing information, organism characteristics (age, size, sex, lipid content, ...), effect type and site (e.g., liver, kidney, whole organism, ...), the residue, the site of the residue, and the source of the data. For fish, birds, and mammals, the database contains data for 58, 32 and 19 species, respectively, covering 76, 72, and 127 different chemical combinations, respectively. The database has more than 10,000 records, and the database is freely searchable at <http://cfpub.epa.gov/ecotox/>. The contents and data retrieval tools will be presented. This abstract does not necessarily reflect EPA policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

WP31 Identifying and Reducing Ion Imbalance Toxicity in an Industrial Effluent. K. Anderson, C. Allen, K. Brown, K. Lafortune, K. Wormer, ASci-ETL, Duluth, MN, The prevalence of TDS toxicity in municipal and industrial discharges is widespread across much of North America. While simple analytical measurements and literature searches can quickly determine

TDS thresholds for most freshwater organisms, identification and reduction of the specific components of TDS toxicity can present unique challenges from both a toxicological and water treatment standpoint. A New England industrial effluent, acutely toxic to *Ceriodaphnia dubia*, was subjected to effluent fractionation techniques including ion-exchange, salts addition, and species sensitivity. The results were used to identify a sodium/calcium imbalance as the causative toxicity agent. The TIE procedures were also designed to produce useable data for the subsequent Toxicity Reduction Evaluation (TRE).

WP32 The biological monitoring method using *Daphnia magna* in the rice field. T. Abe, H. Sato, T. Saito, K. Yawata, T. Kotani, Chemical Science & Engineering, Tsuruoka National Institute of Technology, Tsuruoka, Japan. Biological monitoring is useful to define the biological safety in the environment. To confirm the usefulness of the biological monitoring method using *Daphnia magna*, the river water samples were tested in 2005, 2006. The water samples were collected from 10 sites of three rivers (Aka, Uchi and Ohyama) in Tsuruoka city, Japan. Aka river is primary river in Tsuruoka city. The river water samples were evaluated by *Daphnia magna* 24/48hr immobilisation test. Also the river water samples analyzed by ion-chromatography, atomic absorption spectroscopy (AAS) and inductively coupled Plasma (ICP) atomic emission spectrometry. The concentration of K^+ , Na^+ , Mg^{2+} , Pb , Zn , Cl^- , NO_3^- , PO_4^{3-} , SO_4^{2-} were measured and compared with the *Daphnia* monitoring assays. Highly *Daphnia* immobilisation rate occurred in May, June and August (spring and summer), whereas *Daphnia* immobilisation did not occurred almost in October and December (winter). We thought one of the reasons that Tsuruoka city have many rice field and rain (snow). These results would suggest other toxic substances also might cause *Daphnia* immobilisation. This study indicated usefulness of *Daphnia* monitoring method and necessity of further studies.

WP33 Development of Ecological Soil Screening Levels (Eco-SSLs) for Ecological Risk Assessments (EcoRA). L. Kapustka, Golder Associates Ltd, Calgary, Alberta, Canada; L. Oosterbroek, S. Goudey, HydroQual Laboratories Ltd., Calgary, Alberta, Canada; A. Hawkins, Naval Facilities Engineering Service Center, Port Hueneme, CA. The process and criteria for establishing Ecological Soil Screening Levels (Eco-SSLs) for chemicals of concern identified in Ecological Risk Assessments (EcoRA) are presented. An ecological risk assessment (EcoRA) is a structured investigative process. A list of chemicals of concern is compiled for the site. Screening level concentrations are then defined and compared to measured values or other available data. Historically, this process has been repeated for every new site under investigation because there were no standard screening level concentrations for individual chemicals. The US EPA recognized the need and value of establishing standard ecological soil screening levels (Eco-SSLs) for Superfund Ecological Risk Assessments in 2000 (USEPA Work Group Eco-SSLs). Eco-SSLs have been established for a number of compounds based on published data. The methodology developed for evaluating data was well documented and can be applied to other chemicals for establishing Eco-SSLs of known and comparable quality. This will be illustrated through the development of Eco-SSLs for chemicals of interest to the U.S. Department of Defense. These include metals found in bullets, signaling flares, igniters, tracers, explosives, primers, boosters, detonators, and casings (antimony, silver, barium, chromium (VI), and nickel), perchlorate and the high melting point explosive cyclotetramethylenetetranitramine (HMX). Establishing Eco-SSLs for these chemicals will eliminate the need to repeat the standard review process at every site that contains these chemicals. This eliminates the redundancy and substantially reduces the cost.

WP34 Amphibian Metamorphosis Assay Thyroid Histopathology: Approach to reading studies, diagnostic criteria, severity grading, and atlas. K.C. Grim, L.W. Touart, OSCP, US EPA, Washington, DC. In support of the proposed new OECD Amphibian Metamorphosis Assay Test Guideline for the detection of substances that interact with the thyroid axis, a guidance document was developed that standardized histopathology reading practices, diagnostic criteria, severity grading, and data reporting and compilation in an effort to maximize comparability between pathologists and to reduce bias for this endpoint. It also presents a reference atlas of normal microanatomy of *Xenopus laevis* thyroid glands and an atlas of core diagnostic criteria with examples of severity grades. Over several meetings with experts in amphibian thyroid histopathology, core diagnostic criteria were determined to be thyroid gland hypertrophy/atrophy, follicular cell hypertrophy, and follicular cell hyperplasia. Additional qualitative criteria are follicular lumen area (or colloid

area), colloid quality, and follicular cell height/shape. The severity grading scheme employs a four grade approach which describes ranges of variation within assigned ordinal classes, generally being listed as not remarkable, mild, moderate and severe and is semi-quantitative. The purpose of this severity grading approach is to provide an efficient, semi-objective mechanism for comparing changes (compound-related effects) among animals, treatment groups, and studies. Proposed descriptions of lesions for scoring the four core criteria are also provided. This resource allows for greatly improved diagnosis and consistency in interpreting histopathological lesions associated with chemical interference in thyroid gland structure and function.

WP35 An Analysis of Pesticides as Potential Ecotoxicological Risks to the Florida Apple Snail, *Pomacea paludosa*. D.J. Call, N.B. Vyas, Department of Natural & Applied Sciences, Univ. of Dubuque, Dubuque, IA; N.B. Vyas, Current Address: USGS Patuxent Wildlife Research Center, Beltsville Lab., U. S. Geological Survey, Beltsville, MD. The apple snail, *Pomacea paludosa*, is a native herbivore in the food web of freshwater wetland ecosystems in Florida. As the nearly exclusive dietary component for the endangered snail kite, *Rostrhamus sociabilis*, as well as a prey item for other wildlife species, it is important that viable populations of the snail be maintained. The snail population is subject to a variety of stressors, including habitat loss and fragmentation, hydrological changes, competition from introduced exotic snails, and chemicals. This study evaluates the ecotoxicological effects of various pesticides upon the snail by utilizing information on pesticide use in Florida, pesticide concentrations in surface waters of southern Florida, pesticide/pesticide class toxicity toward the apple snail, and pesticide/pesticide class toxicity toward surrogate invertebrate species. Toxicological information on apple snails is limited. However, results suggest that, for pesticides that have been both tested with molluscs and also recently detected in Florida surface waters, apple snail populations are not likely to be impacted directly by exposure to (1) organic herbicides with specific phytotoxic modes of action, (2) organochlorine insecticides, (3) organophosphate or pyrethroid insecticides, (4) the biological insecticide *Bacillus thuringiensis*, or (5) organic fungicides. Toxicity toward the apple snail by pesticides from these classes would likely occur only at concentrations that are considerably higher than those reported in Florida surface waters. However, the apple snail is highly sensitive to the inorganic aquatic herbicide and general biocide copper sulfate, with a 96-h LC50 of 7.42 $\mu\text{g/L}$. The apple snail is also known to be sensitive to chelated formulations of copper-containing aquatic herbicides. Indirectly, apple snail populations in the immediate vicinity of any aquatic herbicide application will likely be negatively impacted for some time by the loss of emergent vegetation for reproduction (i.e., ovipositing of egg clusters and embryo development) and loss of algae and other plant food resources. Further work is needed to determine possible chronic effects on snails from pesticides that bioaccumulate.

WP36 Toxicity Equivalency Values (TEQs) for Polychlorinated Biphenyl Mixtures. M.T. Lukaszewycz, L. Burkhard, US-Environmental Protection Agency, Duluth, MN. The results from toxicity tests of Aroclors and other polychlorinated biphenyl (PCB) mixtures are most often expressed using the total concentrations of PCBs. However, PCB mixtures are contaminated by polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) and failure to account for their presence will result in incomplete assessment of their toxicity when toxicity is expressed on a dioxin equivalency basis. This report compiles 2,3,7,8-substituted PCDD/F data and dioxin-like PCB data for the commercial PCB mixtures and subsequently, derives toxicity equivalency values (TEQs) for each mixture, using World Health Organization toxicity equivalency factors and the measured composition data of the mixtures. TEQs were derived for Aroclor, Clophen, Kanechlor, Chlorofen, Sovol, Delor, Phenoclor and Chinese PCB mixtures. The TEQs were similar across the different PCB product lines, and for fish, greater than 50% of TEQs were due to PCDD/F contents of the mixtures for the higher chlorinated mixtures. In comparison to the dioxin-like PCBs, few measurements have been performed for PCDD/Fs in the commercial PCB products. This abstract does not necessarily reflect EPA policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

WP37 Effects of 2,2',4,4'-tetrabromodiphenyl ether 47 (PBDE-47) on zebrafish development. J. Colman, S. Lema, N. Scholz, P. Swanson, J. Incardona, NOAA Fisheries, Seattle, WA. Polybrominated diphenyl ethers (PBDEs) are routinely added to a myriad of consumer products, where they successfully reduce fire related damage and injury. However, these

widely produced compounds have become pervasive organic contaminants in the environment and in the tissues of fish, birds, marine mammals, and humans. Little information is available regarding the potential toxicity of these chemicals on humans and animals. Studies in rodents suggest subtle neurodevelopmental defects resulting from embryonic exposure. Using the zebrafish model, we are investigating the impacts of embryonic exposure to PBDE-47, the most abundant PBDE congener found in tissue samples from wild fish. Embryos exposed continuously to aqueous PBDE 47 beginning 3-5 hrs post-fertilization (hpf) showed no gross defects through organogenesis, but displayed functional and morphological abnormalities, and ultimately lethality, by the larval period. By 120 hpf larvae showed dorsal curvature which developed into a flexion at the hindbrain. Elevated heart rate was observed by 96 hpf, which often progressed into an atrioventricular block arrhythmia. The timing of these effects is potentially coincident with development of autonomic innervation of the heart. Consistent with a neurodevelopmental defect, injection of fluorescent dextran into the hindbrain ventricle demonstrated reduced cerebrospinal fluid flow. In order to identify cellular or molecular targets for PBDEs, we are currently investigating an anatomical basis for these defects.

WP38 Comparative Effects of in ovo Exposure to Selenite and Selenate on Western Fence Lizards (*Sceloporus occidentalis*). S.J. Dunn, L. Talent, Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK. Although many species of reptiles occur in areas where Selenium (Se) is an environmental contaminant, little is known about the effects of in ovo exposure to Se on reptile embryonic development and hatching success. Because most lizards bury their eggs in moist soil where they incubate until hatching, developing embryos may be exposed to excessive levels of Se if the soil is contaminated with Se. Selenium can exist in several forms in the environment and selenite and selenate are two common forms found in soil. The objective of our study was to compare the effects of in ovo exposure to selenite and selenate on embryonic development and survival of western fence lizards (*Sceloporus occidentalis*). Fence lizard eggs were exposed to seven concentrations of both selenate and selenite. Eggs were obtained from a captive population of western fence lizards that originated from animals captured in the San Joaquin Valley in California. Forty-eight hours after oviposition, fertile lizard eggs were placed in Se-spiked expanded perlite, artificially incubated at 26°C, and examined daily for mortality. There was a dose-related response for both selenite and selenate. However, lizard embryos were more sensitive to selenate. The LC50 values for selenate and selenite were 34.3 µg Se/g perlite and 129.1 µg Se/g perlite, respectively.

WP39 Effects of Pharmaceutical Exposures on Innate Behaviors of Larval Fathead Minnows. M. McGee, K. Grove, H.L. Schoenfuss, Biological Sciences, St. Cloud State University, St. Cloud, MN. A wide variety of emerging contaminants, including estrogenic hormones, alkylphenols, and pharmaceuticals have been found in many anthropogenically altered surface waters. The effects of some of these compounds on adult fishes, including the fathead minnow, *Pimephales promelas*, have been well established and include changes in morphology, physiology, and behavior. However, the effects of these compounds on larval fishes are less clear and previous studies often considered only lethality and vitellogenin induction as endpoints. In addition, many emerging contaminants, especially pharmaceuticals, have modes of action that may not readily correlated with previously established endpoints for xenoestrogens. In this study, we tested the hypothesis that larval fathead minnows exposed to emerging contaminants singularly or in complex mixtures suffer reduced ability to perform innate avoidance behaviors. Fathead minnow larvae, like many other larval fishes, use an innate 'C'-start behavior to rapidly move away from any threat stimulus. Several emerging contaminants tested are known to affect the hypothalamus-pituitary axis and may either delay the fishes response to a threatening stimulus or decrease the velocity of the ensuing avoidance motion. We used a digital Redlake high speed video camera to record responses of previously exposed larval fathead minnows to a threatening stimulus. The resultant video recordings at 1,000 frames/second were used to measure the time to induction of the behavior as well as the escape velocity in larval fishes exposed to several classes of compounds including estrogens (E1, E2, EE2), alkylphenols (nonylphenol, octylphenol) and pharmaceuticals (acetaminophen, fluoxetine, carbamazepine) singularly and in mixture. Video recordings were transferred to NIH Image software for frame-by-frame analysis of reaction delay and reaction velocity. Detailed results of these experiments will be presented at the conference.

WP40 Ecological Risk Assessment in Support of Developing a Rehabilitation Strategy for the Deloro Mine Site, Deloro, Ontario, Canada. J.T. Kroetsch, CH2MHILL Canada Limited, Kitchener, Ontario, Canada; B.E. Sample, CH2MHILL, Sacramento, CA. Mining and manufacturing activities at the Deloro Mine Site (Mine Site) began in the mid 1860s until 1961. Activities included the mining and extraction of gold, production of arsenic, silver, nickel, cobalt, and stellite, and refining and smelting of radioactive concentrate. These operations resulted in large quantities of mine tailings, refining slag, calcium arsenite, arsenate and arsenic-based pesticides having been deposited on the site, contaminating soil, groundwater, sediment, and surface water within the mine property. The Ontario Ministry of the Environment (MOE) assumed control of the Mine Site in 1979. The MOE is developing a rehabilitation strategy and the final management plan for all wastes at the site. Through previous investigations, it was apparent that the most viable solution for managing contaminated material at the Mine Site involved isolation and containment techniques. An approach that includes cleanup to "natural background" is prohibitively costly and was not considered to be the most prudent expenditure of public or private funds. Instead, a more pragmatic approach was adopted, in which mitigative action was directed at risk reduction. As part of this project the risks to human and ecological receptors associated with the Mine Site following rehabilitation were assessed. An ecological risk assessment (ERA) was conducted to evaluate potential risks to wetland/riparian plants, benthic invertebrates, fish, amphibians, terrestrial plants, soil invertebrates, birds and mammals at the Mine Site. A total of 17 COCs were identified based on exceedances of the soil, sediment, and water quality benchmarks in the various media including arsenic, antimony, cobalt, copper, iron, nickel, thallium and uranium. Measured tissue concentrations in plants and fish were compared to literature-derived tissue-based toxicity thresholds. Site-specific ambient media toxicity bioassays and biological surveys were used as additional lines of evidence. The results of the ERA were used to determine the scope of remedial activities proposed at the Mine Site to ensure that there will be no unacceptable risks to ecological receptors following rehabilitation.

WP41 HPLC-ICP/MS Analysis of Thyroid Hormone and Related Iodinated Compounds in Tissues and Media. B.C. Butterworth, D.E. Hammermeister, P.A. Kosian, J.T. Haselman, S.J. Degitz, J.E. Tietge, Mid-Continent Ecology Division, US EPA, Duluth, MN. Quantifying thyroid hormone (TH) and the synthetic precursors and metabolic products of TH is important for developing models of the hypothalamic-pituitary-thyroid (HPT) axis as well as for understanding the effects of xenobiotics on HPT axis function. In this study, the development of a high performance liquid chromatography-inductively coupled plasma/mass spectrometry (HPLC-ICP/MS) method is described that allows for the detection of 3-monoiodotyrosine (MIT), 3,5-diiodotyrosine (DIT), 3,5-diiodothyronine (T2), 3,5,3'-triiodothyronine (T3), 3,3',5'-triiodothyronine (reverse T3), 3,3',5,5'-tetraiodothyronine (T4 or TH), and the glucuronide conjugate of T4 (T4-G) in a single sample. This method has three main steps: sample preparation, chromatographic separation of analytes by HPLC, and detection of iodinated compounds by ICP/MS. Sample preparation varies according to the sample type. For serum and media samples, direct injection into the HPLC is generally used, while thyroid gland tissues require proteolytic treatment to liberate compounds covalently bound to thyroglobulin, such as MIT and DIT. The eluent from the HPLC is introduced directly to an ICP/MS operating in a time-resolve mode monitoring mass 127. The selectivity of the ICP/MS detector overlooks non-iodinated chemicals in an otherwise complex sample, allowing for quantification of the iodinated species only. This method was validated using analytical standards and detection limits are typically in the low ng/mL range. This method is quantitatively comparable to conventional radioimmunoassay (RIA) methods when analyzing total T4. The method has been used successfully to assess various samples from *Xenopus laevis*, including: serum, thyroid gland tissue, thyroid gland culture media, and media from hepatic microsomal assays for UDPGT activity. This abstract does not necessarily reflect EPA policy.

WP42 Developing environmental tests for primary industry: Fathead minnow (*Pimephales promelas*) reproductive success under exposure to pulp and paper mill effluent. J.D. Ouellet, J. Werner, Y. Ju, D. Law, Biology, Lakehead University, Thunder Bay, Ontario, Canada. Pulp and paper mills release treated effluent consisting of organic and inorganic compounds into waterways. Phytosterols are organic compounds present in trees that are released during the pulping process and suspected of disrupting the endocrine

system in fish downstream from the mills. There is thus a need to understand and quantify the effects of these chemicals on the life cycles of target aquatic species. We are currently using fathead minnows (*Pimephales promelas*) to determine the effects of different types of effluent on fish reproduction and whether the treatment processes are successful at reducing their biological impact. Short-term chronic bioassay tests using sexually naïve breeding groups of fathead minnows exposed to pulp and paper mill effluent have been developed. Breeding groups of 2 females and 1 male were monitored for 6 days to assess baseline reproductive ability before a 6 day exposure to 10% and 5% (volume/volume) diluted untreated acid-alkaline kraft mill effluent and 100% treated effluent. Egg production, fertilization rate and hatch success were monitored to assess reproductive changes in the breeding groups. Gonad and liver somatic indices and physical changes were compared between the control and treatment groups. Early results show a decrease in egg production as a result of exposure to 10% and 5% diluted untreated acid-alkaline kraft mill effluent, with no change in liver or gonad somatic indices.

WP43 Effects of environmentally relevant concentrations of atrazine on growth and gonad development in fathead minnows (*Pimephales promelas*). Y.P. Palace, B. Park, L.E. Peters, C.L. Baron, Fisheries and Oceans, Freshwater Institute, Winnipeg, Manitoba, Canada. The herbicide atrazine, routinely used to control weeds in corn and other crops, can enter adjacent waterways in significant concentrations via runoff. Previous studies indicate that atrazine exposure can disrupt sexual development in various vertebrates. Monitoring efforts by Environment Canada have routinely detected atrazine in Twenty Mile Creek (Ontario, Canada), a tributary of Lake Ontario that flows through an area of intensive corn production. To determine potential effects on resident fish species in Twenty Mile Creek, five day old fathead minnows (*Pimephales promelas*) were exposed for 21 days to one of four concentrations of atrazine (0, 20, 200 or 1000 ng/L). Exposure concentrations were comparable to those measured in a low-flow year in Twenty Mile Creek. Following the exposure, fish were transferred to uncontaminated water, to be reared to maturity. Growth and gonad histology (sex ratios, intersex, germ cell stages) will be assessed at 4, 7, and 9 months. Breeding trials will be conducted when fish reach maturity to assess potential impacts on reproductive success.

WP44 The effects of Estrone (E1), Estradiol (E2) and Ethenylestradiol (EE2) on the reproductive competence of the fathead minnow. K.K. Grove, S.S. Bartell, C. Blanksma, A. Saleh, H.L. Schoenfuss, Biological Sciences, St. Cloud State University, St. Cloud, MN. Natural and synthetic estrogens found within treated wastewater effluent may impair the reproductive success of the male fathead minnow. In this study we exposed male fathead minnows to three environmentally relevant concentrations of natural (E1, E2) and synthetic estrogens (EE2) for 21 days. In order to assess the overall endocrine disruption abilities these estrogens may have on the males, four day competitive spawning assays were conducted. Secondary sexual characteristics were graded pre- and post- competitive spawning to determine how male fish were able to respond to the competitive challenge through up-regulation of androgen driven secondary sexual characters. Plasma samples were obtained for the detection of the female precursor egg yolk protein vitellogenin. Livers and testes were dissected, gonadosomatic and hepatosomatic indices were measured, and histopathology was used to detect changes in morphology of testes and livers. Fathead minnows exposed at the higher concentrations of all three compounds exhibited elevated vitellogenin concentrations, reduced reproductive behavior and, in some instances, intersex. It is noteworthy that behavioral endpoints followed across concentrations followed inverse U-shaped response curves for all three compounds indicating a complex effect of xenoestrogens on exposed fishes. Furthermore, the observed effects suggest that environmental concentrations of several estrogens may disrupt reproduction in male fishes.

WP45 Gene Expression in Male Fathead Minnow Liver after Acute Exposure to Trichloroethylene or Carbon Tetrachloride. B.J. Carter, A.M. Green, R&D, EcoArray, Inc., Alachua, FL; C.A. Richter, D.E. Tillitt, Columbia Env. Res. Center, US Geological Survey, Columbia, MO. Examination of gene expression by microarray analysis has been utilized more and more frequently in the field of ecotoxicology to identify mechanisms of action of toxic chemicals. In this study, microarrays were used to examine gene expression profiles in the liver of fathead minnow (*Pimephales promelas*), a species commonly used in ecological risk assessments in North America, after acute exposure to two compounds with similar mechanisms of action: trichloroethylene and carbon tetrachloride. Both of these compounds affect metabolism through the cytochrome P450 monooxygenase pathway (specifically CYP2E1). Adult male fathead minnows were exposed for 96 hr to

a high dose of each chemical (1.0 µl/g BW for both compounds) under static renewal conditions. We used a 15,208 gene, fully-annotated oligonucleotide microarray for the analysis. We compared the hepatic gene expression profiles of either unexposed, trichloroethylene or carbon tetrachloride-exposed fish. The similarities reflect the similar modes of action of these two compounds. These data suggest that microarrays can be used to determine the pathways of additional compounds.

WP46 Effects of Estrogens on Survival and Presence of Embryonic Developmental Abnormalities in *Daphnia Magna*. T.G. Loes, H.L. Schoenfuss, Biological Sciences, St. Cloud State University, St. Cloud, MN. Natural and synthetic estrogens are known to be present in the waters of many lakes and river ecosystems. Many of these environments contain invertebrates, such as *Daphnia magna*, which contribute to the trophic cascade of the aquatic ecosystem as primary consumers. Neonate daphniids (brood parents <24 hrs) were individually exposed to three environmentally relevant concentrations of ethinylestradiol; 0.1 ng/L, 2.5 ng/L and 10 ng/L, for 10 days (n=10 per treatment). A picture of each neonate was taken and survival was determined based on heartbeat. Developmental abnormalities were assessed using a digital camera and dissecting scope. Published 50% mortality rates (LC50) for 17β-estradiol (E2) and ethinylestradiol (EE2) were 2.97 mg/L and 5.7 mg/L respectively. We confirmed LC50 for both compounds using the *daphnia* cultures in the St. Cloud State University Aquatic Toxicology Laboratory to ensure similar sensitivity of our *daphnia* cultures. A ten day exposure to EE2 singularly at three environmentally relevant concentrations did not result in increased mortality or incident rates of embryonic development abnormalities. In a second round of exposures, mixtures of xenoestrogens were prepared and used to expose *daphnia* as described above. Detailed results of these experiments will be presented at the conference.

WP47 Development and Validation of an Insect Bioassay Procedure with the Colorado Potato Beetle (*Leptinotarsa decemlineata*) for detection of Cry3Bb1 biological activity. S.L. Levine, J.P. Uffman, G.M. Mueller, Regulatory Sciences, Monsanto Company, Saint Louis, MO. Monsanto has commercialized corn varieties that are protected against root feeding damage by corn rootworm species by producing the *Bacillus thuringiensis* (Bt) Cry3Bb1 protein. Activity of the Cry3Bb1 protein is restricted to the order Coleoptera and activity is evident within the family Chrysomelidae. To support environmental assessments for these products, a bioassay procedure utilizing diet-incorporation methodology has been developed and validated for detection and quantitation of Cry3Bb1 biological activity. The Colorado potato beetle (CPB; *Leptinotarsa decemlineata*) was chosen as the model organism to assess Cry3Bb1 biological activity because of its commercial availability, ease of rearing and relatively high sensitivity to the Cry3Bb1 protein. A comparison of 7-day EC50 values based on growth inhibition and LC50 values demonstrated similar sensitivity with both endpoints. However, there was lower inter-assay variability when the LC50 value was utilized as the endpoint. LC50 values from more than 75 independent assays, conducted over the past 4 years with purified Cry3Bb1 incorporated into an artificial diet, have ranged from approximately 0.30 to 1.0 µg Cry3Bb1/ml diet with a geometric mean of 0.50 µg Cry3Bb1/ml diet. Based on the results of these assays, acceptance criteria for control mortality and biological activity were developed and subsequently validated. For a 7-day concentration-response to be considered valid, control mortality can not exceed 20% and the LC50 value must fall within a calculated tolerance interval that is slightly wider than the range of historical LC50 values. A synopsis of the bioassay methodology and the approach used to validate this assay will be presented.

WP48 The Use of Proteomics and Metabolomics for Biomarker Determination of Two Freshwater Amphipods, *Hyalella azteca* and *Diporeia* spp. K.J. Ralston-Hooper, B. Sanchez, M. Sepúlveda, Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN; H. Ochoa-Acuña, M. Sepúlveda, Department of Civil Engineering, Purdue University, West Lafayette, IN; H. Ochoa-Acuña, Department of Veterinary Pathobiology, Purdue University, West Lafayette, IN; A. Hopf, K. Kowalski, J. Adamec, C. Oh, X. Zhang, Bindley BioScience Center, Purdue University, West Lafayette, IN; T. Nalepa, Great Lakes Environmental Research Laboratory, Ann Arbor, MI. 'Omic' technologies have only recently been used in the field of ecotoxicology. However, proteomic analysis of vertebrates has been a primary focus with little attention given to invertebrate species. Unlike proteomics, metabolomic analysis has not been widely used but could prove quite advantageous over other 'omic' techniques since metabolites are the end-products of gene expression and protein activity providing a closer link to

functional physiological processes. Therefore, we have used metabolomic and proteomic analysis for biomarker identification in two freshwater amphipods, *Diporeia* spp. and *Hyalella azteca*. Metabolomic and proteomic comparisons were made between atrazine and desethylatrazine exposed and non-exposed *Diporeia* spp. and *Hyalella azteca*. We also compared *Diporeia* organisms residing in stable and declining populations within Lake Michigan so as to gain insight into why these organisms continue to decline. Differentially expressed proteins were identified using 2-dimensional electrophoresis followed by MALDI-TOF analysis for protein identification. Metabolomic differences were identified via GCxGC/MS-TOF. Metabolomic analysis of atrazine exposed and non exposed *Diporeia* yielded 316 metabolites. Of these 316 metabolites, 74 were unique to atrazine exposed organisms, 67 unique to non-exposed organisms, and 175 shared between the two groups. Most prevalent metabolites consisted of fatty acids and amino acids. We are currently in the process of identifying and quantifying these unique metabolites and differentially expressed proteins so as to better understand their potential use as biomarkers of exposure and effects in invertebrate species.

WP49 Sediment toxicity of hydrophobic pesticides to *Chironomus tentans*. Y. Ding, A.K. Rotherth, D. Wang, M.J. Lydy, Zoology, Southern Illinois University Carbondale, Carbondale, IL. Two hundred sediment samples were collected and toxicity evaluated in a previous study in the agriculturally dominated Central Valley, California, USA, and pyrethroid insecticides were the main contributor to the observed toxicity of these sediments. However, approximately 33% of the toxic samples could not be explained solely by the presence of pyrethroids in the matrix. Hundreds of pesticides are currently in use in the Central Valley, CA, but only a few dozen are analyzed for in standard environmental monitoring. A significant amount of unexplained sediment toxicity may be due to pesticides that are in widespread use, but have not been routinely monitored in the environment, and even if some of them were, the concentrations harmful to aquatic organisms are unknown. Preliminary data has indicated that hydrophobic pesticides, such as abamectin, diazinon, indoxacarb, and phorate cause acute toxicity to the midge larvae, *Chironomus tentans*. In this study, toxicity thresholds of 11 hydrophobic pesticides were established using standard 10-d sediment toxicity tests with third instar *C. tentans* larvae, and the endpoints included lethality and growth inhibition. These results are an important first step in evaluating the unexplained toxicity in CA sediments.

WP50 An Analysis of Ecotoxicity Test Results for Pesticides Available in the ECOTOX Database. C. Russom, USEPA/ORD/NHEERL/MED, Duluth, MN; E. Odenkirchen, USEPA/OPPTS/OPP/EFED, Washington, DC. In 1988, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) was amended, authorizing EPA to conduct a review of pesticides registered prior to November 1, 1984 to ensure that the risk assessment met current scientific and regulatory standards. Although data were collected from registrants during the registration process, the open literature provides critical information for this review. The U.S. EPA has developed and currently maintains the ECOTOX knowledgebase (www.epa.gov/ecotox), which is the largest compilation of ecotoxicity data, providing information on the adverse effects of single chemical stressors to ecologically relevant aquatic and terrestrial species. As part of the re-registration review effort, studies identified as potentially relevant for the ECOTOX database through comprehensive literature searches, were collected for each active ingredient, including possible degradates, and data were evaluated and summarized for use in assessing the ecological risk of the pesticide to non-target species, including threatened and endangered species. Data gathered from the open literature and used in the risk assessment were released to the ECOTOX public website as the re-registration reviews were completed. These efforts to collate and abstract data associated with re-registration of pesticide active ingredients have provided an opportunity to assess data coverage and research data gaps as they relate to various categories such as taxonomic classification, including threatened and endangered species, effect / endpoint, study duration, and organism life stage. Results of the data analysis exercise, trends in the available data, and areas for further research will be presented. This abstract does not necessarily reflect EPA policy.

WP51 The bioaccumulation of metal contaminants in the Kuils River, Western Cape, South Africa. A.M. Melato, J. Odendaal, R. Snyman, CPUT, Cape Town, South Africa. In recent years there has been a growth in the establishment and development of human settlements, both formal and informal in the Cape Town area. The area around the Kuils River is not excluded from this. There are various communities in close proximity to the

Kuils River. Together with this, one finds growth in terms of industry and the production sector. This has caused an increased production of potential environmental pollutants, including metals. A variety of everyday sources of metal pollution exist that is entrenched in the modern way of life. The study investigated the accumulation of metals in the Kuils River. Pouch snails (*Physidae*), sediments and water were collected every 2 months for a period of one year. The Inductively Coupled Plasma – Atomic Emission Spectrometer (ICP-AES) were used for analysis of metals. Results revealed that for most metals (Al, Co, Cr, Cu, Fe, Pb, Mn, Ni and Zn), concentrations were significantly higher at site 1 (situated where the river originate, just before the golf course), possibly due to input from the surrounding urban area and a nearby farm. The sediments mean concentrations of Pb (site 2) and Zn (site 1) at some occasions were found to be above the limit, when compared with Canadian Sediment Quality Guidelines for the Protection of Aquatic Life. The agricultural activities and runoff can have an effect for Zn concentration, while Motorway and runoff could be the potential source for Pb in the river.

WP52 Study on the Critical Body burden and the bioaccumulation patterns of pesticide on earthworm, *Eisenia fetida*. K. Park, Hazardous Substances Division, Agricultural Science and Technology, Suwon, South Korea; B. Kim, Hazardous Substances Division, Agricultural Science and Technology, Suwon, South Korea; Y. Park, Hazardous Substances Division, Agricultural Science and Technology, Suwon, South Korea; B. Park, Hazardous Substances Division, Agricultural Science and Technology, Suwon, South Korea; J. Shin, Pesticide safety Division, Agricultural Science and Technology, Suwon, South Korea; M. Jeong, Pesticide safety Division, Agricultural Science and Technology, Suwon, South Korea; A. You, J. Kim, Hazardous Substances Division, Agricultural Science and Technology, Suwon, South Korea. This study was carried out for quantitative analysis of pesticides causing adverse effects and identification of the relationship between body residue and adverse effect. Median lethal concentration of butachlor, isoprothiolane, parathion, and diazinon in earthworms, *Eisenia fetida*, were each 1391, 414, 328, 420 mg/kg and LR50s (median lethal body concentration) of these pesticides were each 0.04, 0.04, 0.02, 0.02 µmol/g respectively. Body residue of parathion in earthworm exposed to treated soil with C14 parathion was 7.3 times as high as the exposed concentration which was the highest treated concentration, 640 mg/kg.

WP53 Environmental property of advanced mono alkyl cationic surfactant APA22. M. Yamane, T. Toyo, N. Nishiyama, -Global R&D-Safety Science, Kao Corporation, Tochigi, Japan; K. Inoue, Global R&D-Material Science, Kao Corporation, Wakayama, Japan. Cationic surfactant is used in a wide variety of hair conditioner, fabric softener and household products. Recently, we have developed mono alkyl cationic surfactant called APA22, N-[3-(dimethylamino)propyl]docosanamide salt, by investigating the relationship between the chemical structure and toxicity of aquatic organisms (e.g. algae, invertebrate and fish). APA22 is formed by the C22 alkyl chain, amide bond and di-methyl tertiary amine group. This substance is readily degraded by microorganisms under both of aerobic and anaerobic conditions. Aquatic toxic value (EC50 and LC50) is also over 1 mg/L for algae, invertebrate and fish. Besides, PEC (Predicted Environmental Concentration)/PNEC (Predicted No Effect Concentration) ratio of APA22 is below 1. This indicates that APA22 is more compatible to the aquatic environment than existed mono alkyl cationic surfactant. In addition to the above results, we evaluated the toxicity of sediment dwelling organism and the partitioning coefficient between sediment/water. In this study we will report the hazardous data and environmental risk assessment of APA22.

WP54 Evaluation of ecotoxicity of solid wastes by collembola and earthworm. M. Abe, M. Yamada, Y. Inoue, National Institute for Environmental Studies, Tsukuba, Japan. To evaluate ecotoxicity of solid wastes by more rapid and low-cost method than a combination of elution test and aquatic ecotoxicity test, we have conducted an ecotoxicity test using terrestrial invertebrates. In this study, we report on a survival test using a collembola, *Folsomia candida* and *Sinella curviseta* and an avoidance test using an earthworm, *Eisenia fetida*. Solid wastes (Bottom ash, Fly ash and Shredded solid waste) from construction waste were mixed with artificial soil (OECD) or cellulose powder at a rate of 0 - 100 % waste and used for tests. Collembola survival test and earthworm avoidance test were conducted using a glass beaker. Both collembola species were not affected by exposure of 100% bottom ash and shredded solid waste but all died within 24h when exposed to 50 % and 100 % fly ash. When exposed to 25 % fly ash, *S. curviseta* died all within 72h but *F. candida* died all within 24h. Earthworm did not avoid shredded

solid waste but avoided 20% bottom ash and fly ash. Earthworm also avoided neutralized bottom ash and fly ash. This suggests that a factor except pH may play an important role in the earthworm avoidance. Factor concerning with the toxicity / avoidance in waste will be discussed.

WP55 Measured Chemical Concentrations are Key to Interpreting In vitro Endocrine Disruptor Assay Results. B.R. Sheedy, M.A. Tapper, J.S. Denny, R.C. Kolanczyk, P.K. Schmieder, Mid-Continent Ecology Division, NHEERL, ORD, U.S. EPA, Duluth, MN; L.R. Toonen, B.J. Johnson, Student Contract, U.S. EPA- MED, Duluth, MN. Two in vitro assays, rainbow trout estrogen receptor competitive binding, and trout liver slice vitellogenin mRNA expression are used to assess the estrogenic potential of environmental xenobiotics. The assays are optimized to detect low affinity binding and Vtg induction. Assay results on hundreds of chemicals across numerous chemical classes are used to develop a decision support system to predict estrogenic potential for untested chemicals. Verification of chemical structure and concentration in assays systems is essential for accurate predictions. Detecting low potency, but significant, receptor-ligand interactions requires testing chemicals to their solubility in assay media to minimize the rate of false-negatives in this screening approach. Chemical measures in binding assays include: stock concentrations, trout liver cytosol binding media at start and end of 20h, 4C incubations. Chemicals in slice assays are also measured in tissue incubation media with and without slice, over time. Characteristic patterns of chemical behavior in binding assays of >200 chemicals have allowed chemicals to be classified in 3 groups: well-behaved (nominal = measured (0h, 20h); stable loss to lab-ware/non-specific binding (msrd < nominal but consistent over time); unstable (msrd = nominal at 0h but decreased or undetectable at 20h). Chemical behavior patterns correlate with noted patterns in binding displacement curves. Examples provided illustrate how trends in chemical uptake, metabolism/conjugation, and elimination in tissue slices over time correlate with chemical properties (LogP; solubility; toxicity) and allow assessment of chemical potential for Vtg induction in relation to cytotoxicity and exposure concentration. Thus, chemical measurements are key to establishing assay protocols, and avoiding misinterpretation of in vitro assay results.

WP56 The effects of fluridone and copper sulfate on natural phytoplankton community- ecotoxicology in aquaculture ponds. A.P. Jacob, D.A. Culver, Evolution, Ecology and Organismal Biology, Ohio State University, Columbus, OH; R.P. Lanno, A. Voigt, Entomology, Ohio State, Columbus, OH; A. Voigt, International Zinc Association, Durham, NC; R. Anderson, Soil Science, Ohio State University, Columbus, OH. Fluridone and copper are commonly applied as herbicide and algicide to freshwater systems to curtail the growth of nuisance vascular plants and algae. Using replicate aquaculture ponds as model ecosystems, we attempted to test whether environmentally realistic concentrations of copper and fluridone can shape natural plankton community in freshwater systems. Copper was added as copper sulfate at 1ppm to eight ponds once every two weeks for three months and four ponds served as controls. Fluridone was applied once at the beginning of the experiment at the rate of 150ml/m3. Pond waters were sampled weekly and monitored for fluridone, free copper ion activity, total dissolved copper, total copper and phyto/zooplankton biomass and species composition. The estimated half-life of fluridone ranged from 10.8 to 1.6 days. Free copper ion activity expressed as pCu ranged from 7.7 to 8.9 whereas in controls, it ranged from 12.3 to 13.4. Elevated free copper ion activity elicited differential response within the phytoplankton community. Copper treatments reduced Cyanophyta biomass whereas biomass of Chlorophyta and Chrysophyta was increased. Fluridone treatments also reduced Cyanophyta biomass and influenced the response of Chlorophyta and Chrysophyta to copper. Though the total zooplankton biomass remained unaffected by copper additions, differences in sensitivity of zooplankton groups were observed. Copper treatments significantly reduced Cladocera biomass whereas Copepoda biomass was significantly higher in copper treated ponds than in controls. The species composition of plankton shifted towards species tolerant to high concentrations of copper. As plankton form the base of aquatic food webs, changes in plankton community composition can affect aquatic systems and the effects of contaminants on the same should be monitored.

WP57 Effects of Short-Term Model EDC Exposures on the Brain-Pituitary-Gonadal Axis of the Fathead Minnow. E. Orlando, J. Thompson, Biological Sciences, Florida Atlantic University, Fort Pierce, FL; N. Garcia-Reyer, K. Kroll, N. Denslow, University of Florida, Gainesville, FL; M. Sepulveda, Purdue University, West Lafayette, IN; D. Villeneuve, G. Ankley,

USEPA, Duluth, MN; K. Watanabe, Oregon Health and Science University, Beaverton, OR. The goals of this research are to further our understanding of how the adult fathead minnow (FHM) brain-pituitary-gonadal (BPG) axis responds in short-term exposures to specific endocrine disrupting chemicals. Male FHMs were exposed for 48 hrs to a range of concentrations of 17A-ethynylestradiol (EE2), zearalenone (weak estrogen), and the antiestrogen, ZM189-154, singly and in a mixture. We also exposed female FHMs to the androgen, 17B-trenbolone, and the antiandrogen, flutamide, singly and in a mixture. We collected brain, pituitary, and gonad from adults and measured expression of regulatory and steroidogenic pathway genes including FSH-B, LH-B, P450scc, CYP 17, and brain and ovarian aromatase using real time PCR. Gene expression data for adults were grounded in sex steroid (E2 and T in females; T and 11KT in males) concentrations measured from in vivo and ex vivo samples via radioimmunoassay or enzyme immunoassay. Aromatase enzyme activity was also quantified in the ovary and brains of both sexes. Within 48 hrs, we have observed a treatment-specific effect on steroid hormone concentrations and aromatase enzyme activity. Gene expression assays are currently in progress. Our data suggest that short-term exposures may be a useful approach to examine the early estrogen- and androgen-receptor mediated effects on the regulation of reproduction in fishes. This research was supported by EPA STAR Grant Number: RD-83184801-0

WP58 Sex Reversal of the Amphibian, *Xenopus tropicalis*, Following Larval Exposure to an Aromatase Inhibitor. A. Olmstead, G.W. Holcombe, P.A. Kosian, J.J. Korte, B.A. Bennett, K.K. Woodis, S. Ostazeski, S.J. Degitz, US EPA, Duluth, MN. Aromatase is a steroidogenic enzyme that catalyzes the conversion of testosterone to estradiol in vertebrates. Modulation of this enzyme's activity by xenobiotic exposure has been shown to adversely affect the hypothalamus-pituitary-gonadal axis in fish species. Aromatase has also been shown to be a critical enzyme affecting the outcome of sexual differentiation in reptile species exhibiting temperature sensitive differentiation. We hypothesized that exposure to the aromatase inhibitor, fadrozole, during the larval development of the tropical clawed frog, *Xenopus tropicalis*, would result in masculinization of the developing female gonad. Tadpoles were exposed to fadrozole at nominal concentrations from 1 to 100 µg/l in a flow-through chamber from <24 hours post-fertilization to metamorphosis (NF stage 66). At metamorphosis, morphologically-examined gonads indicated complete masculinization of all tadpoles at concentrations of 16 µg/l and above and a significant bias in sex ratio towards males at concentrations of 1 µg/l and above. No effects on metamorph times, body mass, or body length were observed. Gonads were randomly sampled for histological analysis and quantitative PCR measurement of expression of aromatase and the gene MGC81029. A subsample of frogs was randomly chosen to be raised to reproductive maturity in xenobiotic-free water. Frogs in all but the highest exposure concentration group were assessed for reproductive potential at sexual maturation using the following endpoints: estrogen, testosterone, and vitellogenin titers, sperm counts from testes, and oocyte counts in ovaries. Sex-reversed females from the 100 µg/l treatment were induced to mate with normal females to assess fertility. Results from this study demonstrate the effects on amphibian reproduction resulting from exposure to an aromatase inhibitor. Additionally they indicate that complete masculinization of female amphibians is possible due to exposure to xenobiotics capable of interfering with steroidogenesis during larval development.

WP59 Development of an Amphibian Reproductive Assay: Baseline Data on the Tropical Clawed Frog, *Xenopus tropicalis*. K.K. Woodis, A. Olmstead, B.A. Bennett, J.J. Korte, S. Ostazeski, S.J. Degitz, US EPA, Duluth, MN. Implementation of the Endocrine Disruptors Screening Program (EDSP) requires development and validation of a full life-cycle amphibian development and reproduction assay to be used as a tier two test. In order to provide a foundation for the development of an amphibian reproductive assay suitable for use in the EDSP, we collected baseline data on the reproductive biology of the tropical clawed frog, *Xenopus tropicalis*. One cohort of frogs was maintained for 30 weeks post-metamorphosis with endpoints representative of important reproductive parameters collected at one or two week intervals. This data was then used to propose an assay design for the amphibian full life-cycle test for EDSP implementation. Male frogs exhibit nuptial pads, an androgen-dependent secondary sexual characteristic, starting at 8 weeks post-metamorphosis (PM) and have measureable concentrations of circulating testosterone (5.3 ng/ml serum). Testosterone concentrations remained above this level at all later time points, but was highly variable among individuals.

Testes sizes in males reached their peak at 22 weeks PM (21 mg) with sperm counts peaking at the same time (25 million sperm/testis). In females, estradiol becomes elevated in the blood at 16 weeks PM (1.5 ng/ml serum) which corresponds with the presences of vitellogenin (4.4 mg/ml serum), vitellogenic oocytes in the ovary, ovarian growth, and oviduct growth. Vitellogenic oocytes increase in number up to 15,000 at 30 weeks PM and account for 75% of the total number of oocytes present in the ovary. The ovary and oviducts continue to grow in mass until 30 weeks PM where they have reached sizes of 3.6 g and 0.8 g respectively. This data will provide the biological basis that will guide the development of a full life-cycle assay using this species. For example, these data indicate that male and female *Xenopus tropicalis* reach reproductive maturation at 22 and 30 weeks PM respectively. Full life-cycle toxicity assays with this species should therefore be about 9 months in duration to account for larval development and attainment of adulthood.

WP60 An Update on Fish and chips and the utility of these and other genomic tools. J. Bruno, R.C. Skirrow, H.L. Osachoff, G.C. vanAggelen, Environment Canada, North Vancouver, British Columbia, Canada. For the last eight years, the Toxicology Section at the Pacific Environmental Science Centre (Environment Canada) has been developing and utilizing toxicogenomic tools to evaluate the molecular-level impact of effluents on sentinel aquatic species. Toxicogenomics is a field of toxicology utilizing molecular techniques to identify gene expression changes resulting from material exposures. Toxicological testing, whether laboratory or field based, has been and continues to be an integral toolset for use in evaluating the potential of a toxicant to cause some measurable effect. Traditional endpoint measurements such as death, growth or reproduction were previously the chief means of gauging the deleteriousness of an effluent; however, while many of the effluents of historical concern are no longer acutely toxic, toxicological effects, such as feminization and intersex fish and amphibian, have been observed in fish exposed in the wild. Integrating genomics into the standardized battery of toxicity test methods generates molecular data that can help determine the extent and ecological relevance of exposure. This added information may provide an early indicator of subsequent population or community level effects. The application of genomic tools, such as microarrays and real time PCR, in toxicology testing will be discussed in the context of data obtained from several exposure studies.

WP61 Sensitivity of freshwater snails to aquatic contaminants: chronic toxicity tests with endangered species and surrogates. J.M. Besser, D.L. Hardesty, E. Greer, C.G. Ingersoll, U.S. Geological Survey, Columbia, MO; C.A. Mebane, U.S. Geological Survey, Boise, ID; D.R. Mount, U.S. Environmental Protection Agency, Duluth, MN. Degradation of water quality may be an important factor affecting declining populations of freshwater snails, many of which are listed as endangered or threatened under the U.S. Endangered Species Act. Toxicity databases used to develop water quality criteria include relatively few toxicity data for mollusks, and available toxicity data for snails are predominantly from tests with a few taxa of pulmonate 'pond snails', rather than the more diverse snail taxa inhabiting threatened cave, spring, and river habitats. We conducted chronic toxicity tests with one species of pondsnail (*Lymnaea stagnalis*) and four species of freshwater snails in the family Hydrobiidae: two endangered species from the Snake River valley of Idaho, Idaho springsnail (*Pyrgulopsis idahoensis*) and Bliss Rapids snail (*Taylorconcha serpenticola*), and two non-listed taxa, a pebblesnail (*Fluminicola* sp.) from the Snake River and Ozark springsnail (*Fontigens aldrichi*) from southern Missouri. Toxicity tests with copper, ammonia, and pentachlorophenol were conducted for 28 d in ASTM hard reconstituted water (pH 8.2; hardness 160-180 mg/L as CaCO₃). Effects on survival of adults of the four hydrobiid taxa (from laboratory cultures or field collections) differed between tests with copper and ammonia: pebblesnails were the most sensitive taxon in tests with copper, and Ozark springsnails the most sensitive taxon in tests with ammonia. In copper and pentachlorophenol tests with young Idaho springsnails (about 5-7 weeks post-hatch) and newly-hatched (<7 days post-hatch) pondsnails, Idaho springsnails were more sensitive, with growth of springsnails the most sensitive endpoint in both tests. Two of the five snail species tested exhibited toxic effects in exposures close to or below current chronic water quality criteria. Ammonia reduced survival of adult Ozark springsnails at 1.0 mg/L total ammonia, below the current chronic criterion of 1.3 mg/L (for pH 8.2 and 20 degrees C). Copper reduced survival and growth of early-life-stage Idaho springsnail at 7.5 ug/L, below than the previous hardness-based criterion (14 ug/L at a hardness of 170 mg/L), but greater than the new copper chronic criterion based on Biotic Ligand Model

(3.9 ug/L for ASTM hard water). These results suggest that some water quality criteria may not adequately protect freshwater mollusk taxa.

WP63 Effects of pulsed suspended clay exposures on *Daphnia magna*. S. Robinson, S.J. Klaine, Biological Sciences, Clemson University, Pendleton, SC. Rain events cause sediments to be washed into aquatic systems resulting in significant increases in total suspended solids. These events tend to be episodic in nature due to stormwater runoff. It has been shown that constant exposure to suspended clays effects the growth and reproduction of *Daphnia magna*, however little is known about the effects of pulsed exposures. The mechanism of clay toxicity is a clogging of the intestinal tract preventing the assimilation of food. Data demonstrate that daphnia purge clay from the gut when they are placed in clean water. This research focused on the effects of pulsed suspended clay exposures on *D. magna*. Organisms were exposed to suspended clay of varying concentrations for 24 hours and then placed in clean media for the remainder of the 21 days. During the experiment, organism length, days until becoming gravid, and total number of neonates were noted each day. Data shows a difference from the control in growth and the number of days to gravidity for the higher pulse concentrations used. These results suggest that pulsed clay exposures may be less toxic than continuous exposures due to the organisms' ability to depurate ingested clay particles.

WP64 Longitudinal Changes in Potential Toxicity of Coal Bed Natural Gas Produced Water Along Beaver Creek in the Powder River Basin, Wyoming. L.A. Johnson, C.J. Boese, J.S. Meyer, Zoology and Physiology, University of Wyoming, Laramie, WY; B.A. Morris, CBM Associates, Inc., Gillette, WY. In the Powder River Basin (PRB) in northeast Wyoming, coal bed natural gas (CBNG) is extracted from coal seams at depths of up to 500 m. Produced waters are concurrently pumped from a coal seam and piped to a central discharge point, and sometimes are discharged into ephemeral drainages like Beaver Creek, a tributary to the Powder River. Total ammonia, CO₂, Na⁺ and HCO₃⁻ concentrations are high in waters from some of the deeper coal seams. We evaluated the fate and effects of ammonia in CBNG produced water discharged into Beaver Creek from August 2006 through January 2007. The study included (1) in-stream monitoring of fish and amphibians, (2) in-stream toxicity tests at 6 sites using caged fathead minnow larvae (FHM; *Pimephales promelas*), (3) concurrent ambient-pH and CO₂-controlled toxicity tests in the laboratory with the same batch of FHM exposed to effluent and stream water, and (4) analyses of water quality parameters in the effluent and the stream. Although 96-h survival in-stream and in the laboratory did not decrease significantly compared to controls (p > 0.05), 144-h survival decreased in some ambient-pH exposures in the laboratory as pH increased due to CO₂ degassing. In Beaver Creek, pH increased along a downstream gradient from initially circumneutral values at the discharge point, but it did not increase as much as in the laboratory; ammonia concentrations decreased downstream, probably due to assimilation by aquatic organisms; SO₄²⁻ concentrations increased downstream, probably due to in-stream dissolution of CaSO₄; and Ca²⁺ concentrations decreased downstream, probably due to precipitation of CaCO₃. Although a major-ion-toxicity model predicted acute toxicity because of the high Na⁺ and HCO₃⁻ concentrations, none was observed. Additionally, although the continuous criteria concentration (CCC) for ammonia with early life stages present was exceeded at Site 4 during all three field bouts, some fish and other aquatic life appeared to breed at that site. We conclude that discharge permits and testing requirements for CBNG produced water should be evaluated to consider the pH drift in laboratory toxicity tests and how ammonia criteria should be applied in ephemeral drainages. Key words: ammonia, CO₂, fathead minnow, NaHCO₃, toxicity.

WP65 Toxicity of a Representative HMG-CoA Reductase Inhibitor, Pravastatin, to Aquatic Organisms. D. Huggett, W.T. Waller, B.J. Venables, G.C. Nallani, University of North Texas, Denton, TX. A variety of pharmaceutical classes are being detected in the aquatic systems, though few toxicological data are available to reliably determine the risk of these drugs classes in the aquatic environment. HMG-CoA reductase (HMG-CoAR) inhibitors are a class of drugs designed to inhibit the rate limiting step of cholesterol synthesis in humans. HMG-CoAR appears to be very well conserved across species, performing a similar function in fish and other aquatic vertebrates. In arthropods, this enzyme is involved in the biosynthesis of juvenile hormone. In order to better understand the potential impacts of these compounds in aquatic environments, aquatic organisms were exposed to the hydrophilic HMG-CoAR inhibitor pravastatin. Aqueous 48hr LC50 values for fathead minnow and Japanese medaka were > 1mg/L. Ceriodaphnia

dubia 48hr EC50 was 0.308 mg/L. A 14d six brood chronic study with *C. dubia* revealed a reproductive no observable effect concentration (NOEC) of 0.125 mg/L. Additional long term chronic data will be provided for the fathead minnow and *C. dubia*.

WP66 Assessing the sensitivity of freshwater mussels to coal effluents and coal slurries. N. Wang, J. Kunz, C. Ingersoll, USGS, Columbia, MO; C. Kane, USFWS, Gloucester, VA; S. Alexander, USFWS, Cookeville, TN; R. Neves, D. Hua, USGS, Blacksburg, VA; B. Evans, USFWS, Abingdon, VA; C. Walker, OSM, Pittsburgh, PA; J. Jones, USFWS, Blacksburg, VA. Coal mining-related discharges and runoff containing metals, hydrocarbons, surfactants and other pollutants enter streams in the upper Tennessee and Cumberland River basins, where 30 freshwater mussel species are federally listed endangered. The objective of this study is to assess acute and chronic toxicity of coal effluents and slurries to mussels and standard bioassay organisms. Grab samples of surface water, collected in Mud Lick Creek about 0.5 and 1.0 km downstream of a coal company discharge at Roda, VA, were used to conduct acute tests with 3-month-old rainbow mussels (*Villosa iris*; 96-h exposure), cladocerans (*Ceriodaphnia dubia*; 48-h exposure), and amphipods (*Hyalella azteca*; 48-h exposure). Fine coal refuse, pressed from coal slurry by a coal plant at Smoky Junction in Scott County, TN, was used to conduct 28-d chronic tests starting with 3-month-old rainbow mussels exposed to water (100% coal refuse) or sediment (25 and 50% coal refuse mixed with control sediment). Acute EC50s for amphipods exposed to 6.25–100% receiving water contaminated with coal effluent were 72 and 77% receiving water, whereas no mortality was observed with cladocerans or mussels exposed to 100% receiving water. By the end of 28-d slurry tests, 100% of mussels survived in all treatments. Preliminary results indicate that (1) the coal effluent was toxic to amphipods, (2) cladocerans and 3-month-old mussels were not acutely sensitive to the effluent, and (3) the coal slurry did not affect survival of juvenile mussels. The effect of slurry on mussel growth will be determined after measuring shell lengths of surviving mussels. Additional tests are planned with various sources of coal effluents or slurries using more test organisms, including newly transformed juvenile mussels, which are generally more sensitive to metals than older mussels.

WP68 Toxicity of three veterinary pharmaceuticals, tylosin, erythromycin and sulfamethazine, alone and in mixture to *Ceriodaphnia dubia*, *Daphnia magna* and *Chironomus tentans*. N.L. Cooper, J.R. Bidwell, C.R. Seery, Oklahoma State University, Stillwater, OK. Acute and chronic bioassays are being conducted to determine the effects of single, binary and tertiary mixtures of sulfamethazine, tylosin and erythromycin on two species of cladocerans, *Daphnia magna* and *Ceriodaphnia dubia*, and on the chironomid, *Chironomus tentans*. Acute bioassays (48-h) with single chemicals with both cladoceran species in moderately hard laboratory water have produced LC50 values for tylosin, erythromycin and sulfamethazine of 565mg/L, 98 mg/L and 87 mg/L, respectively for *D. magna* and 444mg/L, 100mg/L and 77 mg/L for *C. dubia*, respectively. In addition, acute bioassays have been conducted using binary and tertiary mixtures with the effects concentrations for both species being significantly lower than with each chemical alone. Based on the toxic units approach, these mixture effects (tertiary and binary) have been less than additive for both species. Preliminary studies have also begun to look at the effects of each chemical on 10-d survival and reproduction of *Daphnia magna*, with effects levels falling significantly below that found in the acute bioassays. Continued work will be carried out assessing further impacts of these 3 chemicals in the water column on both survival and reproduction in both cladoceran species, in addition to effects on the chironomid.

WP69 Structural effects in the digestive gland of marine limpets living close to superficial hydrothermal vents. A. Rodrigues, L. Cunha, G. Martins, F. Wallenstein, R. Couto, A. Neto, A. Amaral, CIRN, DB, University of the Azores, Ponta Delgada, Portugal. The present study aimed at determining the extent to which the presence of superficial hydrothermal vents provokes measurable effects on the structure of the digestive gland of limpets as well as to relate the extent of these effects to the concentrations of several metals. For this purpose, the digestive glands of marine limpets (*Patella candei gomesii*) sampled from four sites in the coast of São Miguel Island (Azores, Portugal), two with and two without hydrothermal vents, were submitted to: (i) chemical analyses, in order to quantify several metals; and (ii) histological staining, in order to quantify the relative abundance of digestive cells, basophilic cells, and connective tissue cells. Mean epithelial thickness (MET), mean luminal radius (MLR), and mean diverticular radius (MDR)

were recorded as measures of sublethal effects of metals, and the levels of apoptosis were also quantified. In general, the structure of the digestive gland was found to be most affected in the individuals from the two sites exposed to the superficial hydrothermalism. These results are compared to others and discussed according to the concentrations and ratios of several metals.

WP71 Effects of Polychlorinated Dibenzofurans (PCDFs) on P450 Enzymes, Jaw Histology and Tissue Morphology of Mink (*Mustela vison*). J.N. Moore, M. Hecker, Z.J. Matthew, E.B. Higley, J.P. Giesy, Food Safety and Toxicology Center and Center for Integrative Toxicology, Michigan State University, East Lansing, MI; J.N. Moore, M. Hecker, Z.J. Matthew, E.B. Higley, Zoology, Michigan State University, East Lansing, MI; S.J. Bursian, Animal Science, Michigan State University, East Lansing, MI; S.D. Fitzgerald, Diagnostic Center for Population and Animal Health, Michigan State University, East Lansing, MI; J. Khim, J.P. Giesy, Biomedical Sciences and Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; J.L. Newsted, Entrix, Inc., Okemos, MI. Mink (*Mustela vison*) are often utilized as a sentinel species for ecological risk assessment of dioxins and dioxin-like compounds. This investigation determined the potential dose- and time-dependent effects of environmentally-relevant concentrations of 2,3,4,7,8-pentachlorodibenzofuran (PeCDF) and 2,3,7,8-tetrachlorodibenzofuran (TCDF), and their mixture on adult mink under controlled laboratory conditions. Three doses of each TCDF and PeCDF bracketing estimated environmentally-relevant dietary exposure levels and one mixture dose were administered in feed to mink for 180 d. Concentrations of TCDF and PeCDF in adipose and hepatic tissues were measured at 0, 90, and 180 d. Ethoxyresorufin O-deethylase (EROD) and methoxyresorufin O-deethylase (MROD) activities were also measured in liver after 0, 90, and 180 d as indicators of the biologically available fraction of a delivered dose. Mink were also examined histologically. There was a statistically significant and dose-dependent increase in the both EROD and MROD enzyme activities for all treatments, which confirmed the utility of these enzymes as a functional measure of exposure mink to dibenzofurans. However, none of these exposures resulted in any significant, treatment-related morphological or histological effects. These results indicate that while mink were relatively sensitive regarding the induction of hepatic detoxification enzymes the environmentally relevant concentrations of dibenzofurans tested in this study were not sufficient to induce pathological effects in adults.

WP72 Disruption of steroid biosynthesis in rainbow trout (*Oncorhynchus mykiss*) exposed to municipal waste water effluent. J.S. Ings, K.D. Oakes, M.R. Servos, M.M. Vijayan, Biology, University of Waterloo, Waterloo, Ontario, Canada. Municipal waste water effluent (MWWE) is the largest point source of contaminant discharge in Canada. There is evidence that compounds present in MWWEs can potentially disrupt endocrine homeostasis in fish living downstream of effluent outfalls. The objective of this study was to assess the use of short-term in situ caging studies to evaluate the impact of exposure to MWWEs on aspects of steroid biosynthesis in fish. In the fall of 2006, juvenile rainbow trout (*Oncorhynchus mykiss*) were caged in 100 and 10% effluent dilutions downstream of a MWWE outfall, as well as at an upstream reference site, for 21 days. Following exposure, somatic measurements including length, weight, liver weight and gonad weight were taken. Plasma was collected for measurement of circulating steroid levels. Gonad and head kidney were collected for quantifying the mRNA abundance of a key protein, the steroidogenic acute regulatory protein (StAR), which is the rate-limiting step in both sex and corticosteroid biosynthesis. Results showed no changes in somatic measurements following exposure. There was a significant decrease in circulating 17 β -estradiol levels in females in both downstream sites compared to the reference fish, but no significant change in testosterone levels. There were no significant changes in 17 β -estradiol or testosterone levels in male fish. Cortisol levels were not significantly different between sites in both sexes. In females, a decrease in StAR mRNA levels commensurate with decreases in 17 β -estradiol was seen in the ovary, while no change in StAR mRNA levels was observed in the head kidney. Overall, this study demonstrates changes in endocrine function, specifically steroid disruption, with exposure to MWWEs in rainbow trout.

WP73 The Development of Standardized Toxicity Tests with the Leopard Frog (*Rana pipiens*). P.M. Jackman, K.G. Doe, Environment Canada, Moncton, New Brunswick, Canada; B.D. Pauli, R. Scroggins, Environment Canada, Ottawa, Ontario, Canada; C. Fridgen, Trent University, Peterborough, Ontario, Canada. Certain amphibian populations are declining. Adverse effects resulting from exposure to pesticides have been cited as one

possible reason for these declines. It is difficult to establish guidelines or “safe levels” for the protection of native amphibians from contaminants as their general sensitivity to these compounds is incompletely known. One reason for this is a lack of standardization of the methods used to conduct toxicity tests with amphibians. The Environment Canada laboratory in Moncton, NB is establishing standard methods for rearing and breeding of *Rana pipiens*. Populations of adult leopard frogs have been maintained since 2002 and several successful breeding trials have been conducted. Test method conditions are being established for conducting acute toxicity tests (4 days) with *Rana pipiens* tadpoles. To date seventeen pesticide formulations and 5 other chemicals of concern have been evaluated. Results from these acute toxicity tests were used to compare the sensitivity to in-use pesticides of native amphibians against standard test species (fish, invertebrates, plants, bacteria) and assess whether pesticide regulatory programs based on acute toxicity tests with standard test species are protective of native amphibian species. Preliminary analyses suggest acute toxicity of pesticides to *Rana pipiens* is similar to that of standard test species. In addition, chronic experiments were conducted to investigate the influence of diet, water quality, loading density, and pesticides on tadpole development. Effects on survival, growth, time to metamorphosis, and gonad development/histology were evaluated for these tests.

WP74 A Comparison of the Reproductive Effects of Five Human Pharmaceuticals on Two Species of daphnia (*Daphnia magna* and *Ceriodaphnia dubia*). L.A. Constantine, D.B. Huggett, Environmental Sciences, Pharmacokinetics, Dynamics and Metabolism, Pfizer Global Research and Development, Groton, CT; D.B. Huggett, Department of Biology, Institute of Applied Sciences, University of North Texas, Denton, TX. The goal of this project is compare the survival and reproductive effects of five human pharmaceuticals on both *Daphnia magna* and *Ceriodaphnia dubia*. The *Daphnia magna* studies, were conducted as per OECD Guideline 211 and the *Ceriodaphnia dubia* studies, as per U.S. EPA method 1002.0. Based on the life-cycle of *Daphnia magna* and *Ceriodaphnia dubia*, the duration of the studies are 21-days and 7-days, respectively. A comparison of data obtained when *Daphnia magna* and *Ceriodaphnia dubia* are exposed to 5 different human pharmaceuticals will be presented. NOEC and LOEC values for the standard endpoints of survival and reproduction as per OECD 211 and EPA 1002.0 will be used to determine whether one species may be considered more sensitive than the other or if similar effects are observed in both species. The current EU “Guideline on the Environmental Risk Assessment of Medicinal Products for Human Use”, requires a 21-day reproductive study in *Daphnia magna* as per OECD 211, to support the Phase II Tier A analysis. Based on the duration and resources associated with a 21-day study versus a 7-day study, will these data indicate that it is reasonable to conclude that the survival and reproduction data obtained from the 7-day *Ceriodaphnia dubia* study may be as applicable as *Daphnia magna* data in determining the PEC/PNEC ratios for groundwater and surfacewater (as applicable), when assessing the potential risk of human pharmaceuticals to the environment following patient use.

WP75 Phototoxicity of Benzo[a]pyrene on the Coral *Porites divaricata*. M. Guzman-Martinez, P. Ramirez-Romero, Hidrobiologia, Universidad Autonoma Metropolitana, Mexico, D.F., Mexico; A. Banaszak, ICMYL U.A. Puerto Morelos, Universidad Nacional Autonoma de Mexico, Puerto Morelos, Quintana Roo, Mexico. A ubiquitous group of contaminants are polycyclic aromatic hydrocarbons (PAHs), the majority of them enter the environment when fossil fuels are burned. PAHs toxicity is magnified by the presence of solar ultraviolet radiation (SUVR), causing what is known as phototoxicity. Coral reef ecosystems around the world are located in areas where there is high radiation intensity, the transparency of their waters allow SUVR to deeply penetrate the water column and, intense touristic activities release PAH into the systems. In Mexico the Caribbean Sea represents a highly valuable natural area where tourism and biodiversity conservation are in competition. For all these reason the present work evaluated the joint effects of SUVR and benzo[a]pyrene (BaP) on the coral *Porites divaricata*. Coral samples were collected at 1 m depth and transported to the laboratory. The branches were cut to 2 cm length and placed in groups of 12 in 3 L aquariums. Two replicate aquariums were used for each BaP concentration (0.95, 1.9 y 3.8 µg/L) and also for the control and solvent control groups. Corals were exposed to BaP at night allowing them to bioaccumulate for ten hours. Then the organisms were transferred to fiber glass tanks with running sea water (30 °C.), placing one replicate group per concentration under either, a plastic sheet that allowed the SUVR to penetrate or under a plastic sheet that cut most of the SUVR.

Twice a day (6 am and noon) for six days, *in situ* chlorophyll fluorescence measurements of the coral algae were taken to assess the toxic effects and, mortality and bleaching were evaluated at the end of this period. Results showed that shallow water corals like *Porites divaricata* can bleach and that their photosynthetic efficiency is affected when exposed to BaP and SUVR even after 2 days in clean water. An LC₅₀ of 1.72 + 5.7 µg/L was calculated which is lower than most reports of phototoxicity on reef organisms. Most bleaching occurred on the upper portion of the coral branches and therefore, bleaching could be a reversible effect on this corals since algae can migrate from one section to another on the coral branches, but mortality is definitive. This results point to the possibility that touristic activities at high intensity may cause harm to shallow water corals.

WP76 Adding Ecological Realism to Plant Testing. T.G. Pfleecker, M. Blakeley-Smith, D. Olszyk, US EPA, Corvallis, OR; M. Plocher, Dynamac, Inc, Corvallis, OR. Current test protocols for the protection of nontarget plants used when registering pesticides in the United States and many other countries depend on two tests using greenhouse grown, agricultural seedling plants. The seedling emergence and vegetative vigor tests are used to assess the ecological risk of new or reregistered pesticides to the environment, in particular, to nontarget plants and plant communities. In an effort to bring more realism to plant testing protocols while maintaining simplicity and low costs, we are in the process of developing field methodologies to: 1) determine plant community responses resulting from single and multiple applications of herbicides and 2) develop methods appropriate for a Tier III field test. Three native plant species, (*Festuca roemerii* Roemer’s fescue, *Clarkia amoena* Farewell-to-spring, *Prunella vulgaris* Self-heal), and one introduced species (*Cynosurus echinatus* Bristly dogstail grass) were started in the greenhouse in individual cells prior to transplanting. In 2007, seedlings were planted in two fields in the Willamette Valley, Oregon containing cover crops (Oregon State University Botany Farm and Hyslop Crop Science Farm). Individual plots at each site were prepared by removing vegetation within 1 m² using a propane burner followed by hand weeding. One of each species was planted 10 cm apart in a square in the middle of each 60 cm x 60 cm plot. Every two weeks after transplanting, canopy volume was measured for each plant until frost. Ripe seeds were also collected over this time period. In 2006, only glyphosate was used at the OSU Botany Farm. In 2007, glyphosate at 0.01, 0.1 and 0.2 x FAR (32 fl oz/A; 2.2 Kg/ha) or aminopyralid at 0.037, 0.136 and 0.5 x FAR (7 fl oz/A; 0.5 Kg/ha) was applied either 1, 2, or 3 times, two weeks apart for a total of ten treatments per pesticide including the control. Preliminary results indicate that 1) native plants can be grown from seed for plant testing protocols, 2) field tests can be developed that add realism and are interpretable and 3) low levels of herbicides can change the dynamics of plant community development.

WP77 Using a Tissue Residue Approach to Assess Impacts on Fish and Aquatic Invertebrates: Case Study for PAH and PCB. A. McElroy, Stony Brook University, Stony Brook, NY; M. Barron, U.S. Environmental Protection Agency, Gulf Breeze, FL; S. Kane-Driscoll, Exponent, Inc., Maynard, MA; T. Preuss, Aachen University, Aachen, Germany; T. Parkerton, Exxon Mobil Biomedical Sciences, Annandale, NJ; J. Steevens, USACE, Vicksburg, MS; J. Meador, NOAA Fisheries, Seattle, WA. As part of a Pellston Workshop held in June 2007, this is the second part of two posters considering the use of tissue residues for assessing risks organic chemicals to fish and aquatic invertebrates. A case study for tissue residue approach (TRA) for PAH and PCB is described to demonstrate the considerations of data availability and use, modeling approaches, considerations of exposure route, metabolism, analysis matrix, as well as mechanisms and modes of toxicity. Use of TRA for PAH and PCB must consider the wide range of chemicals that are included in each of these classes of compounds (i.e., parent PAH, alkylated PAH, total PAH). Metabolism and mechanism of action of the differences in compounds can be addressed through the use of potency factors such as the dioxin toxicity equivalents. The case study outlines the use and challenges of TRA within the context of an ecological risk assessment.

WP78 Comparative toxicity of pesticides to four freshwater invertebrate. T. Kwon, S.W. Fisher, Entomology, The Ohio State University, Columbus, OH. Pesticides are applied to environment continuously, extensively, and in combination to boost their effect and reduce costs. Joint action between pesticides is commonly referred to as synergistic, antagonistic, or additive, depending on the relative toxic potency of the pesticides in the mixture. This study determined the 2-d toxicity of several pesticides on a body residue basis in *Lumbriculus variegatus*, *Daphnia magna*, *Hyalella azteca*, and *Chironomus*

riparius. In the experiment of *Lumbriculus variegatus*, the LC50 values ranged from 4.637 mg l⁻¹ for chlorpyrifos to 36.761 mg l⁻¹ for isoprothiolane, while the LR50 values showed from 0.961 mmol kg⁻¹ for diazinon to 5.166 mmol kg⁻¹ for chlorpyrifos differed by factor of 5.3. The order of toxicity on basis of LC50 values is not identical to LR50 values, suggesting different toxicokinetic. Toxicity of pesticide mixture was 5.281 mg l⁻¹ for LC50 and 3.503 mmol kg⁻¹ for LR50, suggesting additively not out of range of single compound LC50s and LR50s. In the test of four organophosphorous with three organisms, *Hyalella azteca* was determined the most sensitive organism by factor of 40 to 6,362 on the basis of LC50, but *Daphnia* was the most insusceptible organism.

WP79 Influence of Elevated Hardness on Ammonia Toxicity to Fish and Aquatic Invertebrates. C.A. Smith, R. Gensemer, E. Van Genderen, Parametrix, Albany, OR; K. Ramage, Pima County Wastewater Management, Tuscon, AZ; E. Curley, Camp, Dresser, & McKee, Denver, CO. This study was conducted to determine whether hardness exerts a significant enough effect on acute ammonia toxicity to be used as a basis for deriving site-specific ammonia standards in ephemeral and effluent-dependent waters with elevated hardness, such as in the arid West U.S. This was facilitated by conducting a series of acute toxicity tests with freshwater fish (*Pimephales promelas* and *Oncorhynchus mykiss*) and invertebrates (*Hyalella azteca* and *Ceriodaphnia dubia*) over a range of hardness and pH levels. For each species, six toxicity tests were conducted at three nominal hardness levels (100, 300, and 600 mg/L as CaCO₃) and two nominal pH levels (7, 8). For both fish species examined, results were consistent with previous studies showing ammonia toxicity was primarily due to unionized ammonia. In contrast, ammonia toxicity to invertebrates was best explained by a joint model wherein both the ionized and un-ionized ammonia fractions played an important role. Although hardness did not significantly influence acute ammonia toxicity to either fish species, a significant relationship was found for invertebrates, where the toxicity of total ammonia at pH 8 decreased with increasing hardness for *C. dubia* and increased with increasing hardness for *H. azteca*. These were not consistent with previous results for either invertebrate, so additional *H. azteca*, *C. dubia*, and *P. promelas* studies were conducted by independently manipulating sodium in conjunction with hardness and alkalinity. The results of these studies confirmed that elevated sodium (as alkalinity) offers considerable protection to *H. azteca*, *C. dubia*, and *P. promelas* against ammonia toxicity when coupled with elevated hardness; however, increasing sodium alone (as either NaCl or alkalinity) without also increasing hardness has variable effects on the acute toxicity of ammonia to these species. This study supports the limited toxicity literature available which suggests that hardness may influence acute ammonia toxicity, but only with concomitant changes in sodium or other cations related to hardness. This also corroborates the current AWQC for ammonia's (USEPA 1999) suggestion that, ammonia WERs greater than 1 may be observed, but only when a difference in ionic composition, in conjunction with pH or hardness, is present between site and laboratory waters.

WP80 Field and Laboratory Evaluation of an Ammonia-dominated Industrial Effluent. P.L. Cravatt, J.R. Bidwell, N.L. Cooper, Zoology, Oklahoma State University, Stillwater, OK. This study evaluated the effects of an industrial wastewater effluent that contains varying levels of ammonia on the biota in a reach of the Verdigris River in Oklahoma. Assessment techniques included basic water quality monitoring, macroinvertebrate and fish community sampling and in situ growth studies with the zebra mussel (*Dreissena polymorpha*). Laboratory bioassays were also conducted with the effluent to compare the results from toxicity tests to results found in the field. A series of 48-h acute tests using the fathead minnow (*Pimephales promelas*) were performed with unadjusted effluent (Avg. pH = 7.8, Avg. ammonia level = 7.2 mg/L) and pH (8.5 and 9.0) and ammonia (10, 20, 30 mg/L) adjusted effluent. At normal effluent pH, no toxicity to the fish was observed in any of the ammonia treatments, while at pH 8.5 the LC50 values of effluent containing 20 and 30 mg/L total ammonia were 61.7 and 42.0%, respectively. The largest effect on toxicity was observed at pH 9.0 with LC50 values of 66.4% at 10 mg/L, 23.1% at 20 mg/L and 14.3% at 30 mg/L total ammonia. Based on these data, and on the normal ranges of pH and ammonia that have been observed in the effluent, ammonia is probably not a primary acute stressor in the wastewater. No significant effects of the effluent were observed in the receiving system, although fish were attracted to the mixing zone.

WP81 Partitioning of Model Environmental Contaminants to Organic Matter in Aquatic Systems. K.L. Fallert, J.B. Belden, Department of Environmental Studies, Baylor University, Waco, TX. Although partitioning

coefficients such as water-sediment and octanol-water are commonly used to evaluate environmental fate, limited previous research has examined differential partitioning between various types of organic matter found in streams. Since particulate organic matter comprises a large portion of benthic macroinvertebrate consumers' diets, niche feeding groups that specialize on particular size classes of organic matter may experience different exposure to contaminants if differential partitioning occurs. In this study we examined the partitioning of a series of model environmental contaminants to various types of organic matter, including coarse leaf material (coarse particulate organic matter, CPOM) and leaf material processed by amphipods (fine particulate organic matter, FPOM). The environmental contaminants were chosen based upon polarity and ionization state at a neutral pH. Our data follows the trends of a previous study which illustrated with ciprofloxacin, a fluoroquinolone class antibiotic, where FPOM experienced sorption rates 1.6 orders of magnitude greater than that of CPOM. From initial studies, propranolol, a weak base pharmaceutical that is primarily ionized at the pHs examined, followed this trend most closely. Trifluralin, a neutral pesticide, and 17 β -estradiol, a natural hormone, also exhibited moderate differential partitioning between FPOM and CPOM. This work illustrates a greater need to expand research in the environmental fate of such compounds given the widespread anthropogenic contamination of streams across North America and Europe.

WP82 Impacts of surface water on the development and metamorphosis of *Xenopus laevis*. B. Moser, J. Rayburn, G.R. Cline, M. Hamissou, Biology Department, Jacksonville State University, Jacksonville, AL. In recent years, toxicological endpoints have been expanded to include sub-lethal endpoints largely due to concerns over long-term effects of toxins on populations. Endpoints frequently examined include factors that affect reproductive capability, normal behavior, and growth and development. Urbanization is a cause of non-point source pollution in surface waters. To examine the impact of urbanization on aquatic organisms in surface waters of local watersheds, *Xenopus laevis* tadpoles (stage 48) were exposed to surface waters from three creeks in Calhoun County Alabama throughout metamorphosis (stage 66). Sites chosen were impacted by various degrees of urbanization. Site 1 was located at the confluence of Choccolocco Creek and Murray Creek in the Talladega National Forest between two rural livestock farms. Sites 2 and 3 were both located in Oxford Alabama. Site 2 was located on Cane Creek at a local organic dairy farm, and site 3 was located on Snow Creek within a heavily industrialized area. Exposure controls were kept in dechlorinated tap water. Tadpoles were kept in 10-gallon glass aquaria with 20 L of exposure water. Twenty tadpoles were placed in each aquarium with temperature maintained at approximately 20°C. Endpoints examined included size, developmental stage (Nieuwkoop and Faber 1967), and time to metamorphosis. Developmental stage was variable within exposed populations of individual aquaria. Overall, Snow Creek developed the slowest, followed by Cane Creek. Symptoms of tadpole edema disease were observed in control tadpoles, but not in tadpoles exposed to water from the sites. This study indicates that differences in developmental times, size, and time to metamorphosis differed among treatments, with urban treatments exhibiting greater impact.

WP83 Biomonitoring: Scat as an indicator of body burden in mink (*Mustela vison*). M.S. Shotwell, D.P. Kay, ENTRIX, Okemos, MI; M.J. Zwiernik, J.N. Moore, Zoology, National Food Safety and Toxicology Center and Center for Integrative Toxicology, Michigan State University, East Lansing, MI; S.J. Bursian, J.P. Giesy, Animal Science, Michigan State University, East Lansing, MI; J.S. Khim, J.P. Giesy, Biomedical Sciences and Toxicology Center, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; L.L. Williams, U.S. Fish & Wildlife Service, East Lansing, MI. Mink (*Mustela vison*) are often utilized as a sentinel species for ecological risk assessment at sites where contaminants of concern are dioxins and dioxin-like compounds. Utilizing mink scat as a biomonitoring tool to determine internal exposure to polychlorinated biphenyls (PCBs), dibenzo-p-dioxins (PCDDs), and polychlorodibenzofurans (PCDFs) via a non-destructive method is a concept that has not been practiced with wild mink. To determine the relationship between concentrations of PCDD/DFs in tissues and in scat, mink were fed PCDFs in a controlled laboratory study. Mink were exposed to seven treatments including three doses each of 2,3,4,7,8-pentachlorodibenzofuran (PeCDF) and 2,3,7,8-tetrachlorodibenzofuran (TCDF) as well as an environmentally relevant mixture of the two congeners. Three mink were euthanized before initiation of feeding to determine background concentrations of PCBs,

PCDDs, and PCDFs. Treatment group mink were killed at 90 or 180 days to determine concentrations in liver and adipose tissues. A composite of scat samples for each treatment was collected for analysis on days 2, 23, 45 and 90. In addition scat was collected from individual mink on day 180. Concentrations of both PCDFs in scat had significant positive correlations with concentrations in liver and adipose ($r^2 = 0.94-0.97$, $p < 0.01$). Therefore, analysis of mink scat is a potential non-destructive method to predict concentrations of PCDFs in tissue.

WP84 Avian Consumption of Contaminated Water: Addressing Present and Future Issues. J.P. Isanhardt, T.R. Rainwater, S.B. Cox, M.J. Hooper, Env'tl Toxicol, Texas Tech Univ, Lubbock, TX; R. MacRae, US Fish and Wildlife Service, Albuquerque, NM; D. Fry, American Bird Conservancy, Washington, DC. Availability of clean water is critical to the daily survival of wild birds, while migratory species are dependent on water sources as they labor to reach their wintering or breeding grounds. Contaminated water in agricultural, industrial, and mining areas is a threat to migratory birds, as their need for water can preclude their ability to choose clean sources. Water availability in semi-arid and arid environments is a particularly important consideration in the life of local or migratory birds as its scarcity makes it a critical commodity. Reports document tissue accumulation, sublethal effects, and thousands of mortalities in birds as a result of consumption of water contaminated with environmental pollutants including pesticides, metals, petroleum, salt, and other chemicals. While some threats, such as consumption of cyanide in leach solutions and tailings ponds at gold mines, have been partially addressed through bird exclusion techniques, others still remain a significant hazard to birds. 200 birds, comprising 24 species from 10 families, were found dead at three mine sites located in New Mexico and Arizona in 2000 after consuming acid mine water. Future issues include new open-pit mines, generation of contaminated water from oil and gas drilling, and potential changes in water availability due to climate change. While water availability and the aversive nature of contaminated water are important factors involved in a bird's response to thirst and subsequent choice in water source, dehydration is likely one of the most important factors. Dehydrated birds can acquire a higher dose of contaminated water in less time than their non-dehydrated counterparts, which is of particular concern for migratory birds. Water consumption volumes and rates are not known for the majority of avian species, and allometric estimations may underestimate the potential for chemically-induced injury in cases where birds ingest water at higher consumption rates than allometric equations would predict during periods of gorge drinking. Probabilistic risk techniques can be used to estimate the distributions of possible exposure and effects resulting from avian consumption of contaminated water sources. These factors need to be considered when estimating risk to avian species that come in contact with contaminated water.

WP85 Effects of Triclosan and Triclocarban on Estuarine Bacterial and Phytoplankton Productivity. W. Palefsky, University of Georgia, Savannah, GA; W. Palefsky, A. Peck, J. Smith, M. Frischer, Institute of Oceanography, Savannah, GA. The presence of pharmaceuticals and personal care products (PPCPs) in natural environments has emerged as a contemporary threat to the functional integrity of aquatic ecosystems. Triclosan (TCS) and Triclocarban (TCC), broad-spectrum antimicrobial additives incorporated into numerous consumer products, are among the myriad compounds comprising PPCPs. Due to incomplete removal during wastewater treatment and the subsequent disposal of treated wastewater in aquatic systems, TCS and/or TCC have been found in natural waters worldwide, including lakes, streams, rivers and estuaries. Effects of a variety of PPCPs have been described for multiple freshwater aquatic organisms, but significantly fewer studies have examined the effects of these compounds on estuarine species. Because freshwater and estuarine systems differ greatly in chemical, biological, and physical processes, it is not appropriate to extrapolate data from rivers and streams to estuaries. Therefore, the purpose of this research was to monitor the functional response of estuarine bacterial and phytoplankton communities to the presence of TCC and TCS. Nine microcosms containing whole natural water from the Skidaway Estuary, GA, were established in a greenhouse and used in triplicate for 3 treatment groups: control, 0.1 µg/L TCS and TCC and 10 µg/L TCS and TCC. Protein synthesis activity, measured as 3H-labelled leucine incorporation, was used to monitor bacterial community functional response 1 and 24 hours after dosing. Primary production, estimated by $H^{14}CO_3$ incorporation, was used to assess the functional response of the phytoplankton community 4 and 48 hours subsequent to dosing. At the high concentration, both bacterial and phytoplankton productivity were significantly lower

than controls at both sampling time points. However, bacterial and primary production appeared to be stimulated by low concentrations of TCC and TCS. Future studies involving larger scale tidally-influenced mesocosms will focus on both structural and functional responses of estuarine bacterial and phytoplankton communities to the presence of environmentally relevant concentrations of TCC and TCS.

WP86 The Effect of Artificial Sea Salt Preparation on Strongylocentrotus purpuratus Fertilisation Success. C.V. Eickhoff, J. Pickard, L. Stavroff, M. Wilson, P. Howes, C. Sullivan, Ecotoxicology, Cantest Ltd., Vancouver, British Columbia, Canada. An echinoderm fertilisation assay is a frequently used endpoint for the evaluation of a sublethal effect from sediments, effluent, or chemical. The type of artificial sea salt and its preparation can produce different results when using the test organism *Strongylocentrotus purpuratus*. The fertilisation success of *S. purpuratus* was compared among treatments of different types of artificial sea salt and the preparation techniques used. Six commercial brands (Instant Ocean, Crystal Sea Marine Mix, Kent, SeaChem Reef Salt, Ocean Pure Sea Salt, and Red Sea Salt) were prepared using six different combinations: with or without aeration; in dechlorinated, hardened Vancouver city tap water or Type II deionised water; and aging for 24 or 48 hours. Overall, the greatest fertilisation success occurred in salts that were prepared with aeration in Vancouver city tap water, and allowed to age for 48 hours. Fertilisation success with sea salts prepared without aeration was generally lower than when aerated. Similar results compared to the control (filtered and sterilised Vancouver Aquarium sea water) were obtained with Ocean Pure Sea Salt using Vancouver city tap water at both aging times and DI water aged for 48 hours, and Red Sea Salt in both aging times and preparation waters. Ocean Pure Sea Salt also produced similar results to the control when prepared without aeration. Crystal Sea Marine Mix produced similar results to the control when aerated, prepared in DI water, and aged for 48 hours. Fertilisation success with remaining brands and preparations was markedly lower.

WP87 Reproductive Failure of Queen Conch (*Strombus gigas*) in the Florida Keys. N.D. Denslow, K.J. Kroll, D. Barber, Physiological Sciences, University of Florida, Gainesville, FL; R.A. Glazer, G.A. Delgado, Florida Fish and Wildlife Conservation Commission, Marathon, FL; P.D. McClellan-Green, North Carolina State University, Raleigh, NC; N.J. Brown-Peterson, University of Southern Mississippi, Hattiesburg, MS. The queen conch (*Strombus gigas*), a large marine gastropod and a symbol of the Keys, has exhibited catastrophic reproductive failure throughout most of the island chain. Despite a fishing moratorium implemented in 1986, the population has continued to decline. Male and female conch found near shore show serious gonadal atrophy when examined by histology; whereas, the offshore adults appear to be normal. After reciprocal transplants between the off-shore/near shore environments, it was apparent that the near shore conditions caused reproductive collapse within 3 months of transplant. The distance between these two isolated habitats is 1-2 miles. We are developing a "tools box" to characterize reproductive and physiological biomarkers from the near and off-shore conch. Data suggest that a combination of stressors may be responsible for the observed deficits. We have tested biomarkers against heat, hypoxia, metal, and organic pollutants. We are also characterizing conch yolk, egg laying hormone, and sex steroids. In our analyses of heat shock proteins, higher concentrations of Hsps 60, 70 and 90 were observed in the hemolymph and digestive gland of offshore conch compared to near shore conch, while Hsp 60 was higher in the neuroganglia of near shore conch. Egg laying hormone (ELH) is also lower in near shore animals, and histological inspection of neural ganglia from near shore females showed substantially reduced amounts of tissue compared to offshore females. We have begun to identify proteins that are important for reproduction and oxidative stress using proteomics methods. Our data suggests that near shore pollution may be responsible for the decline in reproduction.

WP88 Growth response of different green microalgae to the acute toxicity of pesticides. M.I. Abdel-Hamid, Botany Department, Faculty of Science, Mansoura University, Mansoura, Dakahlia, Egypt. Standard algal inhibition tests were carried out to assess the toxicity of eight pesticides on growth of some green unicellular algae. The tested pesticides include six herbicides (Atrazine, Dichloroprop, Glyphosate, Chlorsulfuron, MCPA, and Simazine), an insecticide (Dimethoate), and a fungicide (Propiconazole). The test algae were *Monoraphidium convolutum*, *Monoraphidium controtum*, *Monoraphidium griffithii*, *Scenedesmus obliquus*, and *Chlorella homospaera*. All the test algae were isolated from the River Nile in Egypt except *Chlorella*

homosphaera which was isolated from a soil sample. Parallel biotests were carried out using the ISO standard test alga *Pseudokirchneriella subcapitata* (formerly, *Selenastrum capricornutum*), for results comparison and validation. All biotests were carried out in polystyrene microplates and kept for four days under conditions favorable for algal growth. The lowest pesticide concentration (mg l^{-1}) inhibiting algal growth by 50% (EC_{50}), compared to control, was quantified from dose-response curves. Relatively low concentrations of some pesticides stimulated the growth of certain algal species. Pesticides toxicity (EC_{50}) fluctuated within a wide range between 0.0025 mg l^{-1} to 155 mg l^{-1} and was highly dependent on the test alga and the tested pesticide. Most of the Egyptian isolates maintained growth responses greatly comparable to those of the standard test alga *Pseudokirchneriella subcapitata*. The remarkable variation in sensitivity of the test algae to pesticides toxicity indicates that biotests using single species representing algae in general, involve distinct limitations. The results were validated through proper statistical analyses.

WP89 Ecotoxicological Effects of Abamectin on Soil Invertebrates in Different Test System. X. Diao, Aniaml Science, Hainan University, Haikou, Hainan, China. Abamectin, an antiparasitic agent with high efficiency, can be excreted in the feces of treated animals and enter the environment when amending the soils with manure. Nevertheless, only very little information on effects of abamectin on soil fauna is known. The aim of this study was to evaluate the sublethal toxicity of abamectin on soil dwelling organisms in different test system and to elucidate the possible environmental risk of abamectin to non-target organisms. The results showed that direct toxic effects of Abamectin are likely to occur at test realistic concentrations in single test system. Springtails were the most sensitive species and reproduction was the most sensitive endpoint among the three tested species in the single species system. The reproduction of the springtail was significantly affected at abamectin concentrations of 0.25 mg/kg . Abamectin had no effect on the survival of enchytraeides and earthworm, whereas the number of juveniles of enchytraeides, and earthworm, was reduced at concentrations above 10 mg/kg and 0.25 mg/kg respectively. In prey-predator test system, survival and reproduction of predator *H. aculeifer* and the prey *F. fementaria* and population dynamic were studied. The number of adults and juveniles of prey *F. fementaria* were reduced with $\text{LOEC } 1 \text{ mg/kg}$ and 0.25 mg/kg respectively after abamectin exposure and predation. Reduction of the number for juveniles of predator were found after exposure of abamectin. The variation of predator population was due to food depletion caused by a decreased availability of prey, rather than to the lethal effects of abamectin on predator. Key words: Abamectin; Soil invertebrates; Ecotoxicological effects; Prey-predator system

WP90 UV Radiation Toxicity and Fluoranthene Photoinduced Toxicity to *Daphnia magna* in Ohio Reservoirs. R.R. Otter, M. MacMillan, L. Knoll, E. Overholt, C. Williamson, M.J. Vanni, J.T. Oris, Zoology, Miami University, Oxford, OH. The direct UV toxicity and photoinduced toxicity of fluoranthene to *Daphnia magna* was studied in single-treatment evaluations in a laboratory system under simulated sunlight in water from 3 Ohio reservoirs. Five concentrations of fluoranthene (100, 400, 800, 1600, and 5000 ng/L) were tested. In toxicity tests with nonacclimated *Daphnia* there was a significant relationship among UV toxicity, fluoranthene photoinduced toxicity and water quality characteristics (light attenuation coefficient (K_d), suspended solids (SS), dissolved organic carbon (DOC), chlorophyll *a* and the percent agriculture in the watersheds). In tests with nonacclimated *Daphnia* median lethal times (LT_{50}) were inversely related to K_d , SS, DOC, chl *a* and percent agriculture and directly related to fluoranthene water concentration. There was no relationship among LT_{50} 's and water quality characteristics using *Daphnia* acclimated to UV radiation. Site specific environmental parameters that affect UV penetration can determine the rates of mortality due to direct UV toxicity and fluoranthene photoinduced toxicity.

WP91 The influence of sediment choice on the health and survivorship of the freshwater dipteran *Chironomus* spp. in chronic study designs. C. Banman, J.A. Roberts, M.E. Kern, Ecotoxicology, Bayer CropScience, Stilwell, KS; A.E. Putt, C.R. Picard, M.J. Bradley, Ecotoxicology, Springborn Smithers Laboratories, Wareham, MA. Studies conducted to support the registration of plant protection products often include those designed to test their effects on sediment dwelling organisms. Protocol requirements for these studies vary depending on the region of the world in which registration is being sought. Standard study guidelines have been developed by the USEPA and the OECD. Methodologies for both acute and chronic exposure exist but in some cases were written for the evaluation and assessment of contaminated natural

sediments. Further, sediment test guidelines can be variable and differences can influence both study design and results. One of these differences is the sediment used. Sediment is the single most important factor impacting the survival and health of the freshwater midge (*Chironomus* spp.), a commonly tested invertebrate. OECD guidelines (OECD 218 & OECD 219) suggest formulated sediment to promote consistency of sediment preparation in hopes of reducing this variable. USEPA guidelines and methods focus on the use of natural sediments. Our experiences have shown that the quality of natural sediments can have a dramatic effect on organism health and survivorship, making it difficult to meet control performance criteria. This is especially true for chronic exposures starting with young organisms (<24 hours old) where meeting the 20 day survival criteria can be problematic. Also, finding a reliable, consistent, and clean source of natural sediment can be a challenge. Any sediment used must consistently provide the necessary conditions for good growth and survival, without which it is impossible to conduct reliable experiments to evaluate toxicity. Specific sediment properties such as the quantity and quality of organic carbon can dictate the toxic response. In these experiments the health and survivorship of the midge (*Chironomus* spp.) was evaluated in both natural and formulated (OECD 218) sediments with a focus on early their life stages.

WP92 Examining the relationship between pulp mill effluent and endocrine disruption: attempts to explain the presence of hermaphroditic fish in the Wabigoon River. M.S. Pollock, M.G. Dube, L. Clarke, Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; J. Laporte, R. Schryer, Golder Associates LTD., Saskatoon, Saskatchewan, Canada. It is well documented in the literature that some pulp mill effluents act as reproductive and endocrine disruptors. However, their impact is not always consistent with regard to species or endpoints affected. In the current study, we seek an explanation for the presence of intersexed walleye (*Sander vitreus vitreus*) with significantly altered hormone levels in the Wabigoon River of Dryden, Ontario. The Wabigoon River receives effluent from a bleached kraft pulp and paper mill, as well as effluent from a municipal waste water plant. We conducted a partial life cycle test exposing fathead minnows (*Pimephales promelas*) for 21 days to reference water (free of effluents), 20%, 40%, or 60% treated bleached kraft pulp mill effluent. Although an exhaustive suite of endpoints were examined including effects on adults, eggs, and offspring, the only notable changes were a decrease in testosterone in males with increasing effluent concentration and vitellogenin induction in males exposed to 60% effluent. These results did not concur with our previous field survey of the Wabigoon River which indicated severe endocrine disruption. Several hypotheses are discussed to explain these discrepancies including length of the life cycle test, species response differences, as well as the presence of other endocrine disrupting factors in the Wabigoon River. Specifically, we offer evidence from published studies indicating that either hypoxia or municipal waste water, alone or in combination with pulp mill effluent, may explain the discrepancy between our studies.

WP93 Does *C. ariakensis* accumulate more microbial pathogens than *C. virginica* increasing the pathogenic risk for human consumption? C.L. Mitchelmore, J. Cook, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, Solomons, MD. The ability of *Crassostrea virginica* to act as a reservoir and/or vector of disease is well documented, but this ability in *C. ariakensis* has yet to be fully determined. Specific differences in the uptake and retention of pathogens (especially *Vibrio* spp.) by the two oyster species have yet to be fully elucidated. Our overall objective is to determine if the uptake and retention of human pathogens differ in *C. ariakensis* compared with *C. virginica* and how these differences may relate to human consumption risks and fishery closures. We compared the uptake (4 and 24 hours) and retention of *Escherichia coli* (representative indicator of fecal contamination; 4 and 8 days depuration) and pathogenic *Vibrio parahaemolyticus* (8 and 16 days depuration) in both diploid and triploid specimens of *C. ariakensis* and *C. virginica*. Quantitation was carried out using both standard MPN-based procedures and PCR analyses to discern between viable and non-viable microbes using reverse-transcriptase (RT) PCR. Uptake of *E. coli* was greater in *C. virginica* at 4 hours but after 24 hours both species were similar. However, depuration was significantly reduced in *C. ariakensis*. With *V. parahaemolyticus* elevated uptake at 24 hours was observed in *C. ariakensis*. *V. parahaemolyticus* was reduced to very low levels in both oyster species by Day 8, with no differences observed between oyster species. In addition to gaining a basic understanding of pathogen accumulation potentials the results will also be made available to facilitate the development

of models to predict risks for human consumption and aid in management and regulatory decisions.

WP94 Influences of the Genetic Variability in the CYP1A Gene Expression of Catfish (*Ariopsis felis*) From Four Coastal Areas of Gulf of Mexico. A. Arroyo-Herrera, M. Roca-Olmos, O. Zapata-Perez, Recursos del Mar, Cinvestav-Merida, Merida, Yucatan, Mexico; A. Quiroz-Moreno, F. Sanchez-Teyer, Unidad de Biotecnologia, CICY, Merida, Yucatan, Mexico. In the aquatic environment, the induction of CYP1A in fish is commonly used as a biomarker of exposure to environmental pollutants such as PAHs and PCBs. Previous studies performed in catfish collected in the coastal areas of Gulf of Mexico have demonstrated significant differences in the CYP1A gene expression in fish collected from three of lagoons of the Gulf of Mexico: (Coatzacoalcos, Mecoacan, Terminos and Celestun). In the present study, close to two hundred fifty hardhead fish (*Ariopsis felis*) were collected and analysed. CYP1A gene expression was determined in liver of male fish by amplification with reverse transcriptase-polymerase chain reaction (RT-PCR), and the genetic structure of this population, was determined using Amplified Fragment Length Polymorphic (AFLPs) markers, to identify and to compare individuals, populations, and species. The analyses of AFLPs revealed that the population of fish collected in Mecoacan Lagoon showed significant differences with regard to the other populations analyzed by what is considered that may have some effect in the CYP 1A expression gene
Keywords: CYP1A, gene expression, AFLPs, Catfish, *Ariopsis felis*.

WP95 A surrogate sub-chronic toxicity test method for waters with high total dissolved solids. R.B. Naddy, G. Mc Nerney, K. Tapp, D. Pillard, ENSR, Fort Collins, CO; B. Parkhurst, H&F, Laramie, WY; J. Lazorchak, U.S. Environmental Protection Agency, Cincinnati, OH; M. Smith, The McConnell Group, Cincinnati, OH. Total dissolved solids (TDS) are often identified as a toxicant in whole-effluent toxicity (WET) testing. The primary test organism used in WET testing, *Ceriodaphnia dubia*, are very sensitive to TDS ions, which can be problematic when differentiating the toxicity of TDS from those of other contaminants. *Daphnia magna* is not as sensitive to common ion toxicity as *C. dubia* but is still relatively sensitive to other contaminants. We used a 4-d static-renewal survival and growth method using *D. magna* to help identify the toxicant in an effluent from a discharger with elevated TDS. Because of the high TDS, we needed a test organism that was sensitive to most contaminants but less so to TDS ions. We compared the sensitivity of the 4-d *D. magna* method to the standard, short-term chronic 3-brood *C. dubia* method and to the 21-d *D. magna* chronic study to determine its applicability in WET testing, toxicity identification evaluations (TIEs), and other toxicity testing scenarios. The statistical endpoints calculated for the 4-d *D. magna* study were similar to the 21-d *D. magna* study but were substantially higher than for the 3-brood *C. dubia* study. For example, the IC25s for the 4-d *D. magna* study, the 3-brood *C. dubia* study and the 21-d *D. magna* study were (based on chloride): 1,449 mg/L, 377 mg/L, and 2,108 mg/L, respectively. Results indicate that this test would be useful for differentiating TDS toxicity from other contaminants in TIEs and as a compliance study method for dischargers where the presence of TDS ions is an ongoing issue.

WP96 Striped Bass Habitat Use in the San Francisco Estuary Determined Using Otolith Microchemistry. D.J. Ostrach, John Muir Institute of the Environment, Center for Watershed Sciences & Department of Civil & Environmental Engineering, University of California Davis, School of Veterinary Medicine, Davis, CA; C.C. Phillis, Department of Earth and Planetary Science, University of California, Berkeley, Berkeley, CA; M.A. Gras, Q.Z. Yin, Department of Geology University of California Davis, University of California Davis, Davis, CA; P.K. Weber, Chemical Biology and Nuclear Science, Lawrence Livermore Laboratory, Livermore, CA. Habitat use has been shown to be an important factor in the bioaccumulation of contaminants in striped bass. This study examines migration in striped bass as part of a larger study investigating maternal transfer of xenobiotics to progeny in the San Francisco Estuary. Habitat use, residence time and spawning migration over the life of females was studied (n = 50). Female striped bass were collected on the Sacramento River during the spawning runs of 1999-2001. Additional samples were obtained in 2005 from the San Joaquin River and nearshore Pacific Ocean. Otoliths were removed, processed and aged via otolith microstructure. Subsequently, otoliths were analyzed for 87Sr/86Sr to determine habitat residence and migration patterns. Strontium isotopic results indicated 79% of the analyses were in the freshwater range, 18% were in the estuarine range and 3% were found to be in the marine range.

Salinity exposure during the last year before capture was examined more closely for comparison of habitat use by the maternal parent to contaminant burden transferred to progeny. Results will be combined with contaminant and histological analyses to better understand the bioaccumulation of contaminants and the effects they and habitat use have on fish populations in the San Francisco Estuary.

WP97 A Novel Method to Develop an Otolith Microchemistry Model to Determine Striped Bass Habitat Use in the San Francisco Estuary. C.C. Phillis, Department of Earth and Planetary Science, University of California, Berkeley, Berkeley, CA; D.J. Ostrach, John Muir Institute of the Environment, Center for Watershed Sciences & Department of Civil & Environmental Engineering, University of California Davis, School of Veterinary Medicine, Davis, CA; M.A. Gras, Q.Z. Yin, Department of Geology University of California Davis, University of California, Davis, Davis, CA; P.K. Weber, Chemical Biology and Nuclear Science, Lawrence Livermore Laboratory, Davis, CA. Here we demonstrate a novel method for developing a salinity-otolith Sr/Ca model for the purpose of reconstructing striped bass (*Morone saxatilis*) habitat use in the San Francisco Bay estuary. We used correlated Sr/Ca and 87Sr/86Sr ratios measurements from adult striped bass otoliths to infer striped bass otolith Sr/Ca response to changes in salinity and water Sr/Ca ratio. Otolith 87Sr/86Sr can be assumed to accurately record water 87Sr/86Sr because there is no biological fractionation of Sr isotopes. Water 87Sr/86Sr can in turn be used to estimate water salinity based on the mixing of fresh and marine water with known 87Sr/86Sr ratios. The relationship between adjacent analyses on otoliths of Sr/Ca and 87Sr/86Sr by LA-ICP-MS and MC-ICP-MS ($r^2 = 0.65$, $n = 66$) is used to predict water salinity from a measured Sr/Ca ratio. The nature of this non-linear model lends itself well to identifying residence in the Delta and Suisun Bay, but does not do well locating residence within the more saline bays west of Carquinez Strait. An increase in the number of analyses would improve model confidence, but ultimately the precision of the model is limited by the variability in the response of individual fish to water Sr/Ca.

WP98 Sensitivity of Antarctic Spirorbirds to Metal Contaminants and the Role of Resuspended Sediments. N. Hill, E.L. Johnston, School of BEES, University of New South Wales, Kensington, Sydney, New South Wales, Australia; C.K. King, Environmental Protection and Change, Australian Antarctic Division, Kingston, Tasmania, Australia. Antarctica is generally considered a pristine environment, however increasing human activity and the habitation of research stations has in some cases led to localized contamination. Antarctic species are thought to be particularly susceptible to contaminants including metals, due to their slow metabolism and growth rates, and to their lack of previous exposure. However, few studies have examined the toxicity of contaminants to Antarctic species and therefore there is little evidence to support this theory. In addition to contaminants in the dissolved phase, marine organisms that live immediately above the seafloor may be exposed to metals from sediment that are resuspended into the overlying water by disturbances. In this study, the sensitivity of spirorbid polychaetes, a dominant taxa on hard substrates in Antarctica, was investigated. Spirorbirds were exposed to copper, lead and zinc individually and in combination, via water in aqueous exposures or via sediment ingestion using a novel method to resuspend spiked sediments. Spirorbirds exhibited a behavioural response to copper concentrations as low as 25µg/L, however the LC50 for copper was 584µg/L. Similarly this species is tolerant of high concentrations of zinc (LC50 > 5000µg/L) and the effect of multiple metals was not additive. The addition of resuspended sediments spiked at low and moderate metal concentrations had a significant negative effect on spirorbid behaviour and health. This study provides some of the first evidence that Antarctic marine species may not be as sensitive to metal contaminants as theory predicts. However, the resuspension of contaminated sediments was shown to be an important pathway for toxicity in hard substrate organisms.

WP99 Polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) in current and historical samples of avian eggs from nesting sites in Buzzards Bay, MA, USA. S. Jayaraman, M.C. Cantwell, D.E. Nacci, Atlantic Ecology Division, U.S.EPA, Narragansett, RI; C.S. Mostello, Massachusetts Division of Fisheries & Wildlife, Westborough, MA; I.C. Nisbet, I.C.T. Nisbet and Company, North Falmouth, MA. We measured concentrations of polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) in eggs from breeding colonies in Buzzards Bay, MA, USA. Eggs from two piscivorous bird species, common (Sterna hirundo) and roseate (Sterna dougallii) terns, were collected in spring 1972, 1994 - 96,

1998 – 99 and 2005. Prior to analyses, we predicted temporal declines in tern egg PCBs in association with declines since the 1970s in sediment PCBs from a nearby Superfund site, New Bedford, MA. However, we expected a temporal increase in PDBE concentrations in tern eggs, reflecting local and globally-transported industrial contamination from these compounds used in recent years (primarily) as flame retardants. As predicted, PCB concentrations have declined since 1972 in eggs from both tern species. For example, total PCB concentrations, reported as the sum of eighteen selected PCB congeners, averaged 157,322 ng/g lipid for 1972 samples and 34,602 ng/g lipid for 2005 samples of common tern eggs. PCB congener patterns in tern eggs have also changed. The predominant congeners found in tern eggs collected in recent years included PCBs 118, 153 and 138, which contributed to 66-70% of total PCBs; whereas lower chlorinated PCBs predominated the PCB patterns from earlier years (1972). PBDEs were measured in extracts from these same egg samples using a novel negative ion mass spectrometer method and reported for eight selected congeners. As expected and in contrast to the decline observed for PCBs, total PBDE concentrations have increased from detection limit (< 3 ng/g) in 1972 samples to an average of 1,086 ng/g lipid for 2005 common tern egg samples. Results from these analyses were also compared to PCB and PBDE concentrations measured for recently collected (2003) eggs of tree swallows (*Tachycineta bicolor*), insectivorous birds drawn to nesting boxes located in the Superfund site. Statistical analyses are underway to evaluate contaminant-specific interspecies variations, assess the influence of the Superfund site on PCB contamination, and characterize the potential for adverse effects from these toxic contaminants in avian eggs.

WP100 A State Agency Perspective on Addressing Emerging Issues in Minnesota. J.L. Crane, M. Ferrey, L. Solem, S. Hennes, A. Preimesberger, C. O'Dell, P. Hoff, Environmental Analysis & Outcomes Division, Minnesota Pollution Control Agency, St. Paul, MN. The Minnesota Pollution Control Agency (MPCA) considers emerging issues as new areas of environmental concern not currently incorporated into regular environmental protection activities in Minnesota. The MPCA is developing a framework to assist in the identification of emerging issues that have the potential to be important in Minnesota, involve multiple MPCA programs and/or staff, have a significant impact on the MPCA's budget, and are of significant public interest. A process plan is being developed to identify key participants and responsibilities, including: 1) an emerging issues team of scientists to identify and track emerging issues and evaluate potential impacts to Minnesota, 2) satellite team members to provide expertise on specific emerging issues, and 3) supervisory and management leaders to provide support and guidance to the staff team, as well as to help design an agency-level approach to each issue so it can be integrated into core regulatory/prevention programs. Regular input from MPCA staff, programs, and leadership, as well as stakeholders, will be included in the process plan. To carry this process forward, the MPCA's emerging issues team is developing an emerging issues inventory to identify those issues most important to Minnesota. The approach being used to identify the highest priority issues considers how widespread the contaminant or issue is, the current national or state regulatory stance on the issue, a characterization of the risk associated with the contaminant or issue, and the pertinence of the topic to Minnesota's environment. The team is examining the gaps in scientific understanding of each priority issue and the opportunities for the MPCA to address the issues through a variety of means such as: conducting applied research with collaborators to fill data gaps, preparing technical guidance, conducting informational seminars, and evaluating pollution prevention opportunities.

WP101 Determination and characterization of nonylphenol isomers in technical mixtures and real samples by one- and two-dimensional gas chromatography-mass spectrometry. W. Ding, Dept. of Chemistry, National Central University, Chung-Li, Taiwan. Nonylphenol isomers (NPs) have considerable industrial applications and have also been detected as the degradation products of nonylphenol polyethoxylate surfactants (NPEOs) in various environmental matrices. The technical nonylphenol mixtures are very complex due to vary in branching of the nonyl chain. In order to understand the environmental distribution and fate of NPs, it is necessary to be able to characterize the NP profiles from technical mixtures and environmental samples. In this study, gas chromatography-mass spectrometry with 100-m length GC column and two-dimensional gas chromatography-mass spectrometric techniques were employed to characterize five technical NP mixtures with fish and breast milk samples. The data were used to assess

the similarity of NP isomer profiles to ascertain if the NP residues in the real samples could be described by technical NP mixtures.

WP102 From paint to a pain killer? The environmental fate of 4-chlorobenzotrifluoride. C.J. Young, R.F. Gómez, S.A. Mabury, Department of Chemistry, University of Toronto, Toronto, Ontario, Canada; M.D. Hurley, T.J. Wallington, Ford Motor Company, Dearborn, MI. In an effort to reduce volatile organic compounds (VOCs) from paint solvents, replacements containing non-VOC compounds have been proposed. One such compound is 4-chlorobenzotrifluoride (CBTF) for which environmental fate studies have not been conducted. The objective of this study was to examine the atmospheric fate of CBTF and aqueous fate of its product(s). Based on previous studies, predicted final products of aqueous photolysis are likely to be 3,4-dihydroxybenzoic acid or a salicylic acid derivative. Smog chamber experiments were performed to confirm atmospheric oxidation kinetics and determine products. A rate constant of 2.2×10^{-13} cm³ molecule⁻¹ s⁻¹ was observed for hydroxyl radical addition to CBTF, consistent with previous studies. Offline sampling and GC-MS analysis confirmed the sole product of CBTF atmospheric oxidation as 2-chloro-5-trifluoromethylphenol (*o*-CTFP). The high water solubility of this compound suggests it will rain out of the atmosphere and end up in aqueous systems. Aqueous photolysis of *o*-CTFP proceeded at a rate of $(7.5 \pm 0.5) \times 10^{-3}$ s⁻¹ in deionized water, corresponding to a half-life of 1.6 ± 0.1 hours. The mechanism of aqueous degradation was investigated using LC-MS-MS, ion chromatography and ¹⁹F NMR. Photolysis was observed to be the primary aqueous fate and yielded a completely dehalogenated final product of 3,4-dihydroxybenzoic acid, which has no known toxicity.

WP103 GreenScreen - A Practical Eukaryotic Screening Assay for Genotoxic Contaminants: Environmental Monitoring and Hazard Assessment. A. Knight, Gentronix Limited, Manchester, United Kingdom; R. Walmsley, Faculty of Life Sciences, University of Manchester, Manchester, United Kingdom. Genotoxic, DNA damaging, chemicals present in the environment originate from a number of anthropogenic sources including chemical manufacturing, textile and dye industries, paper mills, petroleum refineries, landfill and pharmaceutical wastes. Expanding legislation is resulting in increasingly stringent controls on effluent discharges and highlights carcinogens and mutagens as priority pollutants. Genotoxic pollutants produce more subtle chronic effects in ecological populations and can cause a variety of biological consequences in higher animals and humans including cancer and reproductive anomalies. However, many established genotoxicity assays commonly used for pharmaceutical testing in drug discovery are not practical to use in a non-specialist laboratory or in the field. Genotoxicity screening assays are required with simple protocols, which give relevant and useful results. The GreenScreen assay uses eukaryotic (yeast) cells, genetically modified to express green fluorescent protein when responding to DNA damage, resulting from exposure to genotoxic contaminants. Genotoxicity is assessed by induced cellular fluorescence, whilst reduction in cell proliferation simultaneously characterises acute toxicity. The assay employs handheld portable instrumentation and disposable elements. This novel technology will be presented with results from a number of validation projects, characterising the toxicity and genotoxicity of a range of industrial effluents, estuarine waters, contaminated sediments and landfill drainage, as well as standard chemicals of environmental concern. The correlation of results with benchmark ecotoxicological assays will also be highlighted.

WP104 Effects of trilostane on reproductive endocrinology of the fathead minnow. L.S. Blake, D.L. Villeneuve, K.M. Jensen, D. Martinović, M.D. Kahl, J.D. Brodin, E.A. Makynen, E.J. Durhan, G.T. Ankley, US EPA Mid-Continent Ecology Division, Duluth, MN; L.S. Blake, Integrated Biosciences, University of Minnesota-Duluth, Duluth, MN. Trilostane is a competitive inhibitor of the steroidogenic enzyme 3β hydroxysteroid dehydrogenase (3β HSD). Given this mechanism of action, it would be expected to disrupt synthesis of multiple steroids involved in regulating fish reproduction. We assessed effects of a 21-d water exposure to trilostane (60, 300 and 1500 μ g/L) on aspects of steroidogenesis and reproduction in adult fathead minnows (*Pimephales promelas*). Additionally we used a suite of in vitro assays to examine trilostane's direct impacts on hormone production (measured by radioimmunoassay [RIA]) and gene expression (using quantitative polymerase chain reaction) in gonad tissue. In vivo exposure to 1500 μ g of the drug/L for 21 d decreased fish fecundity and decreased vitellogenin (vtg) in females, but did not change in plasma vtg concentrations in males. Male gonadal-somatic index (GSI) was increased by exposure to trilostane, but there was no effect

on female GSI. Waterborne exposure to trilostane did not alter the abundance of 3β HSD, 11β HSD, steroidogenic acute regulatory protein, or androgen receptor transcripts in the gonadal tissue. However, ex vivo estradiol (E2) production by gonad tissue collected from fish exposed to 60 μ g trilostane/L in the 21 d test was significantly lower than that of tissue from the controls. When ovary tissue from unexposed fish was treated with trilostane in vitro, 0.64 and 3.4 μ M decreased E2 production, while 0.05 and 0.25 μ M increased E2 production. However, no direct effects on aromatase activity were detected, suggesting that the changes in E2 production likely resulted from impacts on the production of androgenic precursors like T and androstenedione (AD). Trilostane was found to cross-react with the T and AD antibodies, confounding our ability to clearly discern trilostane's effects on androgen production. These data suggest interplay between direct effects of the chemical and potential compensatory responses at the tissue level. Results of this study help establish linkages between modes of action at the biochemical level and reproduction, an ecologically relevant endpoint. *The contents of this abstract do not necessarily reflect official EPA policy.*

WP105 Aquatic Toxicity of Gold and Silver Nanoparticles. B.A. Rabe, ERM, Holland, MI; G.F. Peaslee, E. Helderop, Hope College, Holland, MI; T.B. Higgins, M. McMillan, R. Johnson, G. Choi, Harold Washington College, Chicago, IL. With the increased exploitation of nanotechnologies in such areas as drug-delivery, gene therapy, and in vivo and in vitro bioassays, so too goes the potential environmental exposure from nanomaterials through treatment and disposal of nanomaterial waste. This study focuses on gold and silver nanoparticles and their toxicity as a function of chemical identity, size, shape and stabilizing agent. A modified Frens method was used to make gold and silver nanospheres. To prevent aggregation, the particle surfaces were modified with 16-mercaptohexadecanoic acid (MHA). Characterization of the resulting nanospheres of both gold and silver was performed and their toxicity was assessed using acute and short-term chronic exposures using water fleas (*Daphnia magna*) and fathead minnows (*Pimephales promelas*).

WP106 A survey of polydimethylsiloxanes in personal care products and household commodities. Y. Horii, K. Kannan, Wadsworth Center, New York State Department of Health, Albany, NY; Y. Horii, K. Kannan, Department of Environmental Health Sciences, State University of New York at Albany, Albany, NY. Over the last three decades, silicones have been widely used in consumer products such as electronics, furniture, healthcare, cosmetics, cookware, and medical devices because silicones are believed to be inert. Nevertheless, a few reports suggest that silicones, particularly cyclic polydimethylsiloxanes (PDMSs), may have direct or indirect toxic effects such as estrogen mimics and adverse immunologic responses. For evaluation of the sources of human and environmental exposures, characterization of PDMSs in consumer products is needed. In this study, we measured concentrations of cyclic (D4-D7; octamethylcyclotetrasiloxane [D4], decamethylcyclopentasiloxane [D5], dodecamethylcyclohexasiloxane [D6], tetradecamethylcyclopentasiloxane [D7]), and linear PDMSs (L4-L16) in a variety of consumer products (n=76), including hair care products, body care products, cosmetics, cookware, and sanitation products. Concentrations of PDMSs were measured using a GC-MS at selected ion monitoring (SIM). PDMSs are present in gas chromatograph parts including inlet septa, vial seal, and capillary columns. To reduce instrumental blank levels of PDMSs, many kinds of GC septa and vial seal at different inlet temperatures were tested. Concentrations of cyclic PDMSs in the consumer products analyzed ranged from <0.1 μ g/g to 9380 μ g/g, <0.05 μ g/g to 81800 μ g/g, <0.05 μ g/g to 43100 μ g/g, and <0.05 μ g/g to 846 μ g/g for D3, D4, D5, D6, and D7, respectively. Concentrations of linear PDMSs varied from <0.05 μ g/g to 16800 μ g/g. D5, D6 and D7 were the dominant compounds in most of the products in our analysis. The results suggest that a wide variety of exposure sources exist for cyclic PDMSs, and that these materials are used on a daily basis.

WP107 Occurrence and fate of chlorinated and brominated polycyclic aromatic hydrocarbons in waste incinerators. Y. Horii, K. Kannan, Wadsworth Center, New York State Department of Health, Albany, NY; Y. Horii, K. Kannan, Department of Environmental Health Sciences, State University of New York at Albany, Albany, NY; G. Ok, Department of Environmental Atmospheric Science, Pukyong National University, Busan, South Korea; T. Ohura, Institute for Environmental Sciences, University of Shizuoka, Shizuoka, Japan. Chlorinated polycyclic aromatic hydrocarbons (Cl-PAHs) are ubiquitous contaminants in urban air. Emissions from vehicle exhaust and waste incineration are considered as sources of Cl-PAHs. Some Cl-PAHs have been shown to elicit dioxin-like toxicity and mutagenic properties.

Investigation of the sources and environmental behavior of halogenated PAHs is important to assess risks of these compounds in the environment and in humans. Nevertheless, only limited studies exist on the sources of Cl-PAHs and brominated PAHs (Br-PAHs). In this study, we measured concentrations of 20 Cl-PAHs and 11 Br-PAHs in fly and bottom ashes from 10 municipal waste incinerators from South Korea. Halogenated PAHs were detected in all of the ashes that we measured. Concentrations of total Cl-PAHs and Br-PAHs in the ash samples analyzed ranged from 0.1 μ g/g to several μ g/g and from 0.01 μ g/g to few μ g/g, respectively. The concentrations of Cl-PAHs were approximately ten-fold higher than those of Br-PAHs. Chlorinated phenanthrenes (mono to tri) were the dominant compounds in most of the ashes in our analysis. Typical isomers of halogenated PAHs formed during incineration processes were identified. The results suggest that the concentrations of halogenated PAHs in waste incinerator could be higher than those of dioxins and polychlorinated naphthalenes, and waste incinerators are a source of halogenated PAHs in the atmosphere.

WP108 Interactions of Aqueous Tetracycline with Smectite Clays. Y. Ding, B.J. Teppen, S.A. Boyd, H. Li, Crop & Soil Science, Michigan State University, East Lansing, MI. Tetracyclines are a class of antimicrobials that have been extensively used to improve human and veterinary health. Major portions of tetracyclines ingested by people and animals can be released into the environment, raising concerns regarding the potential risks to ecosystems and environmental quality. Sorption by soils is a determinant controlling transport, fate and hence exposure in the environment. Soil mineral fractions are the dominant sorptive domains for retaining these compounds. In this study, sorption of tetracycline by K⁺- and Ca²⁺-saturated smectite clays was measured using a batch equilibration method. Sorption manifested nonlinear isotherms, and was strongly suppressed by the presence of high levels of inorganic cations (e.g. K⁺ and Ca²⁺) in solution. Sorption of tetracycline by K⁺ and Ca-smectite was concomitant with the release of K⁺ and Ca²⁺ from the clays, suggesting that cation exchange processes are responsible for the sorption of tetracycline. X-ray diffraction patterns showed that the swelling of smectite increased as tetracycline sorption increased, and gradually approached a constant basal spacing of 17.5 to 18 Å. These results indicate that the clay-sorbed tetracyclines are intercalated in interlayer regions, and that tetracycline molecules are probably oriented nearly parallel to the clay siloxane sheets.

WP109 Nutrients and Sex Steroids in Canada Goose Feces: Water Quality and Endocrine Effects. L. Yonkos, D. Fisher, Wye Research and Education Center, University of Maryland, Queenstown, MD; P. Van Veld, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA. Nutrients and sex steroids were measured in droppings from migrant and resident Canada geese (*Branta canadensis* spp.) in the Mid-Atlantic region. Aqueous contaminant concentrations were also measured in regional surface waters impacted by goose activities. Where birds are abundant, feeding and rafting behaviors can serve as a means of contaminant transport. Geese don't introduce nutrients to a watershed; rather, they cycle nutrients from existing plant-bound terrestrial sources (via ingestion) to surrounding surface waters (via excretion/defecation). Where they deposit their waste and the bio-availability of nutrients upon deposition determine the ecological consequence to the watershed. Geese also produce copious fecal steroids, both estrogens and androgens. Consequences to aquatic biota of these steroids are a function of concentration, duration and age/life stage at the time of exposure. Measured nitrogen and phosphorus concentrations in goose droppings (dry weight) were 30.0 $\pm$ 16.57 g/kg and 3.5 $\pm$ 0.89 g/kg, respectively. Nitrogen levels were comparable to those of broiler litter (30 to 40 g/kg) while phosphorus was 3- to 5-fold lower than litter levels (12 to 15 g/kg). Likewise, 17 β -estradiol (E2) in goose droppings was 185 $\pm$ 41.8 ng/g compared to 213 $\pm$ 39.5 ng/g in broiler litter. Contaminant concentrations in a goose sanctuary (5 acre shallow pond) increased rapidly upon arrival of ~ 1,500 migrant birds in early Oct., 2005. Pond E2 exceeded 200 ng/L by late Feb., 2006 before decreasing slowly after the early Apr. departure. Similarly, nutrient levels increased from arrival to a maximum at the time of northern migration. E2 was occasionally detected in tidally influenced surface waters harboring substantial bird populations. As in the sanctuary pond, highest incidences were in late February. Nutrient levels were variable in tidal waters, reflecting the frequent flushing and multiplicity of sources to these systems. Estrogenicity of goose feces in aqueous mixture, demonstrated by in vitro induction of an estrogen-sensitive mammary cell assay, was similar to that of broiler litter which was previously shown to produce endocrine disruptive effects in fathead minnow laboratory exposures.

Similar fathead exposures will be used to investigate in vivo goose feces estrogenicity.

WP110 Cyanobacteria and Cyanobacterial Toxins in Wisconsin Surface Waters: Results of a Statewide Monitoring Program. E.A. Harrahy, University of Wisconsin-Whitewater, Whitewater, WI; D.A. Perkins, C.J. Hedman, W.R. Krick, Wisconsin State Laboratory of Hygiene, Madison, WI. The presence of cyanobacteria (also known as blue-green algae) and the toxins that they may produce are of increasing concern in recreational and drinking waters due to their potential health risks to humans and other biota. The Wisconsin Department of Natural Resources conducted a multi-year study to assess the presence of cyanobacteria in Wisconsin surface waters. The objectives of this study were to identify and enumerate cyanobacteria in select eutrophic lakes and ponds, and to analyze for three cyanobacterial toxins in select samples where concentrations of cyanobacteria were high. Samples were collected from lakes and ponds in each region of the state five times during the summers of 2004 and 2005, and one time during the summer of 2006. Cyanobacteria were detected in 74% of the samples in both 2004 and 2005, and in 68% of the samples in 2006. Cyanobacteria cell densities were above the World Health Organization (WHO) guidance value of 100,000 cells/mL in approximately 20% of the samples tested. Select samples with high concentrations of cyanobacteria were then analyzed for anatoxin-a, cylindrospermopsin and microcystin-LR. Approximately 50% of these samples contained one or more toxins, with microcystin-LR being the most frequently detected. Microcystin-LR concentrations ranged from 1.2 to 7,600 µg/L and anatoxin-a concentrations ranged from 0.68 to 1,750 µg/L. Cylindrospermopsin was not detected in any of the samples analyzed. The information gathered in this monitoring study allowed the Wisconsin Department of Natural Resources and local public health agencies to better assess the risks associated with cyanobacteria.

WP111 The consequences of structure on ecotoxicological profiles of perfluoroalkyl acids (PFAs): A review. J. Newsted, Entrix, Okemos, MI; J. Newsted, J. Giesy, National Food Safety and Toxicology Center, Michigan State University, East Lansing, MI; J. Giesy, Department of Biomedical Veterinary Sciences & Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Perfluoroalkyl acids (PFAs) are synthetic fluorinated organic compounds that can be released to the environment during manufacturing processes, from commercial products and or indirectly via oxidation of precursor molecules containing perfluoroalkyl chains. While PFAs have received increased attention in monitoring programs, the assessment of the potential risks PFAs pose to aquatic organisms and wildlife are still being investigated. One PFA that has received much attention is perfluorooctane sulfonate (PFOS), a perfluoroalkyl sulfonate that was withdrawn from production in 2000. While a large body of ecotoxicological information exists for PFOS, a systematic evaluation of the toxicity of other PFAs has not yet been conducted. This evaluation is needed since some PFAs are still in production and new replacement chemistries are currently being developed for older products. The development of some replacement PFAs is based on results from in vitro and in vivo studies that have demonstrated that toxicity is less for PFAs with chain lengths 6 carbons or less. However, a systematic evaluation of the available ecotoxicological data for PFA of varying carbon chain length had not been previously conducted. All currently available toxicity information for PFAs to aquatic plants, aquatic organisms, and wildlife species was assessed. Analysis of these data show that reduced chain length is associated with reduced toxicity and bioaccumulation. For example, the toxicity of perfluorobutane sulfonate (PFBS) to *Daphnia magna* is approximately 40-fold less toxic than PFOS where the bioconcentration factor for PFBS is greater than 1000-fold less than that of PFOS. This reduction in toxicity is also observed with shorter chain perfluorocarboxylic acids. These and other examples for both perfluorinated carboxylates and sulfonates will be discussed.

WP112 Toxicity and transformation of dinitrotoluenes using *Arabidopsis thaliana*. J. Yoon, J.V. Shanks, Chemical and Biological Engineering, Iowa State University, Ames, IA; D.J. Oliver, Department of Genetics, Development and Cell Biology, Iowa State University, Ames, IA. The biochemical and genetic study and toxicity of dinitrotoluenes (DNTs) will be conducive to applying a phytoremediation strategies to contaminated soil and groundwater. This study presents the toxicity and fate of 2,4-dinitrotoluene (2,4-DNT) and 2,6-dinitrotoluene (2,6-DNT), and gene expression in response to DNT exposure using the model plant *Arabidopsis thaliana*, a very popular system in plant science. From the phytotoxicity tests, DNTs have

toxic effects on the growth of roots and biomass of the plant and the reduced forms, aminonitrotoluenes and diaminotoluenes, were less toxic to the plants than the DNTs. Using radiolabeled DNTs, the mass balance was over 86% and the mineralization by the plants was insignificant. The percentage of the bound radioactivity increased with time. Most radioactivity taken up by the plants was located in the roots in a hydroponic system (68% for 2,4-DNT and 48% for 2,6-DNT). Monoaminonitrotoluene isomers and unknown peaks with short retention times were detected by HPLC with a radiodetector as metabolites in the plants. The metabolites of 2,6-DNT were further characterized by proton NMR spectra and the UV-chromatograms when the plants were fed with either 2,6-DNT or 2-amino-6-nitrotoluene. Expression of a glutathione S-transferase (GST) was induced by 10-fold for 2,4-DNT and 4.7-fold for 2,6-DNT, respectively. However, there was no significant difference in the uptake rates and the tolerance when the wild-type and the *gst* mutant were exposed to different concentrations of the nitroaromatic explosives. This indicates that induction of the GST gene is not related to the detoxification of the compounds.

WP113 Screening Chemicals in Commerce to Identify Possible Persistent and Bioaccumulative (P&B) Chemicals in the Great Lakes and Other Surface Waters. P.H. Howard, W. Meylan, Environmental Science Center, Syracuse Research Corporation, N. Syracuse, NY; D. Muir, Aquatic Ecosystem Protection Research Division, Environment Canada, Burlington, Ontario, Canada. A substructure searchable database of 22,000 chemicals was developed by combining the Canadian Domestic Substances List (DSL - 11,317 chemicals), the US EPA High Production Volume (HPV) chemicals (3549), the US EPA TSCA Inventory Update Rule (IUR) chemicals (14,458 - chemicals produced in >10,000 lbs during 1986, 1990, 1994, 1998, or 2002), and a list of Unknown, of Variable Composition, or of Biological Origin (UVCB) substances (3059). Physical/chemical/fate properties were estimated using EPISuite (<http://www.epa.gov/oppt/exposure/pubs/episuitd.htm>) estimate methods to identify potentially persistent (P) and bioaccumulative (B) chemicals. Using QSAR properties and scientific judgment, new chemicals not previously measured in the Great Lakes or other surface waters or sediment have been identified. Chemical and use classes have also been assessed for potential P & B characteristics. Four hundred chemicals were identified with P and/or B characteristics most of which are in current use or recently listed on the IUR. Less than 10% of the individual substances are currently monitored in environmental samples. Chemicals with high P & B properties will be assessed for the potential for being analyzed by existing or new analytical methods.

WP114 Dietary exposure of juvenile rainbow trout (*Oncorhynchus mykiss*) to syn and anti isomers of Dechlorane Plus: Bioaccumulation Parameters and Metabolism. G.T. Tomy, K. Pleskach, J. Hare, Department of Fisheries and Oceans, Winnipeg, Manitoba, Canada; C. Marvin, E. Sverko, Environment Canada, Burlington, Ontario, Canada. Juvenile rainbow trout (*Oncorhynchus mykiss*) were exposed via their diet to separate doses of syn and anti isomers of Dechlorane Plus (DP) in the laboratory for 49 days, followed by 154 days of untreated food to examine bioaccumulation parameters and metabolic products. There was a linear increase in the amount of syn and anti-DP during the uptake phase of the experiment with respective uptake rate constants of 0.387 and 0.203 nmoles per day. The elimination of both isomers from the fish obeyed first order depuration kinetics with calculated half-lives of 51.3 and 37.1 days for syn and anti-DP, respectively. Work is ongoing to characterize metabolites.

WP115 Aquatic ecotoxicity of the selective serotonin reuptake inhibitor sertraline hydrochloride in a battery of freshwater test species. E. Minagh, radiation and environmental science centre, Focas institute, Dublin, Ireland; E. Minagh, Shannon aquatic toxicity laboratory, Enterprise Ireland, Clare, Ireland. Sertraline hydrochloride is a selective serotonin reuptake inhibitor and is widely prescribed to patients suffering from depression, anxiety and other psychiatric disorders. Studies have shown that pharmaceutical products such as sertraline have been identified in surface waters and ground waters. At present there is a lack of information on the aquatic toxicity of the effects of the selective serotonin reuptake inhibitor (SSRI), sertraline hydrochloride on environmental organisms; hence research in this area is timely. This study investigates the effects of sertraline hydrochloride on a battery of freshwater species representing four trophic levels. These included bioluminescence inhibition of the bacterium *Vibrio fischeri* (decomposer), growth inhibition of the alga *Pseudokirchneriella subcapitata* (primary producer), acute and chronic immobilization and 21 d reproduction in the cladoceran *Daphnia*

magna (primary consumer) and mortality of the invertebrate *Thamnocephalus platyurus* and juvenile *Oncorhynchus mykiss* (secondary consumer). Toxicity of sertraline hydrochloride was also investigated using the two permanent fish cell lines, RTG-2 and PLHC-1 using two viability endpoints. The sensitivities of the test species to sertraline hydrochloride were as follows: *Pseudokirchneriella subcapitata* > 21 d *Daphnia magna* reproduction > 21 d *Daphnia magna* mortality > *Oncorhynchus mykiss* > *Thamnocephalus platyurus* > *Daphnia magna* acute assay > PLHC-1 cell line > RTG-2 cell line > *Vibrio fischeri* determined from the calculated ecotoxicity values (EC50/LC50). The most sensitive species *Pseudokirchneriella subcapitata* was almost one order of magnitude more sensitive than the *Daphnia* 21 day test which was the second most sensitive assay. These results show the advantages of having a tiered battery approach as different organisms varied greatly in sensitivity. These results demonstrate that sertraline adversely affects aquatic organisms at levels several orders of magnitude higher than that reported in municipal effluent concentrations. It is documented, however, that chronic exposure effects may be as a result from nanomolar or picomolar exposure, therefore further research into the chronic toxicity is needed.

WP116 Fate and transport of Irgarol 1051 in a modular estuarine mesocosm. Y. Sapozhnikova, E. Wirth, Marine Ecotoxicology, NOAA/NOS/NCCOS/CCEHBR/HML, Charleston, SC; P. Pennington, M. DeLorenzo, M. Fulton, Marine Ecotoxicology, NOAA/NOS/NCCOS/CCEHBR, Charleston, SC; V. Winder, Marine Biology, College of Charleston, Charleston, SC. Fate and transport of Irgarol 1051 were assessed using a modular estuarine mesocosm containing natural seawater, saltmarsh sediments, marsh grass, shrimp, clams, snails, and naturally derived planktonic and benthic microorganisms. The mesocosms were enclosed in a greenhouse under near ambient conditions, and included a saltwater sump to simulate tidal flux. The exposure was comprised of four replicate treatments of 0, 0.1, 1, and 10 µg/L. Solid-Phase Extraction (SPE) (C18 SPE cartridge, 1g, 6 ml) was used to extract Irgarol and its major metabolite M1 (aka GS26575) from water samples. Sediment samples were extracted using Accelerated Solvent Extraction with 100% dichloromethane at 120°C. Recoveries of Irgarol and M1 from fortified water and sediment samples were 103 and 93% (water); and 85 and 80% (sediments) for Irgarol and M1, respectively. Method detection limits of both analytes were 1 ng/L for water samples and 1 ng/g for sediments. Irgarol and M1 were separated and quantified utilizing Liquid Chromatography Tandem Mass Spectrometry (LC-MS-MS) with ElectroSpray Ionization in Multiple Reaction Monitoring (MRM) mode. The chromatographic separation was achieved using a C18 HPLC reverse phase column. Aqueous concentrations of Irgarol declined by about 90% over the course of the 35 day experiment while Irgarol was accumulated in the sediments. The aqueous concentration of the metabolite, M1 increased over the course of the experiment. The mass balance of Irgarol and its metabolite will be presented.

WP117 Distribution of antifouling biocides in California marinas. Y. Sapozhnikova, E. Wirth, Marine Ecotoxicology, NOAA/NOS/NCCOS/CCEHBR/HML, Charleston, SC; M. Fulton, Marine Ecotoxicology, NOAA/NOS/NCCOS/CCEHBR, Charleston, SC; N. Singhasemanon, N. Bacey, Department of Pesticide Regulation, California Environmental Protection Agency, Sacramento, CA. Antifouling biocides are used to prevent settlement and growth of organisms on submerged surfaces of boats and ships and Irgarol 1051 is currently among the most widely used organic booster biocides worldwide. This study reports Irgarol 1051, its major metabolite M1 (aka GS26575) and diuron (other antifouling pesticide) concentrations found in California marinas. Seasonal water samples were collected in the summer and fall of 2006 from twelve marinas throughout southern and northern California. The samples were extracted using C18 Solid Phase Extraction cartridges (1g, 6 ml) and analyzed utilizing Liquid Chromatography Tandem Mass Spectrometry (LC-MS-MS) with ElectroSpray Ionization in Multiple Reaction Monitoring (MRM) mode. The chromatographic separation was achieved using a C18 HPLC reverse phase column. The highest concentrations of Irgarol and M1 were found in July of 2006, reaching up to 712 and 217 ng/L, respectively. In general, concentrations of both Irgarol and M1 were greater in samples collected during the summer (15 to 712 and 7 to 217 ng/L for Irgarol and M1, respectively) compared to those detected in the fall (12 to 216 and 1 to 39 ng/L for Irgarol and M1, respectively). Diuron concentrations did not exhibit a seasonal trend and remained at the same level in summer (5-24 ng/L) and the fall (7-27 ng/L) sampling. Irgarol is highly toxic to aquatic plants at concentrations as low as 136 ng/L. Thus, the higher

concentrations detected in the California marinas may pose a risk for marine phytoplankton in the contaminated areas.

WP118 Microbial Reduction of Perchlorate in Ammunitions Wastewater: Detoxification by Elemental Iron. S. Ahn, D.K. Cha, Civil and Environmental Engineering, University of Delaware, Newark, DE; B.J. Kim, U.S. Army Engineering Research and Development Center, Champaign, IL; D. Kim, Environmental Engineering, Kongju National University, Kongju, South Korea. US Army and DoD facilities generate perchlorate (ClO₄⁻) from munitions manufacturing and demilitarization processes. Ammonium perchlorate is one of the main constituents in Army's new main charge melt-pour energetic, PAX-21. In addition to ammonium perchlorate, RDX and 2,4-dinitroanisole (DNAN) are the major constituents of PAX-21. In order to evaluate microbial perchlorate reduction as a practical option for the treatment of perchlorate in PAX-21 wastewater, we conducted preliminary biodegradation experiments using glucose as the primary source of electrons and carbon. Batch experiments showed that negligible perchlorate was removed in batch reactors containing PAX-21 wastewater while control bottles containing seed bacteria and glucose rapidly and completely removed perchlorate. These results suggested that the constituents in PAX-21 wastewater may be toxic to perchlorate-reducing bacteria. A series of batch toxicity test was conducted to identify the toxic constituents in PAX-21. Negligible perchlorate was removed from wastewater containing 100 mg/L of DNAN solution after 5 days of incubation while perchlorate in RDX-laden wastewater was removed with the similar rate as in the control bottles, suggesting that DNAN was responsible for inhibiting the activity of perchlorate-respiring bacteria. It was hypothesized that pretreatment of PAX-21 by zero-valent iron granules will transform toxic constituents in PAX-21 wastewater to non-toxic products. We observed complete reduction of DNAN to 2,4-diaminoanisole (DAAN) and RDX to formaldehyde in abiotic iron reduction study. After a 3-day acclimation period, perchlorate in iron-treated PAX-21 wastewater was rapidly decreased to an undetectable level in 2 days. Respirography of iron-treated PAX-21 wastewater after the complete reduction of perchlorate resulted in faster perchlorate reduction. This result showed that iron treatment not only removed energetic compounds but also eliminated the toxic constituents that inhibited the activity of perchlorate respiring bacteria.

WP119 Transformation of antibacterial agent triclocarban in soils and biosolids-applied soils. J. Kwon, K. Xia, K.L. Armbrust, State Chemical Laboratory of Mississippi, Mississippi State University, Mississippi State, MS. Triclocarban is an antibacterial agent, commonly used in cosmetics, household goods and personal care products, plastics, and textiles for antibacterial purpose. The widespread use of triclocarban has raised concerns about the environmental impacts of its residues. Triclocarban has been frequently detected in biosolids, aquatic environment and soils. To understand its fate in soils, two different soils (intact, sterilized, and biosolid-applied) treated with [¹⁴C]-triclocarban at 3.0 mg/kg (¹⁴C-labelled + non-labelled) were incubated for 6 weeks at 25°C. During the experimental period, ¹⁴CO₂ evolved was trapped and the radioactivity was measured weekly. Upon completion, soils were extracted with various solvents to determine the partition pattern of the residue triclocarban within each soil. A separate set-up treated with non-labelled triclocarban was incubated concurrently and the degradation products formed were examined using a liquid chromatography-mass spectrometry (LC-MS). The kinetics of triclocarban biotic and abiotic mineralization in the two soils with different physico-chemical properties will be discussed in detail.

WP120 Evaluation of steroid estrogen and estrogenic activity in surface waters from Central California. R. Lavado, D. Schlenk, Department of Environmental Sciences, University of California Riverside, Riverside, CA; J.E. Loyo-Rosales, E.P. Kolodziej, D.L. Sedlak, Department of Civil and Environmental Engineering, University of California Berkeley, Berkeley, CA. The objective of this study was to evaluate feminizing activity of water samples from waterways of the Central Valley of California, by combining chemical analyses with in vitro and in vivo expression of vitellogenin in juvenile rainbow trout (*Oncorhynchus mykiss*). Water samples were analyzed every two months from July 2006 to April 2007 from 16 sites. The highest 17β-estradiol equivalents (EEQs) detected by both methods were detected in the Sacramento River Delta (9 to 164 ng/L in vitro and <0.1 to 5 µg/kg in vivo) and in the Napa River (0.1 to 68 ng/L in vitro and 0.2 to 12 µg/kg in vivo). High in vitro and low in vivo estrogenicity was observed at the Tuolumne and Merced Rivers. Low in vitro and high in vivo estrogenicity was observed in the upper Sacramento and lower Feather Rivers. These

results indicate the presence of compounds with varied mechanisms of action. The most frequent hormone detected in water was estrone and the highest concentrations were found in the Yuba and the Napa Rivers (23 and 1.4 ng/L, respectively). The highest alkylphenol ethoxylate levels were found in the Napa River (150 ng/L for NP) and Sacramento River Delta (400 ng/L for NP2EO). The levels of "known" estrogenically active chemicals did not correlate with estrogenic activity observed in these waterways by in vitro and in vivo methods. These results indicate that compounds other than steroid estrogens may be responsible for the acute estrogenic activity of water in the Central Valley of California.

WP121 Contaminants of emerging concern in the Eastern oyster (*Crassostrea virginica*) from the Georgia coast, USA. J.S. Smith, A.M. Peck, Skidaway Institute of Oceanography, Savannah, GA. Flame retardants and personal care products and pharmaceuticals (PCPPs) have been found to be ubiquitous in aquatic environments. Little is known about the environmental fate and effects of these compounds, particularly in estuarine and coastal systems, however, many are persistent and bioaccumulative. Because of this, there is growing concern about the fate and distribution of these compounds in Georgia's waters, especially along the coast where rapid development and population growth is likely increasing the release of the compounds to the environment. The eastern oyster (*Crassostrea virginica*) is one of the most abundant bivalve species inhabiting the eastern U.S. coastal zone. *C. virginica* has been used as an integrative water quality bioindicator for decades, because they accumulate chemical contaminants and integrate exposures via the water column. Oysters were collected from viable beds from 21 sites with differing landuses (pristine, harvesting bed, residential, marina, and industrial) in the six coastal GA counties. Sites were sampled a total of four times to include two summers and winters. These samples are currently being analyzed for a suite of emerging environmental contaminants including: polybrominated diphenyl ethers (PBDEs), hexabromocyclododecane (HBCD), synthetic musk fragrances, and methyl triclosan. Data for these compounds are limited for this region, and this is the first attempt to determine the distribution of these compounds along Georgia's coast.

WP122 Redox characterisations of the shallow groundwaters of Inner Mongolia and their implications on the mobilisation of arsenic. P. Bhattacharya, F. She, J. Gunnar, Department of Land and Water Resources, KTH-International Groundwater Research Group, Stockholm, Sweden; A.B. Mukherjee, Department of Biological and Environmental Sciences, Helsinki University, Helsinki, FINLAND; S. Ondra, Faculty of Science, Institute of Geological Sciences, Masaryk University, Bruno, Czech Republic; K.S. Sajwan, Department of Natural Sciences and Mathematics, Savannah State University, Savannah, GA; Z.M. Xie, Department of Resources/Soil Sciences, Zhejiang University, Hangzhou, China. Arsenic (As) king of poison, is an ubiquitous element in nature and the last 1000 years, humans have lived with this toxic element and the next 1000 years, As will be also with them. In 1986, first As in Chinese water was reported. Although across the world there are over one hundred million people slowly being poisoned by the availability of As in drinking water. Inner Mongolia has an area of 1.18 million km² occupying 12% of China's land area & capital Hohhot with 23.8 million people live in this region contaminated with As, about 2.5 x 10⁵ people affected by endemic disease. Inner Mongolia is an arid and semi-arid region where surface water resources are scarce and hence groundwater is the main source of drinking water for the population. As concentration has been reported to be between >1 and 1,480 µg/L whereas drinking water guideline value as per WHO is <10 µg/L. Due to enhanced As concentration in the groundwater, population in this region suffers from skin lesions (keratosis, melanosis and skin cancer) like people in Bangladesh and West Bengal, India. HAB groundwater data show high concentration of As include Fe and Mn have been released under reduction condition. The present study indicates that the shallow HAB groundwater contain high concentration of total As with predominance of As(III). Arsenic concentrations were correlated with Fe, Mn, DOC, HCO₃⁻ and NH₄⁺. The mechanism of the arsenic mobilization is biogeochemical and possibly being triggered by the high DOC concentrations in shallow groundwaters that relates to the practice of dumping the sunflower and the maize wastes on the ground surface. Improved water supply system, employment new water and energy resources, poverty fighting and expertise cooperation are recommended. In this presentation most recent concerns about arsenic contamination in groundwater in Inner Mongolia will be discussed.

WP123 Cadmium detoxification mechanism of evening primrose (*Oenothera odorata*). D. Kim, K. Son, J. Lee, J. Kim, J. Jung, Environmental science and ecological engineering, Korea University, Seoul, South Korea. The purpose of this study is to understand the Cd detoxification mechanism of *Oenothera odorata* that was investigated with predominant species in abandoned mine soils for the foundation of phytoremediation. *O. odorata*, grown in sand culture during 4 weeks, were implanted to hydroponic culture media and were grown for a week without Cd. Roots of intact plants were submitted to 0, 10, 25, 50, 100 and 200 µM Cd and harvested after 3 days after exposure in prepared culture solution. Growth parameters, contents of malondialdehyde, Cd accumulation and cell wall bounded Cd, and thiols compounds were analysed. Biomass of *O. odorata* was only affected in concentrations higher than 25 µM Cd, but the presence of low cadmium concentrations induced significant alterations in constitutive thiols and triggered the synthesis of PCs, bearing two to four oligomeric repeats. The median inhibition concentration (IC₅₀) of root elongation was analysed as 10 µM Cd. 60% of the total accumulated Cd in *O. odorata* was adsorbed to the cell wall of roots, 20% was adsorbed to the cell wall of shoots. It was found from the result that another 20% of Cd by the thiol compounds, such as PCs, GSH, from inside root cell was stored in the vacuole. The correlation between the cadmium to be flowed in to the cell and contents of PCs was lower the correlation between The accumulated cadmium in *O. odorata* and contents of PCs. These results lead us to the conclusion that the Cd is adsorbed in the cell wall and finally it is dissociated and an effect in PCs synthesis it causes. We can classify the *O. odorata* as a Cd hyperaccumulator because it can accumulate more than 100 µg Cd g⁻¹ (DW) in shoot. The *O. odorata* cultivar used in this study might be considered as a Cd-shoot excluder, as most of the Cd taken up by the plant has been retained in roots. The detoxification mechanisms of *O. odorata* is not only Cd chelation by thiol compounds in cell, but also Cd adsorption on cell wall when it was exposed to Cd.

WP124 Arsenic tolerance mechanism of *Oenothera odorata* from a mine population involves the induction of phytochelatins in roots. D. Kim, J. Kim, N. Koo, S. Hyun, Environmental science and ecological engineering, Korea University, Seoul, South Korea. The arsenate tolerance mechanisms of *Oenothera odorata* through comparisons of nonmetallophilous (NMP) and metallophilous (MP) populations exposed to 0~50 µM arsenate were examined using hydroponic culture. Two of 12 populations from various sites were selected for comparison based on amplified fragment length polymorphism (AFLP) results. The As accumulation in roots and lipid peroxidation increased with increasing arsenate in the external solution for both populations. The results of lipid peroxidation indicated that MP individuals were less damaged from oxidative stress than were NMP individuals. NMP individuals accumulated more As in both shoots and roots than did MP individuals. Upon exposure to 50 µM, As accumulation of up to 328 and 304 µg g⁻¹ was observed in the roots of NMP and MP individuals, respectively. NMP species translocated up to 21 µg g⁻¹ of As to the shoot, whereas MP individuals translocated little As (about 4.5 µg g⁻¹) to the shoot over all treatment. The phytochelatin (PC) content was linearly correlated with the As concentrations in roots of both NMP ($y = 0.89x$, $r^2 = 0.979$) and MP ($y = 1.69x$, $r^2 = 0.945$) individuals. The results of relationship between NMP and MP populations indicate that As induced the production of PCs in the roots of MP individuals compared to NMP individuals. The addition of L-buthioninesulfoxide (BSO) to nutrient solution containing As confirmed that PCs play a major role in detoxifying As according to the growth inhibition in MP individuals treated with BSO. Thus, the present work suggested that the induction of PCs in roots might play important roles as As tolerance in *O. odorata* from a mine population.

WP125 Gene Expression Profiles of Fathead Minnows Exposed to Surface Waters Contaminated with Natural and Pharmaceutical Xenobiotics. N.G. Reyero Vinas, N.D. Denslow, Department of Physiological Sciences and Center for Environmental and Human Toxicology, University of Florida, Gainesville, FL; C.M. Lavelle, P.W. Sorensen, I.R. Adelman, Dept. of Fisheries, Wildlife, and Conservation Biology, University of Minnesota, St. Paul, MN; D. Martinović, ORD, NHEERL, MED, U.S. EPA, Duluth, MN. Rivers containing effluents from water treatment plants and high use animal agricultural areas are complex soups of compounds, ranging from pharmaceuticals to natural hormones from human and animal wastes. To test the effects of these effluents on the expression of genes required for reproduction, we caged male fathead minnows (*Pimephales promelas*) and exposed them for 48 hours to effluents at four different locations, known

from prior experience to be contaminated. The four sites were chosen because of their specific locations: up-stream and down-stream from one water treatment plant, a river site receiving agricultural runoff and a site immediately downstream from the metropolitan sewage treatment plant (STP) in St. Paul, MN. Gonads and livers were isolated and immediately frozen in liquid nitrogen for total RNA extraction. We used a 22,000 gene microarray for fathead minnow to test changes in gene expression. For both tissues, exposed males showed significant changes in gene expression profiles among the four sites tested, suggesting that each site had a distinct mixture of compounds. We have also tested a panel of genes consisting of estrogen receptors, steroidogenic acute regulator protein, aromatase, among other key genes from the HPG (hypothalamus-pituitary-gonadal) axis, by Q-PCR. To understand further the effects at one of the sites, downstream from the STP in St. Paul, we exposed male fathead minnows for three weeks and measured their competitive nest holding behavior and their gene expression profiles. Several biological processes are affected by the exposures, which relate to their phenotypic changes.

WP126 Ecogenotoxicological evaluation of cyanobacterial strains using plant and fish bioassays. H.D. Laughinghouse, Department of Biology, John Carroll University, University Heights, OH; H.D. Laughinghouse, D. Prá, A. Rieger, S.I. Franke, Laboratório de Genética e Biotecnologia, Universidade de Santa Cruz do Sul, Santa Cruz do Sul, Rio Grande do Sul, Brazil; M.E. Silva-Stenico, M.F. Fiore, Laboratório de Biologia Celular e Molecular, Universidade de São Paulo, CENA, Piracicaba, São Paulo, Brazil; S.I. Franke, Curso de Nutrição, Universidade de Santa Cruz do Sul, Santa Cruz do Sul, Rio Grande do Sul, Brazil. Water pollution by toxic cyanobacteria is a worldwide problem, worsening with eutrophication. Due to its biological significance, genotoxicity should be a focus for pollution biomonitoring, specially with increasing complexity of the toxicological environment where organisms are exposed. Cyanobacteria have a large number of bioactive compounds, most completely lacking toxicological data. Microcystins are potent cyclic heptapeptides produced mainly by *Microcystis* spp. On one hand, the hepatotoxicity of microcystins has been well-documented, on the other hand information on genotoxic effects of microcystins is relatively scarce. In our study, we evaluated the genotoxicity and ecotoxicity of aqueous extracts from two strains of *M. aeruginosa*: NPLJ-4, with high levels of microcystin and NPCD-1, negative to microcystins but with high levels of aeruginopeptin, a depsipeptide which lacks toxicity studies. Five endpoints using a plant and a fish were applied: root growth inhibition, chromosomal aberrations, mitotic divisions and micronucleus assays in *Allium cepa*, and primary DNA damage (i.e. single and double strand breaks and alkali-labile sites) evaluated by the comet assay in *Actinax* sp. fish. The extracts of NPLJ-4 were diluted at 0.01, 0.1, 1, 10 ppb of microcystins; the same cell dry weight was used to dilute NPCD-1, a parameter for comparison, and water was the control. Preliminary results demonstrated that both strains inhibit root growth and induce root abnormalities. The strain rich in aeruginopeptins seems more mutagenic, altering the cell cycle, observed in other depsipeptides that have reported mitotic arrest by altering spindle metabolism, while microcystins seem mitogenic. Given the lack of studies of this nature for cyanotoxins, these findings are novel and indicate a need for future research on cyanobacterial strains negative for microcystin. The understanding of the potent genotoxicity of *M. aeruginosa* extracts will help determine a possible link between cyanobacterial blooms and high risk of liver cancer found in some areas, and establish water level limits for toxins not yet studied like depsipeptides.

WP127 Responses of *Lemna gibba* exposed to an equitoxic mixture of triclosan and metolachlor across a range of nitrogen and phosphorous ratios. B. Fulton, R. Brain, B. Brooks, Baylor University, Waco, TX. Emerging contaminants such as pharmaceuticals and personal care products (PPCPs) have received increasing attention due in part to their potential toxicity to aquatic biota. Widespread and persistent use of pesticides and PPCPs supports the potential that they may co-occur in aquatic systems, thus leading to potential combined effects in aquatic plants. The present study investigated individual and combined toxicity of triclosan, a widely used antimicrobial disinfectant agent, and a heavily used chloroacetamide herbicide, metolachlor, to *Lemna gibba*. Each compound targets fatty acid biosynthesis; specifically, triclosan inhibits enoyl-acyl carrier protein reductase and metolachlor targets acyl-CoA elongase enzymes. Following a 7-d static renewal exposure to triclosan, the *L. gibba* median effective concentrations (EC50) for wet mass, frond number, and chlorophyll *a* were 84, 98, and 129 µg/L, respectively. A similar 7-d study was performed with metolachlor; EC50s for wet mass,

frond number, and chlorophyll *a* were 67, 98, and 264,000 µg/L, respectively. The same experimental design was used with an equitoxic mixture of the two chemicals to determine the type of joint toxic action. S-values were computed using the EC50 values from each individual chemical as the selected toxic benchmark concentration. A concentration addition approach predicts S to equal 1 at the selected toxic effect (EC50). Respective corresponding S-value results for frond number and wet mass were 0.87 and 0.71, indicating that the interactive effects are similar to concentration addition. Because standardized toxicity tests with plants cannot assess responses under nutrient limitation, *L. gibba* were grown at a range of molar nitrogen and phosphorous ratios including those representative of heavy agricultural rowcrop environments (N:P=2554), Redfield ratio (N:P=16), and waste water effluent (N:P= 0.7). Subsequently, individual and mixture studies with metolachlor and triclosan were performed under various N:P stoichiometries. Results pertaining to the interactive effects of nutrient gradients on the toxicity of this particular mixture to *L. gibba* will be presented in the context of co-occurrence and nutrient gradients.

WP128 Aquatic toxicity of parabens in *Daphnia magna* and *Pimephales promelas*: Application of chemical toxicity distributions. L. Dobbins, T. Valenti, R. Brain, B. Brooks, Baylor University, Waco, TX. Parabens are widely used antimicrobial agents found in numerous pharmaceuticals and personal care products. Parabens are commonly used because of their low toxicity in mammals and are generally recognized as safe. However, toxicity of parabens has not been established in aquatic organisms that could potentially be exposed continuously to parabens discharged to effluent-dominated systems. Utilizing standard, 48-hour acute toxicity tests, fathead minnow and *Daphnia magna* LC50 values were derived for six parabens (methyl paraben, ethyl paraben, propyl paraben, isobutyl paraben, butyl paraben, benzyl paraben) and their primary degradation product (p-hydroxybenzoic acid). In both species, there was greater than a 5-fold difference in toxicities between the least toxic compound, p-hydroxybenzoic acid, and the most toxic compound, benzyl paraben. Increased toxicity was observed with increasing molecular weight of the compounds. LC50 values ranged from 4.59 mg/L to >125 mg/L in fathead minnows and from 3.14 mg/L to >125 mg/L in *D. magna*. Previous studies from our group demonstrated the utility of chemical toxicity distributions (CTD) to evaluate toxicity of chemicals in the same class or with similar mechanisms of action. We used LC50 values to construct CTDs, which allowed us to determine the probability of finding a paraben that causes mortality at or below the expected environmental concentration. The CTDs showed minimal hazard of acute toxicity in the environment, as all compounds cause toxicity at concentrations much greater than expected environmental concentrations. However, several parabens are known estrogen agonists, which suggests that additional study is required for estrogenic responses in fish following chronic exposure.

WP129 Influences of pH on ambient toxicity of the harmful alga *Prymnesium parvum* to aquatic life. T. Valenti, B. Brooks, M. Lahousse, L. Dobbins, Baylor University, Waco, TX; J. Grover, University of Texas at Arlington, Arlington, TX; D. Roelke, Texas A&M University, College Station, TX. The frequency and severity of harmful algal blooms (HAB) in marine and freshwater systems are becoming more pronounced potentially as anthropogenic activities alter physical and biological components of ecosystems. The occurrence of HABs can trigger economic losses that exceed millions of dollars annually by impairing ecosystem functions and biological entities, as well as posing direct threats to human health. Consequently, substantial research has targeted variables that may facilitate environmental conditions in which certain species proliferate rampantly. The haptophyte *Prymnesium parvum* (Golden algae) is a nuisance species that reportedly releases the toxins prymnesin-1 and prymnesin-2. The chemical structures of the toxins suggest that it will act as a weak ionizable base in aqueous solutions, thus becoming more unionized at higher pH ranges. Although both ionized and unionized forms of chemicals may be absorbed, the propensity for absorption by the latter is often far greater. Bioassays were conducted in the laboratory with water samples collected from two reservoirs in central Texas, USA, experiencing fish kills attributed to *P. parvum* blooms, as well as cultures of *P. parvum* reared in the laboratory. Samples were adjusted to environmentally relevant surface water pH ranges (6.5, 7.5, 8.5) to investigate the potential effects of ionization state on toxicity. *Pimephales promelas* and *Daphnia magna* were used as model test organisms in these experiments. There was a definitive relationship between toxicity and pH as survivorship was markedly lower for all bioassays completed at pH 8.5 compared to pH 6.5. In

general, there was a 4-fold difference in LC50 values between pH 8.5 and 6.5. In some experiments, LC50 values could only be calculated for the highest pH due to insufficient mortality at the other pH ranges. Data generated in this study suggests that toxic allelochemicals produced by *P. parvum* act as ionizable weak bases. These findings have implications for ecological risk assessment of HABs and management of fisheries experiencing impacts by *P. parvum*.

WP130 Differences in Lethal Concentrations and Body Burden Values in Three Age Groups of *Xenopus laevis* Tadpoles Exposed to Antimicrobial Xenobiotics. M.L. Kumsher King, K.L. Dickson, G.C. Nallani, W.T. Waller, B.J. Venables, Institute of Applied Science, University of North Texas, Denton, TX. Triclosan is an antimicrobial agent found in personal care products. In a survey by the USGS, triclosan was one of the most frequently detected compounds in U.S. streams, with a median concentration of 0.14 µg/L. At environmentally relevant concentrations, triclosan is not lethal nor does it induce teratogenic effects in *Xenopus* embryos following a 96-hr exposure period. Results of three tests yield LC50 values of 0.81 mg/L, 0.85 mg/L and 0.86 mg/L for 0-wk tadpoles. Surprisingly, the 96-hr LC50 for triclosan in 4-wk tadpoles is 0.24 mg/L and the 96-hr LC50 value for triclosan in 8-wk tadpoles is 0.29 mg/L. These LC50 values are about three times lower than the values calculated for the 0-wk tadpoles and suggest that older tadpoles are more sensitive to triclosan than younger tadpoles. However, GC/MS analysis of body burden estimates a 96-hr LD50 value for 0-wk tadpoles of 7.7 µg/g, whereas the 96-hr LD50 for 4-wk and 8-wk tadpoles is 171 µg/g and 221 µg/g, respectively. Therefore, based on body burden analysis, the 0-wk tadpoles are far more sensitive to triclosan than older tadpoles. The LD50 for 0-wk tadpoles is 22 times lower than 4-wk tadpoles and 29 times lower than 8-wk tadpoles. No methyl-triclosan was detected in any of the tissue samples analyzed and does not appear to form endogenously within the 96-hr exposure period. Triclocarban is also used in personal care products and generally co-occurs with triclosan in surface waters. Streams surveyed by the USGS had concentrations up to 1550 ng/L. Initial studies with triclocarban indicate that it is more toxic than triclosan. The 96-hr LC50 for 4-wk and 8-wk tadpoles is 0.09 mg/L and 0.08 mg/L, respectively.

WP131 A Preliminary Evaluation of the Presence of Organic Wastewater Contaminants in Cave Streams in Eastern Oklahoma and Western Arkansas. J. Bidwell, Department of Zoology, Oklahoma State University, Stillwater, OK; C. Becker, USGS, Oklahoma Water Science Center, Oklahoma City, OK; S. Hensley, R. Stark, US Fish and Wildlife Service, Oklahoma Ecological Services, Tulsa, OK. The prevalence of organic wastewater contaminants (OWCs- antibiotics, hormone residues, various pharmaceutical compounds, and other trace organics) in surface waters of the United States has been reported in a number of recent studies. In karstic areas, surface contaminants may be transferred to ground water and ultimately cave ecosystems where they may impact resident biota. In the present study, we deployed polar organic chemical integrative samplers (POCIS) and semi-permeable membrane devices (SPMD) in six caves and two surface water sites located in the lower Neosho and Upper Illinois River Basins of Oklahoma and Arkansas. The surface water site in Oklahoma was directly downstream from the outfall of a municipal wastewater treatment plant (WWTP) and previous studies indicated a link between this stream and one of the caves investigated. The samplers were left onsite for 30 days and the extracts derived from them were evaluated for 159 different compounds including 68 common OWCs, 33 antibiotics/pharmaceuticals, and 58 pesticides and chlorinated organics. A total of 35 different OWCs and antibiotics/pharmaceuticals were measured in the sampler extracts at the microgram level, with 14 of these compounds measured in cave samples. An additional 32 chlorinated organics, pesticides and OWCs were detected at the nanogram level, with 23 of these compounds measured in cave samples. Cholesterol and phthalates were most commonly detected at the microgram range, while flame retardants, organochlorine pesticides and antibacterial compounds were most common at the nanogram range. Since so little is known about how these organic contaminants may influence cave stream fauna, their presence in these systems, even at low concentrations, is a concern. Additional studies that further quantify OWC levels in these habitats and investigate links between land use activities and cave water quality are critical to understand the risk these chemicals pose to cave habitats.

WP132 Select Current-Use Flame Retardants in the Eggs and Plasma of American Kestrels (*Falco sparverius*) from Southern Ontario. P. Martin, E. Sverko, E. Kaminski, Environment Canada, Burlington, Ontario,

Canada; G. Tomy, Department of Fisheries and Oceans, Winnipeg, Manitoba, Canada; R. Valenzona, University of Waterloo, Waterloo, Ontario, Canada. Egg samples were collected from identified nest boxes from the Niagara region through to central southwestern Ontario. Subsequently, hatching serum samples were collected from the same nest boxes. Samples were analysed for 8 current-use flame retardants: polybrominated diphenyl ethers (PBDE), pentabromoethylbenzene, hexachlorobutadiene, 1,2-bis(2,4,6-tribromophenoxy)ethane (BTBPE), tetrabromo-p-xylene, pentabromotoluene, decabromodiphenyl ethane (DBDPE) and dechlorane plus (DP). The PBDEs were the highest in total concentration in both egg and plasma, 0.6 ng/g - 15.2 ng/g and 0.08 ng/ml - 1.1 ng/ml, respectively. BDE's 47, 99, 100, 153, 154, 138 and 183 were detected in the eggs, however we did not detect BDE's 138 and 183 in the plasma. Similarly, no BTBPE was detected in the plasma but measured in the eggs at 0.02 ng/g - 1.9 ng/g. Both the syn and anti stereoisomers of the chlorinated flame retardant, DP, were detected in eggs ranging from 0.01 ng/g - 0.25 ng/g. The highest egg concentration was measured in the Niagara region, nearest the manufacturer of DP. The spatial pattern for the plasma samples were similar, however only anti-DP was detected. Our findings suggest that the mother Kestrels ingest these chemical from their terrestrial foodweb and are in ovo transferred to the eggs.

WP133 Toxicity of the Quinones Menadione, Plumbagin and Juglone to Freshwater and Estuarine Organisms. C. Mitchelmore, Chesapeake Biological Laboratory, University of Maryland, Solomons, MD; L. Yonkos, Wye Research and Education Center, University of Maryland, Queenstown, MD. Three quinone compounds (menadione, plumbagin and juglone) are acutely lethal to a wide range of organisms at low ppm concentrations but are presumed to degrade rapidly to benign residuals. As such, they are being considered as biocides for ballast water invasive species control. Because of their redox cycling properties, quinone compounds produce highly toxic radical and reactive oxide species which disrupt membrane integrity and damage proteins and nuclear material. Also, their multiple aromatic rings are structurally comparable to xenobiotics with known estrogenic activity. Acute toxicity of parent quinones was investigated by exposure of freshwater and estuarine vertebrate (*Pimephales promelas*, *Cyprinodon variegatus*) and invertebrate (*Ceriodaphnia dubia*, *Americamysis bahia*) test organisms in 48-h rangefinder and 7-d chronic assays. Similarly, toxicity of quinone residuals was investigated by initiating 48-h exposures after 2- to 6-d degradation periods. Sublethal molecular, cellular and developmental effects were investigated via 21-d larval and mature *P. promelas* exposures. Fish were evaluated for evidence of oxidative stress by analyzing DNA strand breakage via Comet assay; for cellular and tissue damage via histology; and for endocrine disruption by quantifying vitellogenin (Vtg) induction and assessing gender modification, and gonadal pathology. In general, species were most sensitivity to juglone, then plumbagin and finally menadione. Lowest IC₂₅ values for each compound (7-d static w/ daily-renewal) were: menadione 55.6 µg/L (*C. dubia* fecundity); plumbagin 33.2 µg/L (*P. promelas* biomass); and juglone 15.4 µg/L (*P. promelas* biomass). Residual toxicity of quinones was a function of initial concentration and duration of degradation before exposure. Elevations in DNA strand breaks occurred in liver and blood cells from some 21-d quinone treatments when compared with controls. Subsequent tests (in vivo and in vitro) of shorter duration were performed to investigate the time course to occurrence of DNA strand breaks. While, no evidence of Vtg induction or of gonadal pathology was seen in mature male fish from any quinone treatment, initial analyses of larval exposures to each of the three compounds suggest a female gender bias. Tissues from additional replicates are being examined to clarify this result.

WP134 Adsorption of Emerging Contaminants on Clay Minerals. K. Miller, B. Smith, J. Caulfield, Chemistry and Biochemistry, University of Denver, Denver, CO. Emerging contaminants are increasingly detected in both surface waters and sediments. Many of these contaminants are highly soluble in water, including caffeine, a proposed anthropogenic marker for aquatic systems. Despite their high water solubility, these contaminants adsorb significantly to some sediments and clay mineral surfaces. Thus, transport predictions of these contaminants in aquatic systems needs to account for the interactions at the surfaces of suspended sediments and minerals. This talk will present adsorption data, spectroscopic studies and modeling efforts to explain the binding mechanisms of these compounds on clay mineral surfaces. Adsorption isotherms were performed with caffeine, antibiotics (lincomycin, tetracyclines) and other contaminants on a series of homoionic smectite clay

minerals. The experimental K_d values for the contaminants ranged from < 0.7 to > 2.5 x 10⁴ L/kg on the homoionic clays. The adsorption measurements were made under varying ionic strength conditions to simulate both fresh water and estuarine systems. Fourier transform infrared (FTIR)[1] and X-ray diffraction (XRD) methods, as well as molecular modeling are used to elucidate the binding mechanisms of these compounds on clay mineral surfaces of clay minerals. Based on these studies, the mechanisms and magnitude of the K_d value are a function of the cation exchanged on the mineral surface, ionic strength of the solution, and the pK_a of ionizable functional groups of the contaminants. This work demonstrates that mineral composition of soils, sediments, and suspended sediments needs to be accounted for when modeling the transport of highly water soluble contaminants in aquatic systems. 1. Caulfield, J.A, Wells, T.A., Miller, K.E., *Clays and Clay Minerals* 2007, 55, 213-219.

WP135 EPA Pilot Study of PPCPs in Fish Tissue. B.D. Snyder, J. Pitt, Center for Ecological Sciences, Tetra Tech Inc., Owings Mills, MD; L. Stahl, Office of Science and Technology, U.S. Environmental Protection Agency, Washington, DC. Obtaining environmental data on emerging contaminants is a priority area of interest for EPA, particularly the subset of emerging contaminants that includes pharmaceuticals and personal care products (PPCPs). Increasing evidence indicates widespread occurrence of PPCP compounds in surface water, sediments, and municipal effluent, but data on the accumulation of PPCP compounds in fish tissue are scarce. To respond to this Agency priority, the Office of Science and Technology within EPA's Office of Water has initiated a pilot study to investigate the occurrence of PPCP chemicals in fish tissue called the EPA Pilot Study of Pharmaceuticals and Personal Care Products in Fish Tissue. The targeted study design for this pilot involved collecting fish samples from five effluent-dominated streams in various parts of the country (Chicago, Illinois; West Chester, Pennsylvania; Orlando, Florida; Dallas, Texas; and Phoenix, Arizona) and from one reference site (Gila River, New Mexico). At each site, sampling teams collected 18 to 24 adult fish of the same resident species in the vicinity of wastewater treatment plant discharges. Field sampling was conducted from August through November 2006. Fish samples were divided into six composites, each containing three or four fish. All fish were frozen and shipped whole to an analytical laboratory at Baylor University. The laboratory analyzed fillet and liver tissue from the fish composites for 24 pharmaceutical compounds using a high performance liquid chromatography-tandem mass spectrometry (HPLC-MS/MS) method, and for 10 personal care products using a gas chromatography-tandem mass spectrometry (GC-MS/MS) method. The pharmaceutical compounds included analgesics, antibiotics, antidepressants, antihistamines, anti-hypertension drugs, and anti-seizure medications. Personal care product chemicals included fragrances/musks, surfactants, and ultraviolet filters. Results for all fish tissue samples should be available in winter 2008. Key words: fish contamination, fish survey, emerging contaminants, PPCPs, wastewater discharges

WP136 Development of a Biotic Ligand Model for the Acute Toxicity of Zinc to *Daphnia Pulex* in Soft Water. M. Clifford, J. McGeer, Biology, Wilfrid Laurier U, Waterloo, Ontario, Canada. The biotic ligand model (BLM) approach to predicting metal toxicity in aquatic media has proven to be successful in explaining the variability that arises due to the influence of water chemistry on bioavailability. The objective of this study was to develop a biotic ligand model for acute zinc toxicity in very soft waters and then to test the model with soft waters from natural sources. Standard 48 h acute toxicity tests with *Daphnia pulex* were used at varying concentrations of Ca, Na, Mg, Cl and K. The pH of test solutions was also varied and two sources of natural dissolved organic matter (Swansee River and Nordic Reservoir) were tested. Natural soft waters were also collected and tested for Zn toxicity. Ca had a dramatic toxicity reducing effect illustrating the competitive interaction between Ca and Zn for Ca uptake sites. Significant effects on the Zn EC₅₀ were also observed with Mg but these were less dramatic than Ca. Other ions (Na, Cl and K) did not alter Zn toxicity. Increasing the organic matter content of test solutions had a toxicity reducing effect. The effect of pH on the EC₅₀ values was positive when the pH was shifted from 6.32 to 8.01. An existing BLM (that had been developed for hard water) was used to predict the toxicity of Zn in test solutions with the result that predicted EC₅₀s did not match well with measured EC₅₀s, particularly for the effects of cationic competition. However it was possible to revise BLM inputs to improve the predictive capacity. The work illustrates that BLM principles apply in very soft waters but

that BLMs developed for hard waters require adjustment prior to application in soft waters.

WP137 Effects of nickel to marine organisms: Compilation of available data and derivation of a marine PNEC. W. Stubblefield, E.J. Van Genderen, Parametrix, Albany, OR; C.E. Schlekat, Nickel Producers Environmental Research Association, Durham, NC. Chronic ecotoxicity data for nickel are relatively scarce; chronic toxicity tests were conducted to assess nickel toxicity to a broad range of marine organisms. New and historic data were used to construct a Species Sensitivity Distribution (SSD) to determine a predicted no effect concentration (PNEC) for nickel in saltwater. The compiled chronic nickel toxicity database contained endpoints for fourteen marine species which included a broad taxonomic representation including unicellular algae (diatom and flagellate), macroalgae (giant kelp and red algae), invertebrates (echinoderms, mollusks, mysid, and annelid) and fish (topsmelt and minnow). PNECs were calculated using both the assessment factor (AF) approach and the species sensitivity distribution (SSD) approach. In the AF approach the PNEC was calculated by dividing the lowest chronic effect concentration (EC₁₀) by 10 since there were more than three taxonomic groups for which chronic data was available. In this case the lowest EC₁₀ value (2.8 µg/L) was reported for the sea urchin, *Diadema antillarum*; therefore, the calculated PNEC was 0.28 µg/L dissolved Ni. Given that the chronic database was sufficiently large, the PNEC was also calculated by means of statistical extrapolation (i.e., SSD analysis), using all available chronic values (EC₁₀ or no observable effect concentration). Two statistical distribution functions were used in analyzing the extant chronic data; the log-normal distribution and a best-fit model. The concentration predicted to not effect 5% (HC₅) of the species as calculated using the log-normal distribution was 3.5 (0.4-14.2) µg Ni/L, while the HC₅ calculated by best-fit (extreme value distribution) was 6.9 (2.6-10.6) µg Ni/L.

WP138 Is the Screening-Level Concentration (SLC) method for deriving sediment quality guidelines predictive of effects on benthic communities in northern Saskatchewan? C. Burnett, K. Liber, Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Sediment quality values can be derived using different approaches and are used in environmental management, regulations, reclamation and risk assessment. The Screening-Level Concentration (SLC) approach is used in Ontario to derive lowest-effect levels (LEL) and severe-effect levels (SEL) for use as sediment quality guidelines. This approach has also been adopted by the Canadian Nuclear Safety Commission (CNSC) to set guidelines for metals (As, Cr, Cu, Pb, Mo, Ni, Se, U, and V) and radionuclides (226Ra, 210Pb, and 210Po) for use at northern Saskatchewan uranium operations. The SLC approach is based on total metal and radionuclide concentrations in sediment, and corresponding benthic community effect indices (abundance and species richness) for a sample site. Here, historical sediment and benthic community data from northern Saskatchewan uranium operations were collected and examined. First, data was explored to find sites that had paired data (benthic community measurements and metal/radionuclide concentrations in sediment taken approximately on the same day). Secondly, sediment chemistry data was screened for exceedences of LEL and SEL values. Lastly, for sites where guidelines were exceeded, a summary of reported effects (no effect or an effect) on the benthic community was recorded for each site. A summary of the results of this analysis will be presented and discussed, and it is suggested that the SLC approach may be too conservative (i.e. often predicts a low effect when there are none). Thus, bioavailable metal fractions, rather than total metal concentrations in sediment, may be more accurate for linking effects on benthic communities with metals in contaminated sediment. The findings from this assessment have implications for the development of updated sediment quality guidelines based on bioavailable concentrations of metals and radionuclides. Keywords: sediment, metals, radionuclides, benthic communities, screening-level concentration approach

WP139 Developing Cadmium groundwater cleanup goals that are protective of river sediments. C. Trapp, J.R. Kastrinos, D. Huber, J. Fitzgerald, B. Fagan, Haley & Aldrich, Inc., Boston, MA. Haley & Aldrich, Inc. developed cadmium cleanup goals in groundwater that are protective of ecological health in river sediments. The source of the cadmium is a historic mill complex adjacent to a major river in New England. Manufacturing activities included assembly, plating, gilding, and hardening of metal parts in several buildings at the site, and electroplating operations. These operations released process wastes, including metals and chlorinated compounds, to soil and groundwater. Groundwater flow then transported the contaminants to

the river sediments and surface water. Existing cadmium concentrations of up to 900 µg/L in groundwater exceed the applicable state cleanup standard of 50 µg/L. Furthermore, cadmium concentrations exceed the sediment toxicity benchmark of 4.98 mg/kg (the Probable Effects Concentration (PEC)); therefore, remediation of cadmium in soil, groundwater and sediments is required to bring the site to closure. Haley & Aldrich developed clean-up goals that are protective of ecological receptors in both the river and river sediments. The cleanup goals considered transport and adsorption of cadmium to sediments, using the Freundlich Isotherm model, incorporating site data, including dissolved cadmium concentrations, and sediment pH. The model conservatively assumes 1.) residual concentrations of cadmium will remain following remediation; 2.) the plume reaches steady state conditions with respect to mass transfer of cadmium; and 3.) cadmium is not adsorbed to mineral soils in the aquifer; adsorption instead takes place exclusively in the organic sediments in the river. Based on the Freundlich Isotherm model, a groundwater clean-up goal of 70 µg/L will reduce cadmium mass transfer such that the 4.98 mg/kg PEC will not be exceeded in river sediments. Since the calculated groundwater clean-up goal exceeds the state standard for cadmium (50 µg/L), the state standard was used as a default clean-up goal. Additional analyses were performed that confirmed the target cleanup goal is protective of surface water quality, based on mass flux and in-stream dilution analysis for seasonal low-flow conditions. Existing cadmium concentrations in soil and groundwater were then compared to develop a target soil cleanup goal (50 mg/kg) that is protective of groundwater, surface water, and river sediments, according to the calculated groundwater cleanup goal.

WP140 The Toxicological Impact of Trace Metal Mixtures Found in Houston Area Drinking Water. A.D. Oyewole, T. Renard, Chemistry, Texas Southern University, Houston, TX. The provision of safe potable drinking water to the public is absolutely crucial in protecting public health. Trace contamination in drinking waters has become a growing concern to the public. Much of the emphasis is being placed on very few individual metals which are currently regulated by the USEPA. Nevertheless, greater attention must be paid to the fact that metal exposure during water consumption very often occurs as mixtures of metals rather than a single metal per dose. Furthermore, low level exposure to some metals may produce toxic effects at the cellular level prior to becoming noticeable at the macroscopic level. Additionally, there are some trace metals not being regulated by the USEPA which current research indicates may produce deleterious effects after long-term exposure. In this study, we will investigate cellular level effects of mixtures of trace metals in mesencephalic neuronal cell cultures. Dose-response experiments using trace metal concentrations ranging from the ppb level to the ppm range will be employed followed by toxicological impact assessments.

WP141 Bioaccessibility testing of metals-contaminated soils and its application in a human health risk assessment in Milton, Ontario. T.P. Morgan-Gray, A.N. Amendola, J.D. Goodin, T. Repaso-Subang, Golder Associates Ltd., Mississauga, Ontario, Canada. It is standard practice in Human Health Risk Assessments (HHRA) to assume that metals in soils are readily available for absorption. Site-specific adjustments are not typically made for differences in bioavailability between site soils and the media used in the toxicity studies upon which toxicity reference values (TRVs) are based, although metal bioavailability is typically lower in soils and varies on a site-specific basis. As such, exposures and consequently risks based on ingestion of metals-contaminated soils are often overestimated in HHRA. Based on this, in vitro bioaccessibility testing of metals-contaminated soils can be conducted to provide more representative risk estimates for the ingestion of metals-contaminated soils. Bioaccessibility is considered to provide conservative estimates of the bioavailability of soil-bound metals which in part, is dependent on the mobilization of contaminants from soils during digestion (bioaccessibility). As part of a HHRA being conducted for a site in Milton, Ontario, potential risks associated with human exposure to metals-contaminated soils via ingestion were evaluated. Forty soil samples were collected from the site and the bioaccessibilities of arsenic and lead were determined using a modified version of the test developed in the laboratory of John W. Drexler at the University of Colorado at Boulder, the Relative Bioavailability Leaching Procedure. The test system is designed to mimic the gastric phase of human digestion. For arsenic and lead, 95% upper confidence limits of the mean (95UCLM) bioaccessibilities of 0.32 and 0.45, respectively, were determined and applied as relative absorption factors (RAFs) for the metals in the HHRA. Use of these site-specific RAFs in the exposure assessment reduced the calculated exposure and thus risk to human receptors

by 60% for arsenic and by 10% for lead relative to those obtained using generic RAFs provided by the Ontario Ministry of Environment (MOE), increasing the remedial levels for the site by the respective amounts.

WP142 Comparison of Current Metal Emissions: Mercury, Cadmium, Lead and Selenium. J. Heinze, Environmental Health Research Foundation, Chantilly, VA; K. Hagelstein, TIMES Limited, Sheridan, WY. The United Nations Environment Programme has called for further research and regulatory activities on mercury and on cadmium and lead. This review provides an analysis of the best available data, including the US EPA Toxic Release Inventory (TRI), to report on metal emissions amounts and trends in the past five years, including industry sources, airborne emissions (stack and area), water and solid waste emissions. In addition, the human and ecological hazard properties of metals are compared, indicating that the most hazardous metal emissions are mercury followed by cadmium, selenium and lead. Analysis of the emissions data reveals that: 1) the metals manufacturing industry is now the major source of airborne metal emissions and these emissions are increasing; and 2) in the metals industry, mercury emissions are decreasing but selenium emissions, which are much larger than mercury emissions, are increasing. This analysis demonstrates a need for more data on site-specific stack emissions and air pollution control efficiencies to reduce metals emissions.

WP143 Secondary Poisoning Of Nickel To Aquatic And Terrestrial Organisms. D. DeForest, Parametrix, Bellevue, WA; C. Schlegel, Nickel Producers Environmental Research Association, Durham, NC; K. Brix, EcoTox, Jacksonville, FL. The risk of nickel to consumer organisms was assessed as part of a larger environmental risk assessment of nickel. Both terrestrial and aquatic food chains were assessed, and both mammalian and avian consumer organisms were included for each habitat. Additionally, both local and regional scales were assessed. A tiered approach was used, with the first tier applying guidance provided by the European Union's Technical Guidance Document. This first tier used a Reasonable Worst Case, e.g., 100% bioavailability of dietborne nickel to consumer organisms, and diets consisting entirely of food with 90th percentile nickel concentrations. Subsequent tiers included refinements such as incorporating bioavailability of dietborne nickel, derivation of species-specific Predicted No Effects Concentrations (PNECs), and derivation of relevant dietary compositions. Predicted Exposure Concentrations (PECs) were based on aggregate measured tissue nickel concentrations of fish and bivalves for aquatic food chains, and were based on modeled earthworm tissue nickel concentrations for terrestrial food chains. Using the generic TGD approach, risk to consumer organisms was possible (i.e., PEC:PNEC ratios were >1) at local scales for nearly all food chains. Risk was also possible at the regional scale for certain scenarios. In more refined tiers, the use of species-specific effects concentrations based on food intake to body weight ratios decreased the possibility of risk for some food chains, as did the incorporation of bioavailability (which ranged from 1.6% for soil-associated nickel to mammals to 10% for food-associated nickel for birds). When all refinements were used, the PEC:PNEC ratio was < 1 in all cases.

WP144 Multiple Effects of Cadmium on the Photosynthetic Apparatus of *Avicennia germinans* L. as Probed by OJIP Chlorophyll Fluorescence Measurements. D. Gonzalez-Mendoza, O. Zapata-Perez, Recursos del Mar, Cinvestav-Merida, Merida, Yucatan, Mexico; F. Espadas y Gil, J. Santamaria, Unidad de Biotecnología, CICY, Merida, Yucatan, Mexico. The toxic effects of cadmium on the photosynthetic apparatus of *Avicennia germinans* were evaluated by means of the chlorophyll fluorescence transient OJIP. The chlorophyll fluorescence transients were recorded in vivo with high time resolution and analyzed according to the OJIP-test that can quantify the performance of photosystem II. Cadmium-treated plants showed a decrease in yield for primary photochemistry, TR0/ABS. The performance index of photosystem II (PSII), PIABS decreased due to cadmium treatment. This performance index is the combination of the indexes of three independent parameters: (1) total number of active reaction centers per absorption (RC/ABS), (2) yield of primary photochemistry (TR0/ABS), and (3) efficiency with which a trapped exciton can move an electron into the electron transport chain (ET0/TR0). Additionally, the F0/Fv registered the highest sensitivity to the metal, thus indicating that the water-splitting apparatus of the oxidizing side of PSII is the primary site of action of cadmium. In summary, cadmium affects several targets of photosystem II. More specifically the main targets of cadmium, according to the OJIP test, can be listed as a decrease in the number of active reaction centers and damage to the activity of the water-splitting

complex. Key words: *Avicennia germinans*, Chlorophyll Fluorescence, Heavy Metals, Photosystem II

WP145 Can potassium uptake rates be used to predict thallium uptake rates? H. Renkema, B. Hale, Land Resource Science, University of Guelph, Guelph, Ontario, Canada; E. Berkelaar, Redeemer University College, Ancaster, Ontario, Canada. As a potassium analog, Tl(I) is readily accumulated by plants; although plant consumption is the primary route of human exposure to Tl, models to predict plant uptake of this metal are not well developed. The possible similarities of Tl and K uptake kinetics by durum wheat (*Triticum turgidum*) and spring canola (*Brassica napus*, a known hyperaccumulator of Tl) were investigated to determine if Tl uptake by plants could be predicted based on K uptake. Fourteen-day-old wheat and canola plants were exposed to 1-75 μM Tl(I) or 5-250 μM K for 30-150 min. Root and shoot Tl concentration were determined and K uptake during exposure was measured by solution-K depletion. Canola accumulated Tl from solution and translocated it to shoots at a more rapid rate than wheat, while accumulation of Tl by wheat and K by wheat and canola occurred at similar rates. Accumulation of Tl by wheat could not be modeled using Michaelis-Menten (M-M) kinetics, while for canola the K_M was 37 μM and I_{max} was 0.35 μg Tl/g root DW/h. For K uptake by wheat roots, K_M was 106 μM and I_{max} 0.21 μg K/g root DW/h. Due to a high rate of uptake at the highest external solution K concentration, M-M parameters could not be determined for K uptake by canola. K (and Tl) influx in the concentration range used should have occurred through the high-affinity saturable K uptake system; at the highest external K concentration, uptake in canola may have occurred via the second less selective uptake system. Uptake rates versus external K were very similar between wheat and canola at all external K concentrations except the highest, so K uptake by canola and wheat would likely have similar K_M and I_{max} values. Canola roots had a higher affinity and maximum uptake rate for Tl than K, which would lead to an underprediction of Tl uptake by canola if K uptake kinetics were used. The unexpectedly high Tl accumulation by canola could be due to high expression of high affinity transport systems for nonessential elements as found in other hyperaccumulating plants of the Brassica family. On the other hand, even though Tl uptake by wheat in this experiment did not follow M-M kinetics, the similarities in uptake rates between K and Tl may allow for the prediction of Tl uptake in wheat using parameters of K uptake.

WP146 Modeling Uptake of Cd, Cu, Ni, and Zn to the Roots and the Joint Rhizotoxic Effects of Cd, Cu, and Ni to Peas (*Pisum sativum* L.) Grown in Hydroponic Mixtures. Y. Wu, W.H. Hendershot, Department of Natural Resource Sciences, McGill University, Ste-Anne-de-Bellevue, Quebec, Canada. Trace metal contamination in soils usually involves several elements present simultaneously. The biotic ligand model (BLM) has been proposed as a promising approach to describe the bioavailability and toxicity of multiple trace metal contaminants in soils. As part of the work in developing a terrestrial BLM, the previously developed model parameters from experiments with individual metals were tested in this study for their ability to predict the uptake of Cd, Cu, Ni, and Zn into pea roots in hydroponic cultures consisting of these ions simultaneously. We used the conditional formation constants that are adjustable as function of pH and Ca concentrations to corresponding experimental conditions and achieved good model fits for Ca, Cd, Cu, and Ni. The largest discrepancy was found with Zn. Techniques used to test for the coincidence of two linear regression models were applied to analyze the uptake interactions between Cd, Cu, Ni, and Zn. The results of these analyses generally supported the BLM assumption of independent binding of metal ions, although exceptions were found with Cd and Zn. The joint effects of Cd, Cu, and Ni in mixtures on root growth were studied and the potential interactions between these ions were also investigated. It was found that root elongation in response to a mixture of Cd, Cu, and Ni ions could be described by the Weibull equations using the sum of the concentrations of all toxicants as the predictor variable. The examination of series of IC₅₀ values and their corresponding 95% confidence intervals provided us a way of analyzing the interactions between coexisting metals in terms of effects on root elongation. Most of the interactions were shown to be additive; exceptions were found with Ni.

WP147 Verification of Terrestrial Biotic Ligand Model (TBLM) to Copper and Lanthanum toxicity to barley. E. Yoshizawa, R. Shoji, Tokyo National College of Technology, Tokyo, Japan. Lanthanum as well as copper is widely used for carbon lightning application, petroleum cracking catalysts, and hydrogen storing alloy and so on, though, toxicity of La is serious due

to the high ionization tendency. Ionization tendency of Cu is lower than that of La, even though it is also known that Cu has toxicity, and many toxicological studies about Cu have been found so far. Recently, Terrestrial Biotic Ligand Model (TBLM) is widely used to determine the toxicity of metals for plants. However the model has been used only for single metal toxicity and not for combination effect. In this study, TBLM was applied to determine the combination toxicity of Cu and La. Briefly, the barley root length was measured for four days exposed the quartz sand simultaneously spiked with two metals. The toxicity was processed with three models, Total Metal Model (TMM), Free Ion Activity Model (FIAM) and TBLM. Total metal concentration which was spiked in quartz sand was used in TMM. Free metal ion activity in quartz sand pore water was used in FIAM. The fraction parameter (f) for the TBLM was used as a dose instead of total metal concentration or free metal ion activity. A fraction parameter f is a ratio of ligands bounded by free Cu ions to total ligand in the surface of barley root. In the TBLM, the addition of two fraction parameters for Cu and La, f_{Cu} and f_{La} , were used as dose parameters. The binding constants of Cu and hydrogen were used $\log K_{\text{Cu}} = 7.25$ and $\log K_{\text{H}} = 5.08$ as referred from study (Shoji et al., 2007). The binding constant of La was decided as $\log K_{\text{La}} = 5.06$ in this study. The root length decreased with increasing in the concentration of metals due to toxicity of Cu and La. No clear relationship between barley root growth rate and Cu or La concentration were found, while those data support the hypothesis that the combination toxicity of Cu and La could be arranged by using addition of two binding rates of each metal to biotic ligand ($f = f_{\text{Cu}} + f_{\text{La}}$). This is because TBLM can consider the effect of pH or coexistent metal ions in soil pore water around rhizosphere on metal ion binding onto biotic ligand. Synergistic, additive or antagonistic effects can be occurred as combination toxicity. Total biotic ligands on the barley surface kept constant throughout the experiment, and toxicity should be occurred after competitive binding among toxic metals to biotic ligand.

WP148 Terrestrial Biotic Ligand Model for Cadmium Accumulation in Soybean. B. Hale, D. Chan, University of Guelph, Guelph, Ontario, Canada; L.J. Arthur, Food Safety Programs Branch, Ontario Ministry of Agriculture, Food and Rural Affairs, Guelph, Ontario, Canada; E. Berkelaar, Redeemer University College, Ancaster, Ontario, Canada. Of all the trace metals in the environment, cadmium (Cd) poses the greatest concern to terrestrial food safety. The accumulation of Cd in crops is not a straightforward outcome of the Cd level in soil. There are several other soil characteristics that have previously played an important role in determining Cd accumulation in crops. The degree of importance of each of the soil characteristics appears to be heavily dependent on the crop species. Cultivars within species have also proven to play an important role determining Cd uptake in the crop. This research will develop a Terrestrial Biotic Ligand Model (TBLM) to predict the accumulation of Cd into soybeans, following the principles demonstrated by Di Toro et al. (2001). Its intent is to support the development of government standards and guidelines for Cd in agricultural soils, and provide producers with information on agronomic practices that will reduce the uptake of Cd into crops. Four cultivars, two of which have previously shown to accumulate Cd at low levels, and the other two at high levels, were assessed at two sites in Ontario. Soils have been collected and analyzed for pH, CaCO₃, Cl, Zn, Mg, organic matter and clay content. Total Cd in soils was on average 390 mg/kg dw (se=18) and 430 mg/kg dw (se=17) at site one and two respectively. Available Cd (identified by CaCl₂ extraction) in soils was on average 17 mg/kg dw (se=1.4) and 7.6 mg/kg dw (se=1.1) at sites one and two respectively. The authors suggest that the difference in available Cd between sites is due to increased Cd sorption to soil solids at site two due to comparatively alkaline soils and greater organic matter content. Interestingly, all cultivars from site one accumulated approximately one-half of the Cd concentrations compared to site two, regardless of lower available Cd at site two. Reduced [H⁺], i.e. higher pH, at site two may have enhanced Cd uptake due to less competition at the roots anionic binding sites. This work also confirmed that heritable and relative differences among cultivars in Cd accumulation persist regardless of soil characteristics.

WP149 The bioaccessibility of nickel from laboratory-spiked and field-contaminated soils. A. Amendola, B.A. Hale, Land Resource Science, University of Guelph, Guelph, Ontario, Canada; A. Amendola, Golder Associates Ltd., Mississauga, Ontario, Canada; M.D. Dutton, CVRD Inco Limited, Toronto, Ontario, Canada. Several bioaccessibility methods have been developed to understand the relationship between soil metal concentrations, the bioaccessible fraction of these metals as determined

by some physiologically-based extraction test, and their bioavailability to the human gastrointestinal tract. This study focussed on a comparison of the bioaccessible fractions of various nickel species (e.g. oxide, sulfate, subsulfide) in laboratory-spiked soils versus field-contaminated soils. An artificial OECD soil (70% sand, 20% kaolin clay, and 10% sphagnum peat) was prepared and spiked with various nickel species at similar ratios as those found in the field-contaminated soils. The bioaccessible fractions of the various nickel species from these soils were determined using three in vitro bioaccessibility methods that have not been validated in animal studies: the RBALP (Relative Bioaccessibility Leaching Procedure) Method, the BARGE (Bioavailability Research Group Europe) Method, and a method developed by Golder Associates, which is loosely based on the RBALP method. The RBALP method does not include an intestinal phase; to simulate the intestinal environment, the pH of the solution was raised to a pH of 7. The results of these investigations are provided.

WP150 Metal Concentrations in Residential Soils. C. Aelion, H.T. Davis, Environmental Health Sciences, University of South Carolina, Columbia, SC; H. Zhen, A.B. Lawson, Epidemiology and Biostatistics, University of South Carolina, Columbia, SC; S.W. McDermott, Family and Preventive Medicine, University of South Carolina, Columbia, SC. Residential soils are generally assumed to be uncontaminated and a limited risk to human health. However, exposure of pregnant women to metal contamination even at low concentrations is a potential cause of developmental delays and mental retardation (DD/MR) in their children. The objectives of this study were to compare toxicity using a general toxicity indicator (Microtox® Toxicity System) and metal concentrations of residential soils in two areas; one area with no statistically significant DD/MR outcome and one area with an identified cluster of children with DD/MR. In each location 120 soil samples were collected based on sampling at the nodes of a uniform grid overlay. All samples were analyzed using Microtox® to determine an effective concentration (EC₅₀) required to inhibit 50 % of the luminescent test organism *Vibrio fischeri*. Sixty samples from the first area (6 mi by 45 mi) and 120 from the second area (4 mi by 5 mi) were analyzed for arsenic, barium, beryllium, chromium (Cr), copper (Cu), lead (Pb), manganese (Mn), mercury, and nickel (EPA method 6010B) by an analytical laboratory. Cr, Cu, Pb and Mn were present in all samples at both locations. All metal concentrations were significantly greater (by ~ 2 to 5x) in the DD/MR cluster area than in the area with no cluster. Some metals were significantly correlated with each other, particularly As and Cr. The role of residential soils in DD/MR outcomes has not been determined, but the ubiquitous presence of toxic metals in residential soils and greater metal concentrations in areas of high DD/MR incidence warrants further investigation.

WP151 Investigating the extent of earthworm trace metal accumulation, physical redistribution and alteration of roadway-derived dust in urban soils. S.M. Lev, Physics, Astronomy and Geosciences, Towson University, Towson, MD; R.E. Casey, Chemistry, Towson University, Towson, MD; J.W. Snodgrass, Biological Sciences, Towson University, Towson, MD; K. Szlavec, Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, MD; E.R. Landa, U.S. Geological Survey, Water Resources Division-National Research Program, Reston, VA; W. Carroll, Environmental Science Program, Towson University, Towson, MD. Roadway-derived dust is a source of contaminants to near-surface environments in urban areas where it may pose a risk to biota. For example, Zn-enriched tire wear particles collect on roadway surfaces and act as a continuing Zn source to the environment. Because earthworms ingest, transport and digest large amounts of soil on a daily basis, earthworms can have a profound impact on soil chemistry and the bioavailability of potentially toxic trace metals. In order to evaluate these effects in an urban ecosystem, two separate mesocosm experiments were carried out simulating conditions in bio-retention cells receiving direct storm water input from a heavily used parking lot in College Park, MD. *Lumbricus rubellus* and *Octolasion lacteum* were abundant in the bioretention cells and were used in both experiments. Results from bioaccumulation experiments indicated for *Lumbricus rubellus*, Zn total body burden increased over time in 200 mg/kg Zn dust-amended soils. After 84 days, the Zn body burden for worms from dust-amended soil was 660 mg/kg as opposed to 490 mg/kg Zn for worms from un-amended soil. In contrast, *Octolasion lacteum* exhibited very little change in body burden over an 84 day experiment. A set of mesocosms with 35 cm deep soils and a one centimeter road dust-amended surface layer were used to investigate earthworm-driven vertical mixing and macrobiotic weathering of the roadway dust layer. Earthworms redistributed

the roadway dust-amended surface layer and increased the environmentally available zinc pool as judged by MgCl₂ extraction after 30 days. On longer time scales (e.g. 90 days), earthworm processes seem to be obscured by abiotic and microbial processes, making the impact of earthworms less evident when compared to control columns. Based on this investigation, earthworms are affecting the size and distribution of the environmentally available Zn pool in an urban ecosystem receiving direct roadway runoff. Since earthworms are the primary food source for some organisms, tissue accumulation can lead to potential contaminant transfer to other organisms.

WP152 Operational uncertainty management in LCA – strategies and methods for its implementation in daily practice. R.K. Rosenbaum, CIRAI, Montreal, Quebec, Canada; O. Jolliet, University of Michigan, Ann Arbor, MI; A. Ciroth, GreenDeltaTC, Berlin, Germany. Quantification and communication of uncertainties related to LCA results is vital for their correct interpretation and use. Operational uncertainty management methods for both inventory and impact analysis greatly enhance the reliability of LCA studies and the trust in their outcomes. In daily practice, routine uncertainty analysis is hampered by the difficulty of finding and assigning uncertainty and variability information to the usually numerous parameters and models used in LCA. We investigate and compare approaches and strategies to identify and quantify main sources of uncertainty, enabling to focus the data acquisition for the uncertainty assessment. For example, an analytical approach based on Taylor series expansion combines uncertainty and sensitivity analysis, enabling to identify dominating sources of uncertainty in the calculations. This technique is very useful to determine the overall uncertainty as well as the contributions of single parameters and models. It is also a promising basis for “streamlined” uncertainty estimation. First evaluation results indicate a good accordance with Monte-Carlo simulations. Combined with exploring other methods, such as fuzzy-logic or Bayesian networks, we aim to overcome the data intensity of ‘classical’ approaches, such as Monte-Carlo simulation, in the future.

WP153 Analytical Uncertainty Propagation in Life Cycle Inventory and Impact Assessment: Application to an Aluminum Front Panel. J. Hong, O. Jolliet, Department of Environmental Health Sciences, School of Public Health, University of Michigan, School of Public Health, Ann Arbor, MI; R. Rosenbaum, CIRAI, Ecole Polytechnique de Montreal, Montreal, Quebec, Canada. Uncertainty information is essential for the proper use of LCA in decision making. So far, parameter uncertainty propagation has mainly been studied using Monte-Carlo techniques that are relatively heavy to implement. The consequence is that uncertainty estimates have often been limited to either the inventory part of the analysis or the impact assessment part, very rarely covering the whole LCA. The present study applies an explicit analytical approach based on Taylor series expansion for lognormal distribution. This innovative method first determines the model sensitivity to each input parameter. It then assesses the overall coefficient of variation on the final result as a function of the coefficient of variation of each individual input. The advantage of this procedure is to explicitly provide the contribution from each parameter as well as very strongly reduce calculation time. Probability distributions obtained with this approach are compared to classical Monte Carlo distributions for test scenarios. An automobile case study - on an aluminum front end panel - demonstrates the feasibility of this method and illustrates its simultaneous and consistent application to both inventory and impact assessment. Coefficients of variation on global warming scores amount to a factor 1.1 for the analytical approach, which is virtually equal to the coefficient of variation of 1.11 obtained by Monte-Carlo techniques. Special care is taken when comparing scenarios to account for the non-independence of input parameters: Distributions are directly determined for the relative difference between scenarios rather than for each scenario independently. This strongly increases the significance of the difference between scenarios, demonstrating the significant advantage of recycled aluminum front-end panel over virgin aluminum and steel due to the gain in weight and the related fuel savings in the use phase.

WP156 Quick Scan, Sustainable Balanced Scorecard and Life Cycle Inventory to measure the trend of environmental impact from business activities in the sustainability report of oil industry. S. Sparacia, Diritto dell'Economia, Trasporti e Ambiente - DETA, Università degli Studi di Palermo - Facoltà di Economia, Palermo, Italy; L. Ciruolo, Dipartimento di Studi su Risorse Impresa Ambiente e Metodologie quantitative - RIAM, Università degli Studi di Messina, Messina, Italy. The “Engaging Stakeholders” (UNEP/SustainAbility, 1996) define the sustainability reporting as

“sustainability reporting covers the development of the triple bottom line or TBL concept, i.e. economic, social and environmental issues or responsibility, accountability and sustainability. It is a stage where all actors have to play their role (stakeholders and report users to as an important extend as the report producers)”. This paper illustrates how to measure the effort of oil industry to reduce environmental impacts over the entire life cycle, from the production of crude oil to the transportation, manufacturing, marketing, and consumption of petroleum products. These diverse operations, which are the building blocks of oil industry, are measured via the analysis of the direct relations that are formed in a quick scan that adopts a set of indicators of the Life Cycle Inventory interlinked by cause-effect relations in a Sustainable Balanced Scorecard. The empirical evidence analyzed in environmental reports of more representative industries of the oil sector demonstrates that improved environmental performance encourage process innovation and enhances corporate image and liability management.

WP157 Case for Broader Use of LCA in Carbon and Energy Savings. M. Gausman, W. Owens, A. Weisbrod, Procter and Gamble, Cincinnati, OH; R. Pant, D. Schowanek, Procter and Gamble, Brussels, Belgium. The world is worried about climate change. Factors that can affect climate change can be tallied using Carbon Footprinting (CF) methods. The environmental footprints of countries, industrial operations, life styles and products can be compared using CF, making it a useful tool. CF is in the spotlight of the public debate on climate change because it is suggested to be used to guide product design and purchase decisions. The more popular ‘cradle to store shelf’ CF schemes focus on a few parameters, neglecting significant energy savings opportunities related to other phases captured in ‘cradle to grave’ CF schemes. Industrial ‘eco-efficiency’ philosophy currently includes the use of LCA to focus on energy and carbon savings for all phases of operations, services, and products. Using LCA as a way to calculate CF comes naturally, but LCAs are often complex and time-consuming, reflecting the external reality. Calculating CF for hundreds of products challenges the data requirements of life cycle inventories. This leads us to question whether LCA, as defined under ISO, is the most suitable tool for CF, or if ‘shortcuts’ can be accepted, particularly for rapidly assessing multiple products in a comparative way. As a multinational consumer goods company with experience in LCA method development and application, we share our LCA approach to derive carbon footprints. The merits and limitations of using LCA for CF in the consumer goods sector will be presented. Key questions from an LCA perspective in calculating a carbon footprint for consumer products are covered: Should one abandon the full life cycle and go only to a “cradle to store shelf” method, abandoning the use phase, disposal, recycling and reuse? Should one abandon the functional unit, the heart of achieving balanced comparisons, for a simple unit such as mass of carbon or the amount of energy? Should one abandon water use, waste, and other measures only for CO₂? The potential of a Carbon Label to guide consumers in their daily purchase decisions will also be discussed.

WP158 UNEP/SETAC recommended characterisation factors for human health and aquatic ecotoxicity: results and future activities. R.K. Rosenbaum, M. Margni, CIRAIG, Montreal, Quebec, Canada; M.Z. Hauschild, H.F. Larsen, Technical University of Denmark, Lyngby, Denmark; T.M. Bachmann, EIFER, Karlsruhe, Germany; M. Huijbregts, D. van de Meent, Radboud University, Nijmegen, Netherlands; O. Jolliet, University of Michigan, Ann Arbor, MI; T.E. McKone, University of California, Berkeley, CA; M. Schuhmacher, Rovira i Virgili University, Tarragona, Spain; D. van de Meent, RIVM, Bilthoven, Netherlands; A. Köhler, M. MacLeod, ETH Zurich, Zurich, Switzerland. Over the last two years, the developers of seven toxicity characterization models collaborated to carry out a comprehensive model comparison as part of the UNEP/SETAC Life Cycle Initiative. The models in this evaluation included CalTOX, IMPACT 2002, USES-LCA, BETR, EDIP, WATSON, and EcoSense. This paper summarizes and draws lessons from this model evaluation process. The main objectives of this effort were to 1) identify specific sources of differences in model results, 2) define common and indispensable model components, and 3) use the selected models to build a “scientific consensus” model, called USEtox, to serve as a repository for recommended practice. USEtox is a parsimonious and transparent tool that currently provides human-health characterisation factors (CFs) for some 1000 chemicals and aquatic ecotoxicity CFs for more than 2000 substances. The accuracy of these factors relative to other models remains within 1-3 orders of magnitude compared to 12 orders of magnitude variation among the chemicals. The main task of model development is complete, but the following future activities are foreseen for the upcoming second phase of the

UNEP/SETAC Life Cycle Initiative: 1) increase of substance coverage and quality assurance of substance data; 2) accommodation of metals; 3) inclusion of terrestrial and marine ecotoxicity; 4) incorporation of indoor emissions; 5) including parameter uncertainty in the uncertainty estimates on the CFs; 6) publication of model documentation 7) development and distribution of a user-friendly version of USEtox; 8) industry/stakeholder workshops on comparative assessment of chemicals and training courses in USEtox. The promising scientific results now need to be transferred into daily LCA practice, which is the main goal of these activities, aiming at a broad acceptance and consideration of the toxicity impact categories.

WP159 Sensitivity of adult reproduction and reproductive development in Japanese medaka exposed to 4-tert-octylphenol. M.L. Haasch, NRC, USEPA, Duluth, MN; D.B. Lothenbach, K.M. Flynn, F.W. Whiteman, D.E. Hammermeister, R.D. Johnson, USEPA, MED, Duluth, MN; J. Nagel, W.J. Backe, SSC, USEPA, Duluth, MN; D. Shadwick, CSC Corporation, Morrisville, NC. In response to legislation, the USEPA is developing assessment tools for identifying chemicals likely to cause sublethal effects on reproduction and reproductive development with ultimate adverse impacts on fish populations. While fecundity and fertility data from short-term adult reproduction assays are directly applicable to population-level assessments, effects on reproductive development appear to be more sensitive but are less directly applicable to population assessments. The protocol in this study incorporated both adult and developmental stages thus providing data for comparisons and development of relationships among endpoints and life-stages. In this study 6 replicate breeding pairs of medaka (*Oryzias latipes*) were exposed to 4-tert-octylphenol (0, 2, 8, 27, 90 and 300 µg/L). Fecundity and fertility were assessed for 5 weeks (4 days/week). Effects on hatch and subsequent reproductive development were assessed by continuing the exposure of the F1 embryos until 43 days post-fertilization. Hatching success was negligible at 300 µg/L. No treatment effects on body weight were observed in either the F0 or F1 populations. Adult fecundity was more sensitive than fertility (LOECs of 8 and 300 µg/L, respectively). In both F0 and F1 generations, the individual genotypic sex (DMY-gene) was compared with several gender-specific endpoints (phenotypes); anal fin papillae, hepatic vitellogenin (VTG) mRNA levels, and gonadal sex. The genotypic F0 male LOEC for increased liver weight, hepatosomatic index and induction of VTG mRNA was 90 µg/L. The genotypic F1 male LOECs for reduced papillae, increased VTG mRNA, intersex, and gonadal sex reversal were 27, 27, 2, and 27 µg/L respectively. These data support previous studies regarding the estrogenicity of 4-tert-octylphenol and indicate the efficacy and sensitivity of assessing alterations of gonadal phenotype through the determination of genetic sex. Relationships among endpoints and life stages will inform further development of protocols optimized for sensitivity, time, reduced animal use, and extrapolation across levels of organization.

WP160 Reduced fertility in frogs following larval exposure to environmental concentrations of ethynylestradiol. I. Gyllenhammar, C. Berg, Department of Environmental Toxicology, Uppsala, Sweden; L. Holm, Department of Anatomy, Biology and Biochemistry, Uppsala, Sweden. Amphibian populations are declining world-wide and one of the suggested reasons is environmental pollutants. We have previously shown that environmental concentrations of the pharmaceutical estrogen and environmental pollutant ethynylestradiol (EE₂) affect gonadal differentiation resulting in female-biased sex ratios at metamorphosis in frogs. It is not yet known if a transient exposure to EE₂ during the larval stage affects reproductive success at sexual maturity. The aim of this work was to investigate if the reproductive organs and fertility in adult frogs are affected after larval exposure to environmental concentrations of EE₂. *Xenopus tropicalis* tadpoles were exposed from hatching until metamorphosis to the measured EE₂ concentrations 0.006, 0.06, and 0.6 nM. Eight months post-metamorphosis the reproductive organs and fertility were evaluated. Larval EE₂-exposure caused a concentration-dependent increase in the proportion of phenotypic females implying sex-reversal of genotypic males. Female-biased sex ratios were found at concentrations as low as 0.006 nM EE₂ (1.8 ng/L). EE₂-exposed males that were not sex-reversed were mated with unexposed females resulting in a significantly reduced fertilization rate compared to the control group. Histological evaluation of the testes showed that EE₂-exposed males had a lower number of spermatozoa in the seminiferous lumen and a higher percentage of irregularly shaped testes than the control group. Among frogs with ovaries there was a significantly increased percentage that lacked oviducts in the highest EE₂-concentration compared with control females. Aromatase

activity in the testes is being evaluated and will be presented and compared with functional, histological, and biochemical effects on the reproductive organs. This is the first study showing that exposure to an environmental pollutant during early life stages in frogs, results in reduced fertility later in life. As environmental concentrations were used the results indicate that reproduction in wild frogs might be impaired by estrogenic environmental pollutants.

WP161 Effects of Ecosystem Change on Chironomid Genetic Diversity using a Novel Microsatellite Gene. I. Njoku, C.S. Bentivegna, Biology, Seton Hall University, South Orange, NJ. Increasing and detrimental levels of pollution has been associated with biodiversity, and over time biota must adapt to changing environments in order to survive. This project has investigated a unique biomarker that should detect changes in genetic diversity and potentially serve as a sub-lethal indicator of environmental health. The biomarker was a novel microsatellite sequence within an unidentified gene. Microsatellite sequences are short repetitive nucleotide sequences that typically have high mutation rates due to slippage of DNA polymerase during replication. Changes in the number of repeats can be detected by PCR and gel electrophoresis. The test organisms were wild chironomids (larvae of midge fly) collected from Kearny Marsh, N.J. Chironomids were collected from Hester-Dendy set for one month on plots that were uncapped or capped with AquaBlok, a clay-based technology intended to reduce bioavailability of sediment contamination. Chironomids were collected in May, August and November of 2006. Species were identified by head capsules and hemoglobin profiles. DNA was isolated from individual organisms and the region surrounding the microsatellite sequence(s) was amplified using gene-specific primers. Resulting bands were visualized on agarose gels. Hierarchical Clustal Analysis compared the presence or absence of bands between individuals within a group and calculated average distance for each individual. Average distance was used as the measure of genetic diversity for a group. Data showed that three species were collected over time, one appeared to be a hybrid of the other two. Gene-specific primers produced multiple bands, some of which varied among individuals but did not appear to be species dependent. Genetic diversity varied between plots in August but was not directly related to capping. Species diversity showed a positive correlation with genetic diversity. Species diversity was greatest in the capped site that was adjacent to an uncapped one, possibly due to migration. The biomarker indicated overall that higher levels of genetic diversity were associated with more complex environments.

WP162 Chironomid Hemoglobin Protein as a Molecular Biomarker for Species Identification and Genetic Diversity using Hemoglobin Protein in Wild Chironomids from a Contaminated Wetland. J. Oh, V. J. Jada, I. Njoku, C.S. Bentivegna, Biological Sciences, Seton Hall University, South Orange, NJ. Chironomids, aquatic larvae of midge fly (Diptera: Chironomidae), are abundant, widely distributed, sediment-dwelling organisms that should be used more often for field studies. One major challenge to their use is distinguishing between species based on morphological characteristics. In this study, hemoglobin protein detected by SDS-PAGE gel was evaluated for its ability to discriminate between species collected at Kearny Marsh, an euhaline wetland that is part of the New Jersey Meadowlands. Hemoglobin protein is highly polymorphic in chironomids and important for their ability to survive in organic, suboxic wetland sediments. Genetic diversity of hemoglobin protein was also evaluated. This was done by comparing hemoglobin bands in chironomids collected from sediments that were capped or uncapped with AquaBlok. Capping of the sites altered the environmental conditions in an otherwise geologically similar environment. Chironomids were collected by Hester-Dendy placed for one month. Collection dates were in May, August and November, 2006. Proteins were separated by SDS-PAGE based on weight (kilodaltons). Hemoglobin profiles from individual larvae were distinguished by the presence or absence of bands as well as band intensities. Band profiles were compared to larval head capsules, which are commonly used to identify species. Results showed unique hemoglobin profiles that corresponded with three different species. The third species appeared to be a hybrid of the other two. The abundance of hybrid individuals increased over time particularly at uncapped sites. Hierarchical clustal analyses of data found that hemoglobin diversity could not discriminate between levels of sediment metal contamination using any of the species. Hemoglobin diversity was more variable in summer than spring or fall and more variable in uncapped than capped sites. Water quality measurements suggested that dissolved oxygen might have influenced hybrid abundance and hemoglobin diversity. Findings

of this study indicated that hemoglobin protein polymorphisms can assist with species identification of chironomids and may serve as a biomarker of changing ecological conditions.

WP163 Identification of genes in early life stage rainbow trout that are responsive to low concentrations of malathion. S.L. Miller, M.J. Carvan, Biological Sciences, UW-Milwaukee Great Lakes Water Institute, Milwaukee, WI; M.L. Rise, M. Rise, Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, Newfoundland, Canada. Organophosphate pesticides such as malathion, are commonly used in agricultural practices internationally. Organophosphate contamination, due to agricultural run-off, poses probable health risks to fish populations within Lake Michigan and its tributaries. In order to better understand these potential health risks, this research aims to elucidate molecular mechanisms by which low concentrations of waterborne malathion impact rainbow trout. Two different early developmental stages of rainbow trout, newly hatched sac-fry and 10 day post swim-up fry, were exposed to environmentally-relevant concentrations of waterborne malathion (3-300 ppb) for 48 hours. Morbidity/mortality data from the two distinct developmental stages of rainbow trout indicated a differential sensitivity to malathion toxicity; swim-up fry were more sensitive than were sac fry. Malathion-responsive genes for each developmental stage were identified by salmonid DNA microarray, and validated through the use of real-time quantitative PCR (QPCR). Reference design microarray experiments were carried out using whole body rainbow trout sac-fry and swim-up fry exposed to 10, 30 and 100 ppb malathion. Microarray analysis indicated that potential biomarkers of exposure include transcripts putatively involved in cellular respiration, iron homeostasis, metalloproteinase activity, and in RNA translation initiation. QPCR validated genes will be considered candidate members of molecular pathways altered as organophosphate pesticides exert their toxic effect on rainbow trout. The results of this research will establish reliable molecular biomarkers of malathion exposure in early developmental stages of rainbow trout.

WP164 Perfluorinated Compounds in the liver of Subantarctic Fur Seal and Franciscana dolphin samples in Southern Brazilian Coast. J. Leonel, R.C. Montone, Departamento de Oceanografia Física, Química e Geológica, Universidade de Sao Paulo, Sao Paulo, Sao Paulo, Brazil; G. Fillmann, Departamento de Oceanografia, Universidade Federal de Rio Grande, Rio Grande, RS, Brazil; K. Kannan, L. Tao, Department of Environmental Health Sciences, Wadsworth Center, Albany, NY. Perfluorinated compounds (PFCs) have been used in a wide variety of consumer products, such as carpets, upholstery, and textiles. However, some compounds degrade to persistent metabolites (for exemplo PFOS) that accumulate in tissues of humans and wildlife. Although studies have examined PFC levels in several wildlife species, no study reports the occurrence of PFCs in marine mammals from Southern America. In this study, concentrations of eight PFCs (PFOA, PFNA, PFUnDA, PFDA, PFHpA, PFDoDA, PFHS and PFDS) were determined in liver samples of two species of marine mammals: Subantarctic Fur Seal (*Arctocephalus tropicalis*) and Franciscana dolphin (*Pontoporia blainvillei*) found stranded on beaches of Southern Brazilian Coast during 2000-2004. This study reported the existence of low but detectable levels of PFCs in South America marine mammals, suggesting distribution of these compounds on a globe scale.

WP165 Chemical purity issues relating to the identity of perfluorooctanesulfonate (PFOS) samples for use as reference standards. N. Riddell, G. Arseneault, B. Chittim, A. McAlees, B. Yeo, Wellington Laboratories, Guelph, Ontario, Canada; R. McCrindle, Chemistry Department, University of Guelph, Guelph, Ontario, Canada. The widespread distribution of fluorinated chemicals, including perfluorooctanesulfonate (PFOS), in the environment and their accumulation in humans continues to receive substantial attention. As such, it is important to note that the production of PFOS derivatives from linear alkyl precursors using electrochemical fluorination is not a clean process but, instead, gives complex mixtures. Indeed, commercial PFOS from 3M contained approximately 86% PFOS, which is present as a mixture of ca 70% linear and ca 30% branched isomers as measured by ¹⁹F NMR spectroscopy. This process also produces PFOS homologues with 5, 6 and 7 carbon chain lengths, perfluoroalkanoic acids and partially fluorinated compounds. Many laboratories are seeking to identify and quantitate PFOS in a variety of samples. In many cases, these laboratories use standards made up from PFOS which has been purchased from one of a number of suppliers. Typically, the PFOS is claimed to be >98% pure. Unfortunately, at least in some cases, the measurements of purity

are simply based on an acid/base titration method after ion exchange with a strong acid resin. Clearly, this analysis is not specific to PFOS and therefore it brings uncertainty to the definition of >98%. The objective of this work was to determine the actual purity of various PFOS standards available on the market. We also summarize the linear to branched isomer ratio in the various PFOS samples, as measured by LCMS and ¹⁹F NMR spectroscopy, and discuss whether or not such differences may have an impact on the "total PFOS" measurement in an environmental sample.

WP166 Biodegradation potential and environmental significance of fluorotelomer-based products. M.H. Russell, B. Szostek, DuPont Haskell, Newark, DE; W.R. Berti, R.C. Buck, DuPont, Newark, DE. Biodegradation of fluorotelomer-based polymers and surfactants in the environment is of interest to determine if they are a significant potential source of perfluorinated carboxylic acids (PFCAs). The aerobic degradation of a commercial fluorotelomer-based acrylate polymer product has been investigated in four geographically representative soils from the continental USA over a period of 18 months. This study was designed to evaluate whether the fluorotelomer moieties covalently bonded to the hydrocarbon polymer backbone can be liberated via degradation processes and subsequently transformed to PFCAs. The polymer test substance used in the study was analyzed to determine the initial content of unreacted raw materials (e.g. fluorotelomer alcohols and fluorotelomer olefins) as well as terminal degradation products such as perfluorocarboxylic acids. During the course of the study, the test vessels were incubated statically with headspace and soil samples analyzed for a series of target analytes including unreacted raw materials, initial degradation products, and terminal degradation products. To determine the relative contributions of the polymer and the unreacted raw materials to the formation of terminal carboxylic acids, a three component kinetic model (polymer, intermediates and terminal carboxylic acids) was developed to calculate the rates of degradation and reaction yields of the acrylate polymer and the unreacted raw materials in forming the terminal carboxylic acids. The equations were solved analytically and fitted to the experimental data using the statistical method of least-squares fit and maximum likelihood. The results of modeling include estimates of the degradation rate of the polymer, the degradation rate of the unreacted raw materials, the reaction yields for each kinetic step together with appropriate confidence intervals. The environmental significance of these results was then assessed by combining the degradation kinetics of the fluorotelomer-based polymer with historical global production rates of acrylate polymers to determine a bounded range of the potential contribution of these polymers as a source of PFCAs in the environment. The calculated potential emission rates of PFCAs from other fluorotelomer-based products are also presented.

WP167 Perfluorinated alkyl acids in biota from Lake Winnipeg (Canada). G.T. Tomy, K. Pleskach, J. Hare, S. Kollar, Department of Fisheries and Oceans, Winnipeg, Manitoba, Canada. Perfluorinated alkyl acids (PFAs) are a diverse class of compounds used in a variety of consumer and industrial applications. The surfactants perfluorooctane sulfonate (PFOS, C₈F₁₇SO₃⁻) and perfluorooctanoate (PFOS, C₇F₁₅COO⁻) have received the most attention due to their ubiquitous presence in humans and the environment. PFOS and PFOA have been detected in human serum, freshwater and marine biota, surface water, and rainwater. Lake Winnipeg is the tenth largest lake in the world with an estimated surface area of 25×10³ km². The watershed is home to more than 5 million people and the lake itself supports a vibrant commercial fishery. PFAs were measured in a variety of fish species from the lake to gain a better understanding of the level of contamination within the watershed.

WP168 Measuring Perfluorinated Compounds in Plasma of Northern Fur Seals (*Callorhinus ursinus*) and California Sea Lions (*Zalophus californianus*). J.R. Flanary, Marine Biomedicine and Environmental Sciences, Medical University of South Carolina, Charleston, SC; J.R. Flanary, J.M. Keller, J.R. Kucklick, P.R. Becker, National Institute of Standards and Technology, Charleston, SC; F.D. Gulland, The Marine Mammal Center, Sausalito, CA. Anthropogenic contaminants may have negative effects on the health of marine mammals and in order to evaluate exposure it is important to determine burdens with analytical measurements. Perfluorinated compounds are an emerging class of contaminants, which have been found to bioaccumulate, be ubiquitous in the environment, have long half-lives, and show toxicity in laboratory animals. Currently, the only perfluorinated compound reported in the literature in northern fur seal (*Callorhinus ursinus*) plasma is perfluorooctane sulfonate (PFOS), however levels of any perfluorinated compound in the plasma of California sea lions (*Zalophus*

californianus) have not been reported. We report here levels of thirteen perfluorinated compounds in these species from a preliminary experiment using pooled plasma samples collected from northern fur seals and California sea lions at the Marine Mammal Center in Sausalito, California and from northern fur seals on St. Paul Island, Alaska. Analytical measurements were performed with liquid chromatography/tandem mass spectrometry (LC/MS/MS). The results show that PFOS was the compound with the highest levels in both species; the average concentration was 6.9 ng/g and 8.7 ng/g in northern fur seals and California sea lions, respectively. In the northern fur seal perfluorotridecanoic acid (PFTrIA) and perfluoroundecanoic acid (PFUnA) had the next highest concentrations at 4.8 ng/g and 3.5 ng/g, respectively. However, in the California sea lions PFUnA and perfluorononanoic acid (PFNA) had the highest concentrations behind PFOS at 2.6 ng/g and 2.3 ng/g, respectively. Currently, analysis of individual samples from these species is being performed to determine baseline concentrations of perfluorinated compounds in plasma.

WP169 Perfluorinated Compounds in San Francisco Bay Harbor Seals. M. Sedlak, SFEI, Oakland, CA; D. Grieg, The Marine Mammal Center, Sausalito, CA; R. Grace, AXYS Analytical Laboratories, Sidney, British Columbia, Canada. In marked contrast to the increase in seal populations along the California coast, seal populations in San Francisco Bay are on the decline. The reasons for the decline are not known with certainty; hypotheses include reduction in number of haul-out sites, increased human disturbance of seals, and a potential increase in the chemical contaminant burden in seals. Fluorinated alkyl substances have been used extensively during the last 50 years in a variety of commercially available products including fire-fighting foams, refrigerants, stain repellants in textiles, and coatings for paper used in contact with food products. As a result of their chemical stability and widespread use, perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) have been detected in marine mammals and aquatic organisms throughout the world including relatively pristine environments such as the Arctic. PFOS and related perfluorinated compounds have been associated with a variety of toxic effects including mortality, carcinogenicity, and adverse development. The objective of this study was to determine concentrations of PFOS and related compounds in Pacific harbor seals (*Phoca vitulina richardsi*) in order to assess the potential for adverse effects on the seal population as a result of exposure to these compounds in the San Francisco Bay. As apex predators that eat a diet primarily composed of fish, seals are also good indicators of the presence of emerging contaminants in aquatic foodwebs. Harbor seals were captured in 2006 and 2007 from haul-out sites within the Bay and blood samples were collected for biological and chemical analyses. Preliminary results suggest that the concentrations of perfluorinated compounds observed in blood collected from San Francisco seals are higher than concentrations reported for other locations such as in the Arctic and the Baltic seas.

WP170 Biomagnification of Polyfluorinated Compounds in the Ringed Seal (*Phoca hispida*) Food Web. S. Sturman, A. Morris, K. Solomon, D. Muir, Environmental Biology, University of Guelph, Guelph, Ontario, Canada; S. Sturman, J. Small, C. Spencer, A. Morris, D. Muir, Environment Canada, Aquatic Ecosystem Protection Research Directorate, Burlington, Ontario, Canada. Biomagnification of polyfluorinated compounds (PFCs) was investigated within the ringed seal food web of populations found near two coastal communities in the Canadian Arctic: Nain, Nunatsiavut and Resolute Bay, Nunavut. Collection of seawater, spring meltwater, and specimens of species known to dominate the ringed seal diet coincided with spring sustenance hunts. Collections were also conducted during the fall to assess seasonal fluctuations of biotic and abiotic concentrations. PFC analyses were performed by LC-MS/MS and stable isotope and fatty acid analyses were utilized to reveal differences in diet and trophic position and ultimately provided information on what is being assimilated by each of the populations. Seasonal fluctuations of PFC concentrations were observed with spring coastal ocean water concentrations elevated above those collected during the fall. These findings are consistent with the hypothesis that meltwater delivery from atmospherically deposited PFCs is a significant pathway for the ringed seal food web. Biomagnification factors are generally lower when calculated using whole body burden estimates rather than liver residue PFC concentrations for ringed seal.

WP171 Partitioning of 6:2 and 8:2 Fluorotelomer Alcohols to Different Sources of Dissolved Organic Matter. N. Carmosini, L.S. Lee, Agronomy, Purdue University, West Lafayette, IN. Fluorotelomer alcohols (FTOHs) are a class of polyfluorinated, neutral, hydrophobic, organic compounds

(HOCs) that are used extensively to manufacture protective surface coatings, surfactants, adhesives, inks, paints, and waxes for a myriad of commercial and industrial products. The environmental fate and distribution of FTOHs has recently come under intense scrutiny due to concerns that they may be a source of persistent fluorinated residues detected in air, water, sewage sludge, and in humans and wildlife. Experimentally determined equilibrium partitioning coefficients for FTOHs among soil, air, water, compartments have been reported, but to date no studies have directly quantified the association between FTOHs and dissolved organic matter (DOM). Since association with DOM may elevate aqueous concentrations, enhance aqueous-phase transport, decrease volatilization, and alter degradation and bioavailability of FTOHs, quantifying DOM-water partitioning coefficients ($K_{i,DOM}$) is essential for accurately assessing their environmental fate. $K_{i,DOM}$ values for 6:2 FTOH and 8:2 FTOH with DOM from soils or commercially available humic acids were measured using either enhanced solubility or dialysis bag techniques. All DOM sources increased the apparent aqueous solubility of 8:2 FTOH, although the magnitude of this enhancement differed with log $K_{i,DOM}$ values ranging from 2.8 to 3.6. The highest $K_{i,DOM}$ values were measured for the commercially available humic acids, which have relatively high aromatic carbon contents compared to soil DOM. $K_{i,DOM}$ values are lower for the shorter chained FTOH as expected. Overall, $K_{i,DOM}$ values appear to be in the same range as values reported for other HOCs with comparable aqueous solubilities and for which associations to DOM has shown to enhance aqueous phase transport by reducing sorption to soils.

WP172 Bioavailability of the veterinary antibiotic erythromycin in an aquatic microcosm. A.M. Jessick, K.L. Henderson, J.R. Coats, Entomology, Iowa State University, Ames, IA; T.B. Moorman, National Soil Tilth Laboratory, USDA-Agricultural Research Service, Ames, IA. There is increased concern of the presence of veterinary antibiotics in the environment due to their widespread use in livestock feed for the prevention of disease and growth promotion. Veterinary antibiotics in aquatic ecosystems are not well understood. In this study, the bioavailability of radiolabeled erythromycin was evaluated in an aquatic microcosm using C8-Empore™ extraction disks and comparing uptake to *Lumbriculus variegatus*. The Empore disks and the aquatic worms were incubated in treatment water at various concentrations and time points. At the conclusion of the study, the disks and worms were extracted and uptake of radioactive erythromycin was determined. Comparisons of relative uptake between disks and the more traditional bioassay were made.

WP173 Biostimulation and Enhancement of Rhizodegradation during Phytoremediation of Perchlorate. V.A. Nzengung, Geology, University of Georgia, Athens, GA. In the late 1990s, basic research identified two main mechanisms of phytoremediation of perchlorate as: (1) Uptake and Phytodegradation, and (2) Rhizodegradation. Uptake and phytodegradation of perchlorate is a relatively slower and undesired process than rhizodegradation. Researchers have observed much higher concentrations of perchlorate (one to two orders of magnitude) in leaf tissues as a result of uptake and slow phytodegradation of perchlorate. The uptake of perchlorate by plants increases under aerobic groundwater and soil conditions and high nitrate concentrations in the root zone media. Meanwhile, rhizodegradation is a favorable process that involves ubiquitous perchlorate degrading microbes utilizing plant exudates/enzymes in the root zone to rapidly degrade perchlorate to chloride, with chlorate and chlorite as intermediate metabolites. In the recent studies, rapid rhizodegradation of perchlorate was successfully achieved by supplying dissolved organic carbon (DOC); utilized as carbon and electron donor sources by root zone bacteria. The DOC sources included sterilized and unsterilized mushroom compost "tea", chicken litter extract, and acetate. In hydroponics and soil bioreactors dosed with DOC and 25 to 40 mg/L perchlorate, degradation of perchlorate to below the IC method detection limit of 2 µg/L was achieved in <10 days compared to >60 days in the control planted bioreactors (not provided external DOC). The average rate of rhizodegradation of perchlorate was 3.1 mg/L-1d-1 for DOC amended reactors, 0.25 mg/L-1d-1 for the controls, and 20 mg/L-1d-1 for soil bioreactors amended with DOC. Also, the concentration of perchlorate in plant tissues harvested from enhanced rhizodegradation bioreactors accounted for only 5% of the initial mass of perchlorate in solution compared to 27% for the controls. The significance of this research is that the potential ecological risks posed by uptake, temporal accumulation, and possible recycling of perchlorate into the ecosystem can be minimized while increasing the rate of phytoremediation by up to two orders of magnitude.

WP174 A Thorough Understanding of the Characteristics of Perfluorinated Acid Reference Materials is Paramount to Generating High Quality Analytical Data. C. Jacoby, 3M Environmental, Health and Safety Operations, Environmental Labs, St. Paul, MN. A thorough understanding of the characteristics of perfluorinated acid (PFA) reference materials is arguably one of the most important aspects of generating high-quality, accurate, and reliable analytical data. Without this understanding, it is difficult to generate quality data with a reasonable degree of confidence. In the modern analytical laboratory, LC/MS/MS has become the predominate method of quantitative PFA analysis. Typically, when preparing reference materials for quantitative analysis, purity corrections and molecular weight corrections are the only consideration. However, in LC/MS/MS a number of other aspects must be considered in applying a highly-specific, dynamic analytical technique such as electrospray mass spectrometric detection. In this study, numerous PFA reference materials were tested individually and as mixtures to determine the potential for effects on LC/MS/MS analytical quantitation. Effects on PFA quantitation in water, methanol, and blood extract matrices related to PFA reference material isotopic substitutions, chemical forms (acid vs salts), isomer distributions, multiple component analyses, and concentration dependence will be presented.

WP175 Aquatic Sediment and Anaerobic Digester Sludge Biodegradation Test Systems Dosed with [3-¹⁴C] 8-2 Fluorotelomer Alcohol. E.C. Schaefer, A.A. Ponizovsky, Wildlife International, Ltd., Easton, MD; W.R. Berti, R.C. Buck, E. I duPont de Nemours & Co., Inc., Wilmington, DE. Biodegradation studies of fluorotelomer-based polymers help determine whether the fluorotelomer moieties, such as fluorotelomer alcohol, covalently bonded in these polymers can be liberated and transformed to perfluorinated carboxylic acids (PFCAs). These studies were conducted in sterilized aquatic sediment and anaerobic digester sludge test systems based on OECD 308 and OECD 311 guidelines, respectively, to assess their reliability by determining the recovery of total radioactivity from dosing with [3-¹⁴C] 8-2 fluorotelomer alcohol (1H, 1H, 2H, 2H-Perfluoro-1-decanol, [3-¹⁴C]; 3-¹⁴C-8-2 FTOH). The sediment layer of the aquatic sediment systems was dosed with 3-¹⁴C-8-2 FTOH and maintained under dynamic flow-through conditions at 20°C. Digester sludge systems (1.5 g sludge solids L⁻¹ mineral salts media) were dosed with 3-¹⁴C-8-2 FTOH and maintained under static conditions (sealed vessels with no shaking) at 35°C. Recovery of radioactivity in the aquatic sediment systems was approximately 100% at days 0 and 28 and approximately 80% at day 7. Overall recovery of ¹⁴C from the sediment layer averaged 78 ± 11% (average ± 95% confidence interval, n = 6). Unextractable or bound residues accounted for approximately 11% of the applied ¹⁴C. The remainder of the radioactivity was found in the aqueous layer (day 0) or in the gas-phase (day 28). An average of approximately 0.7% of the dosed radioactivity was recovered from the rubber stoppers used to seal the vessels or the needles used to aerate the systems. For the anaerobic digester sludge system, recovery of radioactivity averaged 91, 92, and 98 % at days 0, 7, and 28, respectively. Most of the dosed radioactivity was associated with the water + solids phase, ranging from 61% at day 28 to 82% at day 0. The remainder of the applied radioactivity at day 7 ranged from 2.8 to 6.5% in the gas-phase and 13 to 22% associated with the rubber stoppers and needles used to purge the headspace of the test vessels prior to opening. At day 28 the remainder of the applied radioactivity ranged from 2.2 to 9.9% in the gas-phase and 21 to 44% associated with the rubber stoppers and needles. These tests demonstrated the reliability of the dynamic flow-through and static systems to perform aquatic sediment and anaerobic digester sludge studies to assess the biodegradation potential of fluorotelomer-based polymers.

WP176 Aquatic Toxicity of Perfluorooctane Sulfonate and Perfluorooctanoic acid on *Daphnia magna*, *Moina macrocarpa* and *Oryzias latipes* after Acute, Chronic, or Two-generation Exposure. K. Ji, Y. Kim, K. Choi, Seoul National University, Seoul, South Korea; S. Oh, National Institute of Environmental Research, Incheon, South Korea. We determined the toxicity of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) using representative freshwater organisms including *Moina macrocarpa*, an indigenous water flea to Korea and two most frequently employed test species, a freshwater macroinvertebrate *Daphnia magna* and a teleost *Oryzias latipes*. In acute toxicity test, *M. macrocarpa* was about 2-fold more sensitive toward PFOS and PFOA than *D. magna*, showing a 48 h median effective concentration (EC₅₀) at 17.95 and 199.51 mg/L. Reproduction is the most sensitive endpoint in chronic toxicity test, and PFOS is approximately ten-fold more toxic than PFOA. Population growth

as measure with intrinsic rate of population increase (r) was affected by exposure to both PFOS and PFOA ($p < 0.05$), but population decrease was not observed ($r > 0$). In fish two-generation toxicity test, changes in fecundity, gonadosomatic index (GSI), and hepatosomatic index (HSI) of F0 generation were noted. For F1 generation, hatchability, time to hatch, swim-up success and post-hatch cumulative mortality were affected. It was evident that the exposure to parent generation affected the performances of F1 generation: Impacts were observed among control F1 fish of which parent generation was exposed. Continuous exposure from F0 through F1 generations increased the extent of damage. Considering the lipophilic characteristic of both perfluorinated compounds, more research would be needed for biomagnification in food chain of these compounds and their potential long-term consequences.

WP177 Biotransformation of Fluorotelomer-based materials in landfill simulation vessels and in a mixed microbial culture under methanogenic conditions. N. Wang, B. Szostek, R.C. Buck, P.W. Folsom, B.W. Wolstenholme, L.M. Sulecki, M.P. Mawn, W.R. Berti, J.T. Gannon, DuPont, Newark, DE; M.A. Barlaz, Civil, Construction, and Environmental Eng., North Carolina State Univ., Raleigh, NC. The widespread identification of fluorinated acids such as perfluorooctane sulfonate and perfluorooctanoate in the environment has led to questions about their origins. Polyfluorinated acids are industrial chemicals that have been manufactured, used and released into the environment for many years. However, an unanswered question is whether and to what extent may fluorotelomer-based materials degrade in the environment and contribute to environmental loadings of perfluorocarboxylic acids (PFCAs). 8-2 fluorotelomer alcohol [$\text{CF}_3(\text{CF}_2)_7\text{CH}_2\text{CH}_2\text{OH}$, 8-2 FTOH] is a major raw material used to make fluorotelomer-based polymers. If a fluorotelomer-based polymer could be degraded, 8-2 FTOH would be the expected initial degradation product. Further 8-2 FTOH degradation could lead to PFCA formation. Fluorotelomer-based polymers are applied to textiles to provide stain and soil resistance. These treated textiles are present in municipal waste and thus enter landfills. The objective of this research was to determine the potential degradability of fluorotelomer-based materials in (1) a laboratory landfill simulation setting, (2) by a mixed microbial culture enriched from decomposing waste, and (3) by anaerobic digester sludge under methanogenic conditions. The details of the experimental design and results will be discussed. In general, we observed that the biotransformation of 8-2 FTOH in 3.6-L landfill simulation vessels and by a mixed microbial culture under methanogenic conditions was very slow relative to work with soils and activated sludge under aerobic conditions. A FTOH-based acrylate polymer was not degraded by the mixed methanogenic culture after one year. The landfill simulation vessels were operated under conditions of moisture and temperature that were designed to optimize microbial metabolism. Thus, the degradation rate for FTOH-based materials in landfills will likely be even lower than the rate measured in the landfill simulation system.

WP178 Influence of Seasonal Variability on Tissue Distribution and Whole Body Burden of Polyfluorinated Compounds in Ringed Seal (*Phoca hispida*) from the Canadian Arctic. S. Sturman, K.R. Solomon, Environmental Biology, University of Guelph, Guelph, Ontario, Canada; J. Small, D. Muir, Environment Canada, Aquatic Ecosystem Protection Research Directorate, Burlington, Ontario, Canada. The persistence of polyfluorinated compounds (PFC) in arctic marine ecosystems has been demonstrated by accumulation in apex predators, specifically polar bear. Ringed seal are a major component of the polar bear diet and several studies demonstrate the bioaccumulative potential of these compounds; however as liver or plasma samples are typically utilized as surrogates for whole body burdens, these estimates may be overstated. This study investigated the tissue distribution of PFCs in ringed seal from two populations near coastal communities in the Canadian Arctic: Nain, Nunatsiavut and Resolute Bay, Nunavut. PFC analyses were performed by LC-MS/MS. PFOS and PFNA were the predominant compounds in all tissues however contaminant profiles varied amongst tissues. The highest PFOS concentrations were detected in liver collected from Nain while whole body burdens and tissue contamination profiles also varied by location suggesting different routes of PFC exposure. Blood, muscle and liver contribute the greatest to whole PFC body burden; blubber demonstrated greatest seasonal variability. Geographical and seasonal trends were consistent with those documenting atmospheric long-range transport as the primary route of contaminant exposure in the Arctic. Seasonal fluctuations in feeding strategies, behaviour and resulting blubber content influence PFC loading in ringed seal.

WP179 Protein Binding Interactions between Human Serum Albumin and the Linear-Chain Perfluorinated Carboxylic Acids. D.C. Burns, Worsfold Water Quality Centre, Trent University, Peterborough, Ontario, Canada; K.T. Levey, D.A. Ellis, Department of Chemistry, Trent University, Peterborough, Ontario, Canada. Human serum perfluorooctanoic acid (PFOA) concentrations have recently been reported as high as 5 ng/L, with half-lives ranging between 4 and 5 years. In rats, PFOA is a peroxisome proliferator activated receptor (PPAR) that causes liver toxicity and promotes liver carcinogenesis, testicular tumors, and pancreatic tumors. While it remains uncertain whether these effects are translated to humans, the USEPA has released a preliminary risk-assessment of low-level PFOA exposure. A fundamental knowledge of PFCA transport mechanisms and protein-binding interactions within the body remains to be acquired, and is necessary to better estimate the exposure risk that PFOA, and the analogous PFCAs, pose to the general human population. We have investigated binding between two PFCAs (perfluorooctanoic acid; PFOA, and perfluoroheptanoic acid; PFHepA) and human serum albumin (HSA); a hormone-binding protein that is present at high concentrations in blood sera and is also known to bind fatty acids. The PFCAs were titrated into a series of phosphate-buffered HSA solutions (10 – 30 μM) and the associated ^{19}F chemical shift response was used to monitor in vitro protein:PFCA binding. Titration curves for PFOA revealed two unique HSA binding modes: one involving the carboxylic moiety and the other involving the linear perfluorinated alkyl chain (C4-C8). Competition experiments indicated that the linear alkyl chain of PFOA was interacting with the fatty-acid binding sites of HSA, while the carboxylic moiety was interacting with one of the hormone-binding sites. In contrast, PFHepA acid displayed only one mode of binding involving the carboxylic acid and one of the HSA hormone-binding sites. It is well known that short-chain PFCAs are excreted from humans much more rapidly versus their longer-chain analogues. This trend may be the result of additional binding interactions that arise between HSA and longer-chain PFCAs, such that circulatory system residence times for these PFCAs are extended.

WP180 Biotransformation of Perfluorodecyl Acrylate and Perfluorodecyl Methacrylate Monomers and Oligomers in Soils. L.A. Royer, L.S. Lee, Agronomy, Purdue University, West Lafayette, IN. Poly and perfluorinated alkyl compounds (PFCs) represent a unique class of currently irreplaceable synthetic chemicals that have distinctive properties including being oleophobic as well as hydrophobic, stable under strongly acidic, alkaline and oxidizing conditions, and exceptionally heat stable. These favorable product characteristics lead to characteristics of environmental concern including prolonged persistence and a high bioaccumulative potential. Our present work focuses on perfluorinated acrylate (PFA) and methacrylate (PFMA) compounds used to make polymers that are primarily utilized to improve carpet and fabric stain repellency. These polymers consist of perfluorinated alkyl compounds (PFA and PFMA in this study) bonded to a hydrocarbon backbone. We hypothesize that (1) the ester linkages to the hydrocarbon backbones are susceptible to microbial attack after which the released monomers can subsequently degrade to release perfluorinated carboxylic acids (PFCAs) of environmental concern; and (2) microbial susceptibility decreases with increasing oligomer size. Quantifying degradation of the monomers and oligomers in soils is needed to predict how the more complex polymers may degrade. Microbial degradation of PFA and PFMA monomers were monitored over time in a 9-day incubation study with moist silty clay loam soil microcosms. LC/MS/MS was used to analyze and identify the degradation products. PFA and PFMA monomers degraded to fluorotelomer alcohols (FTOHs) and some PFCAs. Maximum levels of 8:2 FTOH were observed on day 3 followed by decreasing concentrations while PFCAs of varying chain lengths from C-4 to C-8 appeared to linearly increase over the 9-day incubation. The estimated half-life for the parent compounds are 9.6 days and 12.9 days for PFMA and PFA, respectively. Degradation products identified included 8:2 fluorotelomer carboxylic acids and 8:2 fluorotelomer unsaturated acids. Oligomers of varying size are currently being synthesized for use in similar soil degradation studies.

WP181 Macroinvertebrate assemblages in sediments and waters of a remediated site in Sydney, Australia. C. Rawson, R. Lim, Environmental Sciences, University of Technology, Sydney, Broadway, New South Wales, Australia; C. Rawson, R. Lim, Institute for Water and Environmental Resource Management, Broadway, New South Wales, Australia; M. Warne, Landcare Research, Lincoln, New Zealand; E. Laginestra, Centre for Environmental Contaminants Research, CSIRO Land and Water, Glen

Osmond, South Australia, Australia; J. Chapman, Sydney Olympic Park Authority, Sydney Olympic Park, New South Wales, Australia. Prior to the 1980s Sydney Olympic Park was contaminated with high levels of industrial chemicals and was a repository for residential waste. In the lead-up to the 2000 Olympic Games, contamination at the site was characterized, and the soils and sediments were remediated using on-site treatment technologies and subsequent on-site consolidation and clay-capping of contaminated soil. The aim of this study was to provide a snapshot of aquatic macroinvertebrate communities inhabiting the sediments and vegetated littoral zone in a number of water bodies in the Park. Sediment cores and sweep samples were taken from sites with different remediation histories - from remnant to partially remediated to fully remediated. Previous chemical analysis showed that sediment and water concentrations of persistent organic pollutants (POPs) varied across the sites. Multivariate analysis (ANOSIM, BIOENV) showed significant ($p < 0.05$) differences in benthic macroinvertebrate community structure between the water bodies. This was more closely related to sediment characteristics (especially size and organic carbon content) than to remediation history or contaminant concentration. Similarly, the aquatic macroinvertebrate community structure in the water column was significantly ($p < 0.05$) different between water bodies and was more closely related to aquatic macrophytes in the littoral region than remediation history. The information from this study provides important insights to managers of the parklands in terms of maintaining healthy aquatic invertebrate assemblages in a rare urban space with ecological (migratory birds and endangered aquatic species), educational and recreational amenities.

WP182 Long-Term Monitoring of Fish Mercury Concentrations in the North Fork Holston River. E. Curtis, A. Shortelle, N. Ruberti, M. Bystedt, C. Butcher, L. Venne, MACTEC Engineering and Consulting, Inc, Kennesaw, GA; K. Roberts, Olin Corporation, Charleston, TN. An industrial facility that operated on the North Fork Holston River (NFHR) was determined to be the source of mercury (Hg) contamination in the NFHR. During facility operations (1951 until 1972), Hg was used as part of the electrolytic chlorine and caustic soda processes. Numerous studies have been conducted on the surface water, sediment, and biota downstream of the former chlorine plant (site) for approximately 80 river miles to monitor Hg concentrations and the overall health of the system as it recovers. Fish advisories have been posted on the NFHR, and Hg concentrations in fish tissue are of concern to piscivorous wildlife inhabiting the NFHR system. Remediation efforts on the NFHR have been ongoing since the plant closed in 1972. Three species of fish (northern hogsucker, redbreast sunfish, and rock bass) have been collected annually in August since 1982 from eight standardized locations downstream of the site. Hg analysis has been conducted on fish filets collected at these eight locations. Hg concentrations in fish are assumed to be ~100% methylmercury, therefore methylmercury was not analyzed on annual collection samples. Since 1982, fish tissue Hg concentrations have decreased between 0.02 and 0.04 mg/kg/year; a substantial total decrease in Hg concentration in each species over the past 25 years. The northern hogsucker was found to have the highest rate of Hg concentration decrease (0.041 mg/kg/year); likely due to being at the lowest fish trophic level. Redbreast sunfish, which have a short life span (up to 5 years in Virginia) and are invertivores (middle trophic level), appeared to be least affected by activities in the river with decreasing average Hg concentrations of 0.021 mg/kg/year. Additionally, concentrations appear to be directly influenced by activities in the river, whether remedial (i.e., source area capping, site wastewater treatment, and sediment excavation) or environmental (i.e., floods). Spikes in concentration occurred directly after dredging in the river and large flood events, followed by consistent recovery rates. However, the combined effect of natural recovery and the remediation activities focused on the sediment and the site which have already been performed. Fish Hg concentrations continue to decrease and are expected to be below the state fish consumption advisory level in the near future.

WP183 PCB Concentrations in Fish Following Partial Remediation of a Small Hazardous Waste Site. J. Field, NOAA/ORR, Seattle, WA; J.W. Kern, Kern Statistical Services, Sauk Rapids, MN; R.J. Sloan, NYSDEC (Retired), Salem, NY. A small, PCB-contaminated hazardous waste site at the downstream end of the Sherman Island Pool of the upper Hudson River (NY) was partially remediated in 1996. Remediation included removal of contaminated on-site soil and adjacent sediment along the river shoreline that was exposed while the water level in the pool was lowered by four feet during the remediation. Annual fish monitoring was conducted between 1995 and 2005 from several locations within the pool, including one

station immediately adjacent to the site, one about 850 meters downstream and another across the pool about 300 meters from the site. We used a multiplicative equation to model PCB concentrations in fish tissue as a function of location, lipid content, year, and species. Multiple linear regression techniques were used to test for differences in mean PCB concentrations among locations and species and to test for differences in temporal trends among locations and species. Differences in fish PCB concentrations among locations were observed for each species within the relatively small spatial scale of the pool. In particular, mean concentrations in fish from the station adjacent to the site were generally much higher than any other location within the pool. The results of our analysis suggest that long-term monitoring strategies that do not adequately consider spatial and interspecies differences in average concentration as well as temporal trends in PCB concentrations may provide misleading results.

WP184 Post Remediation Monitoring of Newton Creek Demonstrates Success of Interim Action. K.L. Schmude, Lake Superior Research Institute, University of Wisconsin Superior, Superior, WI; M. Broses, G.G. Chojnacki, SEH Inc., Chippewa Falls, WI; J.A. Hosch, J.H. Robinson, WDNR, Superior, WI. Newton Creek begins near the Murphy Oil USA (Murphy) refinery in Superior, Wisconsin, and ends at its mouth located at Hog Island Inlet, which discharges to the St Louis River Area of Concern (AOC) on Lake Superior. In 2003, an interim remedial action was performed on the Newton Creek system to remove visually observable contaminated soft sediments from the creek channel. The interim remedial action was jointly funded by the WDNR and the USEPA Great Lakes National Program Office (GLNPO). Approximately 7,300 tons of impacted material was removed from July through September 2003. This included remediation of 6,000 feet of creek channel and 1,100 feet of culverts. Upon completion of remedial activities, the creek channel was restored by placement of breaker run stone overlain by streambed stone. Disturbed areas of the bank were restored via placement of erosion control fabric, coir rolls, seeding and live stake shrubs and trees. Post-remediation monitoring activities for Newton Creek included chemical analysis of sediments and macroinvertebrate benthic organism population studies as part of an on-going effort to evaluate the restoration and health of the aquatic system habitat. Post-remediation total PAH contaminant concentrations in the Newton Creek sediments do not exceed 3 mg/kg and do not appear to pose unacceptable rises to human health or the environment. Significant post-remediation improvements in the benthic macro-invertebrate community were identified including increases in taxa richness and diversity and the appearance of sensitive species. Notable observations include: dramatic increases in black flies and snails; the first time observation of sowbugs, larval beetles in several different families, a mayfly species, crayfish, and a member of the snail family. Prior to remediation, the common macroinvertebrate fauna included only two major groups (midges and worms) compared to post remediation fauna that increased to five major groups with 10 to 25 taxa. Increased macroinvertebrate diversity indicates a positive step toward improved water quality.

WP185 In-situ and ex-situ exposures of *L. variegatus* to PCB-contaminated field sediments. B.A. Beckingham, X. Sun, J. Jersheid, U. Ghosh, Civil & Environmental Engineering, University of Maryland Baltimore County, Baltimore, MD. Polychlorinated biphenyls (PCBs) are hydrophobic legacy pollutants found widespread in environmental media which have potential to enter and accumulate in aquatic food chains. In fact, health advisories prohibiting the consumption of certain fish species are in effect at many PCB-impacted sites. In past research it has been demonstrated that significant bioavailability reductions are achieved by amendment of contaminated sediments with granular activated carbon (GAC). Current efforts in support of this in-situ amendment technology aim to track long-term (2-3 years) bioavailability reduction in sediments of an industrially-impacted river in Upstate New York by field and laboratory exposures of a common oligochaete worm, *Lumbriculus variegatus*. Worms were placed in replicate flow-through cylindrical chambers and lowered to the river bottom at 6 experimental locations and one reference location within a 0.5-acre section of the river and recovered after 14 days. In parallel to this in-situ exposure, ex-situ laboratory exposures were conducted using sediments from the same locations for the same time duration with overlying site water. In both experiments after exposure, worms were cleaned, depurated for 6 hours and frozen until extraction. Worm tissue extracts were processed to remove interferences and analyzed by gas chromatography with electron capture detection according to standard operating procedures. In addition to determining GAC treatment effect over time, the ability of laboratory

exposures to mimic results from the field will be assessed in this research. This paper will present results from the baseline study conducted before GAC amendment into sediments.

WP186 Effects of heavy metals on transcription levels of antioxidant and stress responsive genes of Javanese medaka *Oryzias javanicus*. S. Yum, S. Woo, South Institute, Korea Ocean Research and Development Institute, Geoje, South Korea. The differential expression of eight genes representing stressor biomarkers (*OjaCAT*, *OjaCYP1A*, *OjaG6PD*, *OjaGPx*, *OjaGR*, *OjaGST*, *OjaSOD*, and *OjaUB*) was investigated by real-time quantitative PCR in liver of Javanese medaka, *Oryzias javanicus*, after exposure to Ag, Cd, Cu, Zn, Cr and Ni at various concentrations. The level of *OjaCAT* mRNA increased in a dose-dependent manner on 24-h exposure to Cd, Cu and Zn. However, after Ag, Cr and Ni exposure, a significant decrease in *OjaCAT* levels was observed. *OjaCYP1A* mRNA levels decreased drastically on exposure to all heavy metals tested. *OjaG6PD* mRNA levels showed a dramatic increment after 24-h exposure to Cu and Zn at low doses. However, mRNA levels decreased at high concentrations of Cu and Zn. In the case of Ag, Cd, Cr and Ni exposure, no prominent expression changes were observed. *OjaGPx* mRNA levels in liver were induced by Ag, Cd, Cu and Zn exposure, but suppressed by Cr and Ni exposure. Exposure to all heavy metals tested upregulated mRNA levels of *OjaGR*. *OjaGST* mRNA expression was upregulated by all heavy metals tested in a dose-dependent manner. *OjaSOD* mRNA levels increased on exposure to Ag, Cd, Zn and Cr, but no responses could be observed after Cu and Ni exposure. Positive induction of *OjaUB* expression was observed for all doses of heavy metal exposure. Use of fishes at least 12 months after hatching for assessing heavy metal effects on the expression of antioxidant and stress-related genes is recommended, even though age variations in gene expression changes were observed.

WP188 Potential biomarkers from a Korean collembolan species to cadmium exposure using proteomic analysis. J. Son, K. Cho, Environmental Science and Ecological Engineering, Korea University, Seoul, South Korea; S. Lee, B. Park, Research Station, Nanotextech Inc., Sungnam, South Korea. The goal of this study was to find if the over- or down-expressed proteins after cadmium exposure in a collembolan species might serve as a biomarker for the determination of environmental cadmium. Using 1D-PAGE and nano-LC-MS/MS, an increased expression of ubiquitin and interferon-induced guanylate-binding protein was found after the fifty collembolan exposed to cadmium at the concentration of 3.5 ppm. Interestingly, an up-regulation of a protein as similar to recessive polycystic kidney disease protein was also determined after 3.5 ppm cadmium exposure. At the concentration of 14.0 ppm of cadmium, collembolan over-expressed nuclear receptor coactivator, similar to solute carrier family 22 (organic cation transporter 6), similar to poly[ADP-ribose]polymerase-1, and Hsp82 when compared to the control group. Ubiquitin was also over-expressed in the insects under the same circumstances. The down-regulation of several proteins such as brain glycogen phosphorylase, similar to putative mitochondrial ATP synthase alpha subunit precursor, arginine kinase and carbonic anhydrase was found in the collembolan species after cadmium exposure. From these results, we concluded that the ubiquitin protein at the low contaminated environment of cadmium at the level of 3.5 ppm and the Hsp82 protein at the high contaminated environment of cadmium at the level of 14.0 ppm might be considered for potential biomarkers in collembolans and these proteins were easily determined with only fifty collembolans. *Funded by Korea Institute of Environmental Science and Technology (No. 2007-09001-0043-0)

WP189 The use of microarray to investigate causative factors for the declining numbers of Delta smelt (*Hypomesus transpacificus*) in the Sacramento-San Joaquin Estuary. R.E. Connon, T. Ha, I. Werner, School of Veterinary Medicine: Anatomy, Physiology and Cell Biology, University of California, Davis, Davis, CA. The Delta smelt (*Hypomesus transpacificus*) is a federally listed endangered pelagic fish species, and considered an indicator species of the overall health of the Sacramento-San Joaquin watersheds and estuary. Its numbers have rapidly been declining in spite of remediation efforts. Microarrays have increasingly been used in ecotoxicology to measure the impact of stressors upon an organism, identifying pathways that are altered due to exposure. In order to understand the effects of contaminants upon *H. transpacificus* we have constructed a microarray for this pelagic species, with over 8,000 ESTs. Gene fragments were obtained using a normalized cDNA library of organisms exposed to a number of controlled stressors as well as ambient water samples. Copper is a contaminant of concern in California's Central Valley and is considered one of the most commonly used pesticides

applied to rice fields, orchard and vineyards. This heavy metal can bind to sediment and food particles, and bioaccumulation in predatory fish is a major concern. To assess the effect of copper on the delta smelt, we applied the microarray to measure gene responses on 90-day old juveniles to 150 µg/L copper for 96 hours. Here we present specific genes and clusters of genes responding, and suggest how a multi-biomarker approach can be used to measure stress responses and aid the determination of causative factors for the decline in numbers of this species.

WP190 An Example of EcoPRG Calculations and Use at a Department of Defense CERCLA Site in Texas. M. Weisberg, J. Lindberg, Shaw Environmental, Inc., Monroeville, PA; J. Lindberg, Shaw Environmental, Inc., Knoxville, TN. The Site is an 8,500-acre Department of Defense facility located in eastern Texas that is in the process of undergoing remediation in selected areas. To assist in the cleanup, site-specific ecological preliminary remediation goals (EcoPRGs) have been developed. These EcoPRGs were developed for a subset of chemicals that earlier steps in the risk assessment identified as being of most concern at the facility. Hazards to ecological receptors at the Site were estimated using a baseline ecological risk assessment (BERA), which used site-specific uptake data, as well as sediment toxicity data to estimate potential effects on measurement endpoints. Based on these data, no-observed-adverse-effect-level (NOAEL) and lowest-observed-adverse-effect-level (LOAEL) PRGs were calculated for the BERA COPECs. These media-specific NOAEL and LOAEL PRGs were then used to identify the final EcoPRGs using the Rule of Five (Greenberg and Charters, 2005). The Rule of Five is a method that selects a cleanup goal within the NOAEL-LOAEL risk range for a particular assessment endpoint based on the consideration of points in a geometric progression. Soil EcoPRGs were calculated for barium, lead, 2,4- and 2,6-dinitrotoluene (DNT), 2,4,6-trinitrotoluene (TNT), and dioxin, and sediment EcoPRGs were calculated for mercury, thallium, and lead. These EcoPRG concentrations were compared with exposure point concentrations, i.e., 95% upper confidence limit (UCL) concentrations within each spatial unit of exposure of concern. Chemicals whose UCLs exceeded their EcoPRGs may pose a risk to ecological receptors. The following soil COPECs were recommended for remedial alternatives evaluation, as the facility 95% UCLs exceeded the EcoPRGs: barium, 2,4-DNT, 2,6-DNT, 2,4,6-TNT, and dioxin. For sediment, the 95% UCL for lead exceeded the sediment EcoPRG. Currently, areas with elevated concentrations of these five COPECs are being identified so that remedial alternatives considered in the feasibility study may selectively address these chemical hotspots.

WP192 Treatment of simulated thermoelectric cooling waters for discharge and reuse using pilot-scale constructed wetland treatment systems. L.R. Kushner, L. Dorman, J.H. Rodgers, Clemson University, Clemson, SC. Constructed wetland treatment systems (CWTS) may be used to treat constituents of concern in cooling waters from thermoelectric generation facilities, and may expand the potential for beneficial reuse of these waters. Cooling waters were characterized by identifying constituents of concern based on internal reuse and discharge criteria and CWTS were specifically designed and constructed to treat these constituents of concern. Performance of a pilot-scale constructed wetland for treating simulated cooling waters containing free chlorine, copper, lead and zinc was evaluated in relation to discharge and internal reuse treatment criteria. Performance measures indicated that 94% of total aqueous copper, 38% of total aqueous zinc, 60% of total aqueous lead and all free chlorine were removed in the CWTS. Potential for cooling water to cause corrosion or form chemical scale was decreased, and potential for biofouling was not increased. Pilot-scale CWTS treated free chlorine, copper, lead and zinc and the potential for corrosion, chemical scale formation, and biofouling at rates and extents which show CWTS are a reasonable treatment alternative for beneficial reuse of cooling waters.

WP193 The Degradation and Toxicity of Naphthenic Acids Present in Athabasca Oil Sands Process Affected Waters. N. Toor, K. Liber, Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; M. MacKinnon, Syncrude Canada Ltd., Edmonton, Alberta, Canada; P. Fedorak, Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada. Process affected waters from the Athabasca Oil Sands (AOS) in northern Alberta, Canada, contain a complex mixture of organic constituents. The toxicity of these oil sands process affected waters (OSPWs) have been shown to be, at least partially, related to a relatively persistent group of dissolved organic acids known as naphthenic acids (NAs). In this research, we evaluate the potential for the degradation and associated reduction in toxicity

of OSPWs in wetland environments, a proposed strategy for reclamation at the AOS. Using controlled laboratory microcosms to mimic natural wetlands, we set out to determine if the toxicities of OSPWs generated by Syncrude Canada Ltd. (Syncrude) and Suncor Energy Inc. (Suncor) change as a result of aging and biodegradation over time. Experimental manipulations include two types of OSPWs (Syncrude and Suncor), increased nutrient availability (nitrogen and phosphorus enrichment), and short and long hydraulic retention times (40 and 400 days). For the first time, NAs present in OSPW are tracked over the course of one year in order to investigate the relationships between total NA concentrations (quantification using FTIR), the degree to which different groups of NAs are biodegraded (based on 'fingerprinting' using GC-MS), and any potential reduction in OSPW toxicity as measured by the Microtox[®] bioassay.

WP194 Surfactant Microbubble-Aided Bioremediation for the Treatment of Phenanthrene in the Subsurface Environment. Y. Choi, J. Park, D. Shin, Y. Kim, K. Nam, Seoul National University, Seoul, South Korea. A microbubble made of surfactant is proposed as a new agent for use as a flushing-type soil remediation technology. This microbubble technology has advantages over conventional soil flushing processes as it requires less volume of surfactant solution and reduces channeling in heterogeneous media. More importantly, the microbubble has an air core that occupies around 50% of the microbubble volume, which can carry pollutant-degrading bacteria. Also, when collapsed, the microbubble turns into surfactant solution, which may facilitate desorption of sorbed organic pollutants. These properties have allowed microbubbles to be considered as a potent medium for enhanced aerobic biodegradation in the subsurface. *Quillaja* saponin, a plant-based biosurfactant, was selected as a surfactant for the generation of microbubbles with a lower environmental impact. A saponin-based microbubble carrying phenanthrene-degrading bacteria was generated, with its flushing and phenanthrene degradation capacity tested and compared to surfactant-based flushing. Columns packed with 300 g of Ottawa sand, spiked with 10 or 100 mg/kg of phenanthrene, were used. When a flushing process was performed with 0.2% saponin solution, only 46 and 6% of the spiked phenanthrene was removed after the injection of 3 pore volumes of the saponin solution. However, when 3 pore volumes of microbubbles containing phenanthrene-degrading bacteria were introduced into the column spiked with 100 mg/kg phenanthrene, then left to biodegrade for 8 days at 20°C, about 23% of the phenanthrene was observed to be biodegraded (a four times greater reduction than with the flushing effect of the same pore volume) with additional 4% reduction by flushing effect. The percentage of phenanthrene destroyed corresponded to a mass of 7.2 mg, which was well-matched to the amount of phenanthrene biodegradable based on the oxygen delivered by microbubbles. Our experimental data and stoichiometric calculation indicated that about 3 pore volumes of microbubbles can supply the oxygen required for the complete biodegradation of 10 mg/kg of phenanthrene. Further study is underway to demonstrate that more phenanthrene can be biodegraded by the additional supply of oxygen via the injection of more microbubbles or with the use of a different type of injection, showing that this surfactant-based microbubble would be a viable remediation technology in the subsurface environment.

WP195 Uptake of Lambda-Cyhalothrin and Atrazine by Aquatic Macrophytes in a Laboratory Hydroponic Exposure. I. Mundali, Arkansas State University, State University, AR; I. Mundali, Baylor University, Texas, TX. Phytoremediation is the cleanup of contaminated soils, water or air with plants capable of containing, degrading or eliminating contaminants from the mediums that contain them. It is clean, efficient, inexpensive and non-environmentally disruptive. Using a 5% runoff model from a 0.65-cm rainfall event on a 2.02 hectare land, remediation capabilities of two common aquatic macrophytes in agricultural drainages of the Mississippi Delta, USA, were evaluated in a laboratory exposure. Atrazine, lambda-cyhalothrin and a combination of the two pesticides were hydroponically exposed to the macrophytes for 8d. While more lambda-cyhalothrin was absorbed by *Juncus effusus* (monocot), *Ludwigia peploides* (dicot) absorbed higher concentrations of atrazine. Upward translocation of this herbicide was well displayed after 24h, but by 8d, the roots contained more of this pesticide than the upper plant tissue. Lambda-cyhalothrin was sequestered in the roots of both macrophytes; however translocation into upper biomass was not well exhibited. Higher lambda-cyhalothrin uptake was measured in *J. effusus* after 8d. In the combined pesticides exposure, *L. peploides* absorbed atrazine more efficiently. Chemical properties of pesticides should be considered prior to phytoremediation attempts. Insoluble pesticides such as lambda-cyhalothrin

are quickly adsorbed onto macrophytes in agricultural receiving systems while water soluble chemicals such as atrazine may be absorbed by existing macrophytes.

WP196 Functional Assessment of Plant Communities at Five Restored Sites in a Lower Galveston Bay Estuarine Marsh Complex. D.L. Ray, J. Dobberstine, J.C. Whitney, C.L. Howard, University of Houston Clear Lake, Houston, TX; J. Dobberstine, The Galveston Bay Foundation, Webster, TX. Pierce Marsh is an estuarine marsh complex located within the lower Galveston Bay system. Like many similar marsh complexes along the lower Texas Gulf coast, vegetated communities within Pierce marsh have suffered from the effects of relative sea level rise. Once primarily composed of dense coastal prairie and high marsh, much of Pierce marsh has become open water and low marsh. In an effort to restore the function of these important communities, efforts have been taken to apply various techniques to restore several sites within the complex. Little data is available indicating which restoration technique most successfully replaces vegetation growth and function relative to a natural control site. Efforts to restore this marsh have used several different restoration techniques. This study examines plant community metrics at five restored sites in Pierce marsh according to the design of the restored site (e.g., grid v. sigmoid terrace); data are compared to a natural reference site within Pierce marsh and two nearby impacted sites on lower Galveston Bay. Sites were sampled during June through August of 2007, using a plot transect sample method. Data collected include plant stand density, above and below ground biomass, and plant species diversity. Sediment characteristics, including grain size and chemical components (e.g., TOC, heavy metals, nutrients), were also analyzed relative to the control and contaminated sites to determine if these parameters affected plant community metrics. Initial results demonstrated differences among the different restoration methods.

WP197 Laboratory Simulation to Determine Potential Toxicity of a Polyacrylamide. J. Bouldin, P.S. Wren, S. Green, W. Baker, Environmental Science Program, Arkansas State University, State University, AR. Agricultural-associated contamination is often associated with rain and irrigation runoff events. Synthetic water-soluble polymers of acrylamide known as polyacrylamide (PAM) have been used for soil erosion. This best management practice (BMP) often used for erosion control has the added benefit of decreasing the amount of sediment and sediment-associated contaminants reaching receiving streams. Suspended soil particles bound with PAM tend to precipitate, reducing the risk of agricultural-associated runoff. Laboratory simulations to investigate potential toxicity of an anionic PAM product included exposure of *Pimephales promelas* and *Ceriodaphnia dubia* using 7-day chronic US EPA standard test protocol. PAM product suspended in moderately hard laboratory water was exposed to test organisms with and without the presence of suspended sediment. Reproductive endpoints for *C. dubia* were higher in laboratory simulations with sediment than with PAM product and laboratory water. Calculated IC25 values were 15mg/L in the absence of sediment and 60 mg/L in simulated sediment runoff exposures. Lethal and sublethal endpoints for *P. promelas* exposed to simulation scenarios did not differ. The use of PAM products to reduce field erosion may provide soil savings to the farm manager but also have an additional benefit of reducing contamination associated with agricultural runoff.

WP198 Does the CaCl₂ Extractable Ni from Field Soil Relate to Phytotoxicity?. S. Cioccio, B. Hale, Land Resource Science, University of Guelph, Guelph, Ontario, Canada. Approaches to remediation of contaminated soils include phytoremediation, which is time consuming and removal of the contaminated soil, which is expensive. An alternative method is to chemically treat the soil with limestone to increase its pH and decreases the availability of the metal contaminants. The limitations of this practice have not yet been fully described in terms of extremes of soil Ni concentration, lime treatment and induced trace element deficiencies. These limits are being examined in Port Colborne Ontario, which has soil concentrations of Ni (as high as 5000 mg/kg) well above regulatory guidelines, due to refinery emissions from the early to mid 1900's. The site has been divided into three fields, Hruska West, East and Snider, with 50, 10 and 0 t/ha of lime added, respectively. The fields were planted with soybean in early May 2006 and observations were made throughout the summer. Although the Snider field had the worst plant growth, pockets of healthy plants survived; paired soil and plant samples were taken from multiple locations in this field to determine if soil pH, total Ni (HNO₃ digestion) or bioavailable Ni (CaCl₂ extractions) in soil measurements were correlated to Ni in the plant tissue and corresponding

plant health. Five pairs of soil/plant with a range of plant health were sampled from each of five separate plots; additionally, six separate sites at the perimeter of the field were sampled each as a pair of good and bad plant growth. Plants and soils were hot acid digested in concentrated HNO₃ to determine total Ni concentrations. As well, soil was extracted with CaCl₂ to determine extractable Ni concentrations. Samples were analyzed for Ni using Flame AAS. Total Ni in soil did not relate to the condition of the plants in the field and soil pH was not related to the total Ni present in soil. The CaCl₂ extractions, which purport to estimate "phytoavailable" Ni, did relate to the condition of the plants in the field: as plant performance decreased, phytoavailable Ni increased. A higher soil pH was associated with decreased phytoavailable Ni in soil, which in turn was related to healthier plants. It is possible that soil pH influenced plant health independently of its effect on soil Ni availability; it is also possible that the higher pH decreased bioavailability of Ni to the plants through competition between H⁺ and Ni²⁺ for cationic binding sites on the roots.

WP199 Species composition of 316(b) impingement collections at We Energies Valley Power Plant as an indicator of habitat improvement of the Lower Milwaukee River and Estuary. D. Rodgers, Environmental Technologies Solutions, Kinectrics, Toronto, Ontario, Canada; D. Michaud, We Energies, Milwaukee, WI; B. Anderson, A. Kroken, B. Hudsinski, J. Bilitz, M. Lesperance, K. Tess, J. Krause, K. Berg, M. Oberbeck, K. Haley, Department of Biology, Wisconsin Lutheran College, Milwaukee, WI. In 2004, EPA issued new, performance-based requirements governing the intake of cooling water for power generation. The new requirements, described in the revised Clean Water Act 316(b) Phase II Rule, apply to existing electric generation facilities that withdraw more than 50 million gallons per day. The new performance standards often require studies to quantify entrainment and impingement of aquatic organisms in the cooling water intake flow. The species composition of impinged fish in 2006-2007 studies at We Energies Valley Power Plant on the Menomonee River, in Milwaukee Wisconsin differed considerably from that observed in previous 1975-1976 studies. Changes in species numbers and composition, particularly the presence of sensitive species, are discussed in relation to ongoing changes in habitat of the Lower Milwaukee River and Estuary.

WP200 Bioremediation of a PAH in an aged coal-tar contaminated soil using different in-vessel composting approaches and temperature programmes. B. Antizar-Ladislao, Dept. Water and Environment Science and Technology, University of Cantabria, Torrelavega, Spain; A.J. Beck, Dept. Agricultural Sciences, Imperial College London, London, United Kingdom. The biodegradation of 16 USEPA-listed PAHs during simulated in-vessel composting-bioremediation of an aged coal-tar-contaminated soil amended with fresh green waste compost (FGWC) collected from two landfill sites in the United Kingdom (UK) were studied over 56 days. The experimental design compared three constant temperature profiles (TC = 38 C, 55 C and 70 C) with three variable temperature profiles including treatment at 70 C to comply with regulatory requirements (TP1, TP2 and TP3). The highest disappearance of PAHs was observed in the soil amended with FGWC (53.2% and 48.1% PAHs disappearance in soil amended with FGWC-Site 1 and FGWC-Site 2, respectively) containing lower initial organic matter (TOM) (Initial TOM-FGWC-Site 1 = 25.6 ± 0.6% < Initial TOM-FGWC-Site 2 = 32.5 ± 0.1%). Compared with previous investigations, higher disappearance of PAHs occurred when the same coal-tar soil was amended with fresh green waste (56.0% PAHs disappearance in soil amended with fresh green waste) instead of FGWC. Greatest PAHs removal (75.4 ± 0.1%; k₁ = 0.026 day⁻¹, R₂ = 0.98) occurred at TC = 38 C compared to all variable temperature profiles TP1 (62.1 ± 11.0%; k₁ = 0.016 day⁻¹, R₂ = 0.93), TP2 (71.8 ± 8.2%; k₁ = 0.021 day⁻¹, R₂ = 0.95) and TP3 (45.3 ± 9.7%; k₁ = 0.010 day⁻¹, R₂ = 0.91). This study proved that using thermophilic temperatures (70 C) towards the end of in-vessel composting processes (TP2) resulted in greater PAHs removal than using other variable temperature profiles (TP1, TP3), as long as the increase was stepwise via an intermediate temperature (55 C). Varying the temperature during in-vessel composting to comply with regulatory requirements for pathogen control, promoted contaminant biodegradation, microbial activity and compost maturation. Keywords: Bioremediation, Composting, Kinetics, PAH, Temperature.

WP201 Low Cost, Low Impact Remediation of Recalcitrant Chlorinated Hydrocarbons in Groundwater. L. Gneiding, AMEC Earth & Environmental, Inc., Somerset, NJ; H. Faircloth, CORE Engineering & Construction, Winter Park, FL; T. Fiorillo, 45th CES/CEVR, Patrick

AFB, Patrick AFB, FL. The USEPA considers groundwater contamination from chlorinated organic solvents as one of the most serious environmental problems due to the potential carcinogenic nature and recalcitrant properties of these compounds. Laboratory and field demonstrations have shown that sulfate-reducing and methanogenic bacteria begin the dechlorination process for tetrachloroethene (PCE) and trichloroethene (TCE) but specific dehalo-respiring bacteria are required to the complete dechlorination. Several natural, non-pathogenic microbial species have been isolated that are capable of completely dechlorinating TCE to ethene. A pilot study was conducted in groundwater at Space Launch Complex (SLC) 36 at Cape Canaveral Air Force Station, FL using a commercially available microbial mix and an electron donor combination to determine its effects on the dissolved chlorinated hydrocarbon plume. Initial results indicate increased bioactivity and reduced VOC concentrations.

WP202 Remediation of Bacteria in Ballast Water with Ozone. J. Bearr, C. Mitchelmore, D. Wright, UMCES, Chesapeake Biological Laboratory, Solomons, MD; J. Bearr, Toxicology, University of Maryland - Baltimore, Baltimore, MD. International transport and introduction of non-indigenous and potentially invasive species in ballast water can cause significant ecological and economic damage. This can include the transfer of harmful bacteria (i.e., *Escherichia coli* and *Vibrio cholerae*) that are known to be more abundant in the coastal waters of ports located near inadequate waste water treatment facilities. Ozone application may be applied to remediate the impact of ballast release. This research focused on the efficacy of ozonation on the survival and growth of numerous bacterial indicator species, including: total culturable bacteria, enterococci, *E. coli*, total coliforms, and *V. cholerae*. Experiments were initiated after completion of the ozone treatment onboard the commercial oil tanker, at anchor in Puget Sound, Washington. Samples were taken at test initiation (0 hrs) and at 3 hrs, 6 hrs, 12 hrs, and 24 hrs post treatment. Enterococci, *E. coli*, and total coliforms were measured using commercial (and water-quality testing approved) IDEXX kits. *V. cholerae* was quantified using PCR. Ozonation was found to reduce concentrations of all measurable living bacteria by over 90% at test initiation in comparison to bacterial samples taken from the control tank. Samples taken at 3, 6, 12, and 24 hrs were shown to have significantly less bacteria than samples taken from the control tank. This work was part of a larger project which included quantitation of numerous ballast water species (zooplankton and phytoplankton) before and after ozone treatment to assess efficacy of this proposed ballast water treatment method.

WP203 Comparison of isolation techniques for polar organic compounds using surface waters near mine and milling operations. C. Rostad, US Geological Survey, WRD, Denver, CO; J.G. Schumacher, US Geological Survey, WRD, Rolla, MO; C.J. Schmitt, US Geological Survey, BRD, Columbia, MO. Surface-water samples were collected near a lead mine and mill tailings about 70 miles southwest of St. Louis, Missouri. Water samples contained relatively high concentrations of dissolved organic carbon for surface waters (greater than 20 mg/L), but were colorless, which precluded naturally occurring aquatic humic or fulvic acids. Previous analysis had indicated that samples were devoid of pesticides and acid/base/neutral extractable semi-volatile organic compounds, such as polycyclic aromatic hydrocarbons. Polar organic compounds were isolated by solid-phase extraction using hydrophobic/lipophilic balance, weak anion exchange, and macroporous methylmethacrylate polymer resin phases. All three solid phases isolated dioctyl sulfosuccinate, a filter aid used in the milling process. The weak anion exchange phase was selected and its elution tailored for isolation of the more heavily used alkyl xanthates, which were not found. The hydrophobic/lipophilic balance and macroporous methylmethacrylate polymer resin isolated several isopropyl xanthyl degradation products in the mill effluent and downstream tailings pond.

WP204 Recent Improvements in Analysis of Aqueous Samples for Methyl Mercury: Improved Accuracy and Precision and Lower Detection Limits. A. Carter, Brooks Rand Labs, Seattle, WA. According to EPA Draft Method 1630, distillation is the preferred technique for preparation of water samples for methyl mercury analysis by cold vapor - atomic fluorescence spectrometry. Distillation introduces a significant level of variability and has been found to be the limiting factor in the calculated method detection limit. Recent advances in analytical procedures (Brooks Rand Labs, 2006) have lowered the instrument detection limits substantially from 0.02 ng/L to 0.002 ng/L through the use of automated analysis. Despite the dramatic improvement in the instrumental technique, the method detection limits for distilled samples showed little improvement. A direct ethylation technique has recently been

developed as an alternative to sample distillation (Kerry Tate, 2006). This new technique imparts less variability in the analysis because less matrix manipulation is done compared to distillation. A study was undertaken to compare results for real world samples to one another when different preparation or analysis techniques were applied. The different preparation and analysis techniques compared were: distilled samples analyzed via the manual 1630 method, distilled samples analyzed on an automated methyl mercury analysis instrument, and samples directly ethylated and analyzed using the automated analyzer. The focus of the study was primarily on the quality of the data assessed through reproducibility, particularly at low levels and in various aqueous matrices. Results are presented confirming that through the use of direct ethylation of water samples and analysis using a more consistent auto-analyzer, increased accuracy and precision are achieved at even lower detection limits than what were previously available from commercial laboratories.

WP205 A Comparison of Preconcentration Trap Materials for Use in Determination of Monomethyl Mercury by Cold Vapor Atomic Fluorescence Spectroscopy Mi Sun Um, Brooks Rand Labs LLC, Seattle, WA USA. M.S. Um, A. Carter, Brooks Rand Labs, Seattle, WA; J. Meyer, Applied Speciation, Tukwila, WA. EPA Draft Method 1630 (Monomethyl Mercury Determination in Water Samples) mentions the use of Carbotrap graphitic carbon traps as a means of preconcentrating mercury species from the sample during the cold vapor generation step of the analytical process. However, since the method is performance based, equipment modifications are allowed, provided the user can achieve an appropriate method detection limit and meet all quality control specifications. Tenax, a proprietary trapping material, is an alternative to Carbotrap. Though Tenaxä is used by many laboratories, a formal comparison of the two trapping materials does not exist in the literature. Various pros and cons exist for the two materials. Tenax, for instance, gives a broader, more rounded peak shape by atomic fluorescence spectroscopy than does Carbotrap, which can potentially infringe (usually at the upper end of the calibration) upon the chromatographic peak separation. On the other hand, Tenax seems to be manufactured to a more consistent level of quality than Carbotrap. Carbotraps have been noted to last less than a month of normal use, while Tenax traps generally lasted approximately six months. A study was undertaken to evaluate the strengths and weaknesses of Carbotrap vs. Tenax as a trap material. The traps were tested using a Brooks Rand Model III AFS with a Glas-Col GC oven and a 50-cm GC column packed with OV-3 by Brooks Rand Labs, LLC. All of the preconcentration traps tested in this study were also packed by Brooks Rand Labs, LLC. Several parameters were evaluated and compared, including peak shape, sample retention, and recovery of known quantities of methyl mercury spiked standard over a variety of conditions (e.g., breakthrough, varied purging times, drying times, and desorption temperatures). Carryover was tested by purging highly concentrated standards (1000 pg, 2000 pg, and 4000 pg) and collecting the vapor on the traps, followed by the analysis of blanks. The study was concluded with destructive testing in an attempt to measure the maximum temperatures the traps could withstand while still showing accurate percent recoveries. Keywords: monomethyl mercury, Tenax, Carbotrap, Method 1630, CV-AFS

WP206 Using Dilution to Avoid False Negative Results Caused by Hydrocarbon Interferences in SVOC Analysis. M. Bruce, T. Hula, M. Mol, STL, North Canton, OH. Low concentration risk assessment goals such as the EPA Region 9 PRGs, are fueling the drive for analysis at lower and lower analyte concentrations. Hydrocarbon impacted sites must be demonstrated to have key hazardous constituents below certain decision thresholds in order to establish that certain costly remediation steps are not necessary. Hydrocarbon mixtures are common and significant interferences when determining semi-volatile organic analytes by GC-MS in extracts of environmental soil samples. When the hydrocarbon content of the sample extract is high, the ability to detect and quantify target analytes is degraded. Varying amounts of diesel fuel and motor oil were added to a quantitation limit calibration standard. As the hydrocarbon content increased, a low bias was observed for analytes such as benzyl alcohol, benzidine and 2,4-dichlorophenol. Other analytes were not detected when the hydrocarbon content was high. A few of the "disappearing" analytes were nitrobenzene, pyridine, 4-nitrophenol, and pentachlorophenol. In those instances, the non-detect result was a false negative. Determining the relationship between hydrocarbon content and the frequency of false negatives can guide the analyst toward making the proper extract dilution. This challenging balance point weighs sensitivity and low quantitation limits vs. data accuracy and avoidance of false negatives. For example, diesel fuel concentrations up to 5.9 mg/kg did not affect the quantitation

of nitrobenzene at 33 ug/kg. Once the diesel fuel concentration reached 11.7 mg/kg, nitrobenzene was non-detect. We developed several formulas to calculate the minimum dilution necessary to avoid false negatives. The formulas were tested with real sample extracts spiked with common analytes of concern at the applicable quantitation limits. Spectral deconvolution software is also being evaluated to determine what effect it will have on the minimum dilution to avoid false negatives.

WP207 New evidence of natural formation of dioxins in ball clay; characterization of stable carbon isotope compositions of octachlorinated dibenzo-p-dioxin (OCDD) in natural and anthropogenic samples. Y. Horii, K. Kannan, Wadsworth Center, New York State Department of Health, Albany, NY; Y. Horii, K. Kannan, Department of Environmental Health Sciences, State University of New York at Albany, Albany, NY; B. van Bavel, Department of Natural Sciences, Örebro University, Örebro, Sweden; G. Petrick, K. Nachtigall, Leibniz Institute of Marine Sciences at the University of Kiel, Kiel, Germany; Y. Miyake, N. Yamashita, National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan. Elevated concentrations of dioxins found in ball clays from Mississippi Embayment in the USA, suggested natural formation of dioxins in the environment. The evidence for natural formation of dioxins in ball clay was based on unique congener profiles in undisturbed ball clay deposits and the lack of other anthropogenic contaminants in those deposits. In this study, we provide a novel evidence of natural formation of dioxins, which is based on congener-specific carbon isotopic analysis (CSIA- $\delta^{13}\text{C}$) of octachlorinated dibenzo-p-dioxin (OCDD) in ball clays from the United States and Japan (e.g. Gaerome and Kibushi). The analyses were performed using a combination of double column high performance liquid chromatography (HPLC) clean-up and two dimensional gas chromatography-combustion furnace-isotope ratio mass spectrometry (2DGC-C-IRMS). Values of CSIA- $\delta^{13}\text{C}$ of OCDD and bulk- $\delta^{13}\text{C}$ were used to distinguish dioxins from natural sources (clay), anthropogenic sources (fly ash and pentachlorophenol; PCP), and environmental samples (sediment and soil). High concentrations of OCDD were found in American ball clays at average concentrations exceeding 400 ng/g dry weight. High abundance of OCDD was also found in Gaerome and Kibushi at concentrations of 0.26 and 1.5 ng/g dry weight, respectively. This is the first study to show high concentrations of OCDD in Japanese ball clays. The $\delta^{13}\text{C}$ OCDD in clays ($25.8 \pm 1.1\text{‰}$) was 2‰ depleted ^{13}C than in fly ash ($23.7 \pm 0.8\text{‰}$), and was 6‰ enriched ^{13}C from that of PCP ($-31.9 \pm 0.7\text{‰}$). OCDD found in the ball clays from the United States and Japan, was isotopically distinguished from the anthropogenic sources such as sediment and soil by $\delta^{13}\text{C}$ bulk - $\delta^{13}\text{C}$ OCDD profile. Taken together the isotopic profiles and occurrence of dioxins in ball clays, strongly suggests in situ formation of dioxins.

WP208 Analysis of Jjingangmycin A residue in soil by capillary gas chromatography with precolumn derivatization. H. Zhang, P. Xu, S. Jiang, L. Xie, College of Science, China Agricultural University, Beijing, China. Jjingangmycin A is a non-systemic antibiotic with fungicide action. A method for the determination of Jjingangmycin A residue in soil was proposed. 10 g soil sample was extracted with 10% ammonia solution and vacuum evaporated to dryness, then Jjingangmycin A was derivatized with N,O-Bis(trimethylsilyl)acetamide at 80 centigrade for 30 min. The derivative was detected by gas chromatography (GC) with flame ionization detector (FID) and HP-5 MS capillary column. Jjingangmycin A showed good linearity in the range of 4.4 to 71.0 $\mu\text{g mL}^{-1}$ ($R^2 = 0.9983$) and was quantified with external standard method. The average recoveries range from 84.76% to 101.59%, with relative standard deviations from 2.87% to 8.23%. The limit of detection of Jjingangmycin A in soil was 0.2 mg Kg⁻¹. The degradation of Jjingangmycin A formulation in soil was determined. The results showed that Jjingangmycin A degradation in soil coincided with $C = 6.268e - 0.0174t$, the half-life was about 39.84 hours. Key words: Jjingangmycin A; gas chromatography; derivatization; residue; soil

WP209 Analysis of pesticides in water: Is liquid-liquid or solid phase extraction a better choice? D. Wang, M.J. Lydy, Fisheries and Illinois Aquaculture Center & Department of Zoology, Southern Illinois University, Carbondale, IL. The occurrence of pesticides in aquatic systems can potentially be harmful to non-target species, therefore it is necessary to develop sensitive and reliable methods to detect pesticides in water. In this study, three classes of pesticides were analyzed using a gas chromatograph with electron capture detector and included five pyrethroids, one organophosphate, and 19 organochlorine (OC) pesticides. Water samples (0.5 L or 1 L) were extracted using two methods: 1) conventional liquid-liquid extraction (LLE) and

subsequent cleaned-up by normal phase solid phase extraction (NPSPE) and, 2) extraction through two commercial octadecyl (C18)-bonded porous silica SPE cartridges (RPSPE). The RPSPE method resulted in poor recoveries or complete loss of some of the OC pesticides such as heptachlor, aldrin, gamma-chlordane, alpha-chlordane and p,p'-DDE, while chlorpyrifos, the pyrethroids and other OC pesticides had good recoveries of 65.1-99.6 % with relative standard deviations (RSDs) of 0.6-12.8%. Analyte recoveries using LLE-NPSPE ranged from 66.2 to 125.0% with RSDs of 1.9-13.9 % for all of the analyzed pesticides, and the LLE-NPSPE method allowed extracts to be further concentrated to improve method detection limits. Therefore, the LLE-NPSPE method was the preferred method and was suitable for multi-residue pesticides detection in water samples, while the RPSPE method showed promise for extraction of certain pesticide classes.

WP210 Analytical optimization of PBDEs in environmental samples by GC-MS. H. Wei, A. Li, School of Public Health, University of Illinois at Chicago, Chicago, IL. Polybrominated diphenyl ethers (PBDEs) are flame retardants used in various consumer products. Because of their widespread use and persistence and lipophilicity properties, they have become ubiquitous with exponentially increasing accumulations in the environment and human body. Accurate measurement of PBDEs in different environmental media is essential for the investigation of their fate and human health risk assessment. The objectives of this study were to compare different approaches in laboratory sample treatment and to optimize operational parameters of the analytical instrument. Gel permeation, multi-phase silica gel column and alumina column chromatographic cleanups were used and compared for different environmental matrices in terms of the efficiency of lipid and other interference removal. Quantitative analyses of PBDEs were performed on an Agilent Model 6890 gas chromatograph (GC) coupled with a Model 5973 electron capture negative chemical ionization mass spectrometer (ECNI-MS) detector. The programmable temperature vaporizing (PTV) injection was operated in the mode of solvent vent. Instrumental parameters including initial inlet temperature, injection time interval, oven temperature program, interface temperature, etc., were optimized beforehand using PBDE standards. NIST standard reference material (SRM) 2585 was used to verify the method. The results demonstrated that the measured PBDE concentration values have a good match with the certified ones. Recommendations on sample treatment, instrumental parameters, and fragmented ion selections for specific compounds were put forward for future work.

WP211 SBSE-TDS-GC/MS with in situ Derivatization for Measurement of Bisphenol A Related Chemicals. K. Arizono, T. Mori, H. Ishibashi, Toxicological Sciences, Prefectural University of Kumamoto, Kumamoto, Japan. A new extraction technique using magnetic stir bars coated with polydimethylsiloxane (PDMS) was developed to chemical analysis for processed food samples. This extraction technique is called as stir bar sorptive extraction (SBSE). The extraction mechanism and advantages are similar to those of solid phase micro extraction (SPME), but the enrichment factor, which is determined by the amount of extraction phase (PDMS), is up to 100 times higher. SBSE has been successfully applied to various types of processed samples. As well as miniaturization of sample preparation, the SBSE-thermal desorption approach covers several steps in the traditional methods, e. g. solvent exchange and extract concentration. In this study, we have tried an additional new method that involves liquid phase microextraction with in tube derivatization followed by gas chromatography-mass spectrometry (GC/MS) for the determination of trace amounts of bisphenol A (BPA) related compounds (BPE, BPE, BPB, BPP etc) in liquid samples. After liquid phase microextraction conditions, such as the type of extraction solvent and the extraction time, are investigated, the liquid food samples are applied. The extract is directly injected into GC/MS. This simple, accurate, sensitive and selective analytical method may be applicable to the determination of trace amounts of BPA related compound in liquid samples.

WP212 Occurrence of Sulfonyl Urea Herbicides and Related Compounds in Ontario Surface Waters. C. Marvin, J. Struger, J. Grabuski, S. Cagampan, E. Sverko, Environment Canada, Burlington, Ontario, Canada. A suite of sulfonyl urea herbicides and related compounds were determined in water samples from rivers, streams, and reservoirs across Ontario corresponding primarily to row crop growing areas. 1L water samples were collected during 8 sampling periods from May to October and extracted through OASIS HLB solid phase extraction cartridges, eluted with methanol and analyzed using a liquid chromatography – mass spectrometry method. All compounds were routinely detected with the exception of Acifluorfen. Diuron, a substituted

urea general-use herbicide used for control of broadleaf and grassy weeds, was routinely detected in samples from across Ontario; concentrations in surface waters ranged from 8.4 – 2,800 ng/L. Other commonly detected compounds included Chlorimuron, Nicosulfuron, Fomesafen, and Flumetsulam which was particularly prevalent in the Ottawa area at the eastern end of the province. Detections of all compounds were most frequent in the mid-summer months (application). These compounds were most prevalent where rotation of corn/soybean/grain was more intense.

WP213 Polybrominated Diphenyl Ethers in Tributary and Nearshore Sediments of Lakes Ontario, Huron and Superior. L. Shen, S. Gewurtz, I. Brindle, Chemistry, Brock University, Toronto, Ontario, Canada; L. Shen, S. Gewurtz, E. Reiner, T. Kolic, T. Howell, P. Helm, Ontario Ministry of the Environment, Toronto, Ontario, Canada; D. Burniston, C. Marvin, Environment Canada, Burlington, Ontario, Canada. Tributary and nearshore water quality of the Great Lakes are monitored by Environment Canada and the Ontario Ministry of the Environment to provide information on contaminant loadings to the Lakes and identify potential “problem” watersheds. Surficial sediment samples were collected at the mouth of 47 Canadian tributaries and from 42 nearshore locations in Lakes Ontario, Huron, and Superior. The sediment samples were analyzed for seventeen congeners of polybrominated diphenyl ethers (PBDEs) using Micromass Autospec equipped with a Hewlett-Packard HP6890 gas chromatograph. PBDEs were detected in all samples and BDE209 was the most abundant congener in sediments, occurring in over 90% of samples. BDE 47 and 99 were also detectable in most samples, followed by BDE100, 153, 154, and 183. High levels of PBDEs were found at several tributary sites of Lake Ontario; and two sites had PBDE concentrations greater than 400 ng/g dry wt. Compared to the tributary samples, nearshore sediments of Lake Ontario had lower concentrations of PBDEs, which was in the range of 1.5 to 66 ng/g dry wt. PBDE concentrations were also low in samples collected from Lakes Superior and Huron, regardless of nearshore or tributary sediments, varying from 1.2 to 53 ng/g dry wt. Sampling sites with high PBDE levels had congener-specific patterns that are different from a typical pattern of atmospheric deposition reported in the literature and varied with sampling locations, implying that urban centres and industrial activities near the Great Lakes contribute to PBDE contamination in sediments.

WP214 Spatial Distribution of Perfluorinated Compounds in Sediments and Surface Waters of the Laurentian Great Lakes and Temporal Trends in a Lake Ontario Sediment Core. P.A. Helm, T. Howell, Environmental Monitoring and Reporting Branch, Ontario Ministry of the Environment, Toronto, Ontario, Canada; P.W. Crozier, E.J. Reiner, Laboratory Services Branch, Ontario Ministry of the Environment, Toronto, Ontario, Canada; C.M. Marvin, Environment Canada, Burlington, Ontario, Canada. Environmental monitoring of perfluorinated compounds (PFCs) has been undertaken in sediments and waters of the Great Lakes to establish baseline information as these chemicals come under increasing regulatory scrutiny. The Ontario Ministry of the Environment monitors ambient conditions in the nearshore of the Great Lakes (Lakes Superior, Huron, Erie & Ontario) for water and sediment quality and contaminant occurrences through the Great Lakes Nearshore Monitoring & Assessment Program, while Environment Canada assesses lakewide sediment and water contamination. Sediment concentrations are key indicators of in place pollution for priority pollutants and dated sediment cores provide an indicator of progress towards virtual elimination of such chemicals. Both monitoring programs provide a basis for evaluation of the occurrence of current-use chemicals of concern, such as PFCs like perfluorinated sulfonates and perfluorinated carboxylic acids. Results of monitoring to date indicate low concentrations of PFCs, particularly perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), present in nearshore surface waters and sediments. Concentrations in water ranged from ND (less than 0.5 ng/L) to 15 ng/L for PFOS, which tended to be higher than PFOA concentrations (0.6 to 8.1 ng/L) at Lake Ontario nearshore stations. Higher concentrations were associated with proximity to adjacent urban areas. Comparatively, surface water from Lake Superior stations were generally non-detectable for PFOS and below detection or just above for PFOA, except at a station known to be impacted by the pulp and paper industry. Surface sediment concentrations were low for PFOS and PFOA across all lakes, ranging from ND (0.05 and 0.02 ng/g dry weight, respectively) to less than 2 ng/g. The sediment core results indicate exponential increases of PFOS and PFOA to present day, and do not yet reflect the withdrawal of most uses of PFOS from the marketplace.

WP215 Dynamic Mixtures Interactions. J.W. Boyd, N.T. Boggs, M.L. Theodore, H.T. Le, J.B. Patrone, J. Jackman, RSS, Johns Hopkins University - Applied Physics Lab, Laurel, MD. Physiological response to threats represent a set of complex interactions that build upon current state of health, health history, and additional environmental factors that ultimately form a dynamic system of overall susceptibility. Transient exposures to low doses of compounds may greatly influence susceptibility, but the toxicodynamic effects which can alter the response to subsequent exposures are not well understood. Our laboratory is currently using the mitochondrial electron transport chain as a model biochemical pathway to test mixtures theories at the molecular level, including time-course impacts of dosing; additionally, we are monitoring its relationship with various up- and downstream signal transduction pathways as early response targets relevant to both survival and death. The ability to predict the toxicity of chemical mixtures is a key step toward addressing the susceptibility of both individuals and populations, and we will present our recent research toward the determination of the dynamic mechanisms of mixtures interactions.

WP216 An update on the surveillance efforts of West Nile virus in Lubbock County, Texas. B.J. Barrus, S.M. Presley, Environmental Toxicology, Texas Tech University, Lubbock, TX. Since 2002, we have conducted continuous surveillance for West Nile virus (WNV) in mosquitoes in Lubbock County, Texas. In 2005, Bradford and others published the first report of WNV positive mosquitoes from the Lubbock area. During 2004 and 2005 mosquitoes representing five genera were collected and during 2006 representatives of six genera were collected. Of these genera, three species were collected most often, *Aedes sollicitans*, *Aedes vexans*, and *Culex tarsalis*. Screening for WNV was conducted via reverse-transcriptase polymerase chain reaction (RT-PCR). RT-PCR was performed twice on all positive samples for confirmation. *Culex tarsalis* had the most WNV positive pools of mosquitoes of all specimens tested. Screening results, weather patterns over the three year period, and ongoing research focused upon reservoir/amplifying vertebrate hosts will be presented.

WP217 User-Friendly Point-of-Care Tests to Detect Infectious Disease and Monitor Vaccination Status. D.R. Bienek, C.K. Chang, Applied Lab Sciences, Naval Institute for Dental and Biomedical Research, Great Lakes, IL. Historically, screening of infectious diseases has been challenging in field settings, as diagnostic tests have been limited to well-equipped laboratories employing highly trained personnel. Recent advances in technology have resulted in the potential to develop simple, rapid, point-of-care tests. We are developing lateral flow colorimetric screening tests to verify anthrax immunization status and detect tuberculosis infection. For these applications the following will be investigated: 1) correlation of results to conventional gold standard of diagnosis; 2) diagnostic sensitivity and specificity; 3) use of different sample matrices; 4) potential mitigating factors; and 5) effect of environmental conditions on assay performance.

RP1 Glucose-sulfate conjugates of pyrene as a new phase-2 metabolite formed by aquatic crustacean (freshwater shrimp: Decapoda; Atyidae). Y. Ikenaka, Y. Miyabara, Institute of Mountain Science, Shinshu University, Suwa, Japan; M. Ishizaka, H. Eun, National Institute for Agro-Environmental Sciences, Tsukuba, Japan. The ability to metabolize xenobiotics in organisms have wide degrees of variation. These variation cause a biodiversity of tolerance between each species. In the present study, we investigated the formation of pyrene (four ring PAHs) metabolites by using aquatic crustaceans with special attention to phase-2 metabolites. We found that decapoda; atyidae (*Caridina multidentata*, *Neocaridina denticulate*, and *Paratya compressa*) metabolized pyrene to new conjugation products. The results of structural identification of the new metabolite by de-conjugation indicated that glucose and sulfate combined with 1-hydroxypyrene. The molecular order of the combination is sulfate, glucose, and 1-hydroxypyrene. Further analysis by LC/ESI-MS/MS showed that the molecular weight was 460 (m/z 459; de-protonated ion), and has a glucose-sulfate moiety (m/z 241; fragment ion). Both results indicated that the new metabolite was considered to be the glucose-sulfate conjugation of 1-hydroxypyrene. Glucose-sulfate conjugate is the first phase-2 product that has never been reported before by any organisms. It is known that phase-2 reactions often add the molecules for specific signal. Sulfation of sugar commonly creates a negatively charged molecular environment at any physiological pH that can induce conformational changes, alter solubility, and promote ionic interactions; all of which can significantly influence biological activity. Furthermore, Multixenobiotics Resistance Protein (MRP) is an organic anion transporter, and has an important role for the excretion of xenobiotics from the cell membrane (Phase-3 processes for animals). The sulfation process may stimulate the excretion of xenobiotics by transporters such as MRP. In addition, aquatic environment is the major storehouse of sulfate and contains more than 95% of the total amount of sulfate on Earth. Thus, there are several studies to demonstrate that sulfation is an important pathway to metabolize xenobiotics for aquatic invertebrate. For these reason, glucose-sulfate conjugates may add an important signal for excretion or sequestration of xenobiotics for aquatic invertebrate.

RP2 Ecotoxicity of ceria, silica and silver nanoparticles on soil nematode *Caenorhabditis elegans*. J. Choi, J. Rho, Environmental Engineering, University of Seoul, Seoul, South Korea. Potential effect of ceria, silica and silver nanoparticles on environment was investigated using *Caenorhabditis elegans* ecotoxicity tests. Multi-level biomarker approach was conducted using mortality, growth, reproduction, development and stress-related gene expression, as toxic endpoints. The worm body length did not change by ceria, whereas 15 and 45 nm of ceria exposure caused a decrease in egg formation, which suggest this material may affect reproduction potential of nematode. Ceria exposure leads to the alteration of the expression of some stress genes, such as, heat shock protein-16.1 (*hsp-16.1*), *hsp-16.2*, glutathione-S- transferase-4 (*gst-4*) and vitellogenin-6(*vit-6*). In order to identify whether these altered stress-related genes may lead consequences on higher level of biological organization, RNA interference (RNAi) experiment was also conducted. Overall result suggest nanoparticles have a potential for provoking ecotoxicity on *C.elegans* and RNAi experiment seems to be a considerable potential to identify causal relationship between stress gene expression and higher level consequences, and thus can be a powerful tool for multi-biomarker approach in ecotoxicology. Key words : *Caenorhabditis elegans*, ceria, stress-related gene expression, RNA interference, multi biomarker approach Acknowledgement - This subject is supported by Korea Ministry of Environment as 'The Eco-technopia 21 project (091-071-065)

RP3 Ecotoxicoproteomic approach for the evaluation of cadmium toxicity on the hemolymph proteins of larvae of aquatic midge, *Chironomus riparius*. J. Choi, S. Lee, Environmental Engineering, University of Seoul, Seoul, South Korea. New global technologies, allowing simultaneous analysis of thousands of genes, proteins, and metabolites (so-called 'omics' technologies), are being adopted rapidly by industry, academia, and regulatory agencies. This study evaluated the potential of proteomics in ecotoxicological research (i.e., ecotoxicoproteomics). The aim of this study was to investigate sub-lethal effects of well known contaminant, cadmium on proteome expression in aquatic invertebrate. Larvae of aquatic midge (*Chironomus riparius*) were exposed for 24 h to cadmium in laboratory condition. Classical ecotoxicological toxicity tests, using mortality, growth and development, were performed prior to proteomics study. The influence of cadmium on *Chironomus* hemolymph protein expression was then investigated using a proteomic technique with 2-DE and LC-MS/MS. Results

indicated that exposure to cadmium had significant effects on hemolymph protein expression. Comparing the intensity of protein spots, in total 14 proteins were differentially expressed following to cadmium exposure; their characteristics were identified as globin proteins. They all decreased in the cadmium-exposed larvae. Additionally, most differentially expressed proteins revealed exposure concentration dependant responses. Results indicate that hemoglobin protein may play important role in cadmium toxicity in *C.riparius* and that proteomics approaches seem to have considerable potential to make a valuable contribution to ecotoxicity monitoring and risk assessment. Keyword : *Chironomus riparius*, cadmium, ecotoxicoproteomics, hemolymph, hemoglobin Acknowledgement - This work was supported by the Korea Science and Engineering Foundation (KOSEF) grant funded by the Korea government (MOST) (No.R01-2006-11219-0)

RP4 Transcriptional Response of *Saccharomyces cerevisiae* to Saxitoxin. K.D. Cusick, G.S. Saylor, Center for Environmental Biotechnology, University of Tennessee, Knoxville, TN; K.D. Cusick, G.S. Saylor, Department of Microbiology, University of Tennessee, Knoxville, TN. Saxitoxin is a potent neurotoxin produced by several species of dinoflagellates and cyanobacteria which causes respiratory paralysis in mammals. While the toxic mechanism in mammals is known, the affects of saxitoxin on lower eukaryotic organisms, such as the planktonic communities cohabiting with saxitoxin-producers in aquatic systems, have not been defined. The goal of this study was to examine the transcriptional response of the yeast *Saccharomyces cerevisiae* (S288C) upon exposure to saxitoxin using the Affymetrix genechip array for yeast (Yeast Genome 2.0). Treatments consisted of an exposure concentrations of 2.5 to 5 mg-l for 45 to 90 minutes and a primary test condition of 5 mg-l for 45 min was chosen based on results obtained through a bioluminescent assay utilizing the constitutively bioluminescent yeast strain BYLES. Thirteen genes were significantly up or down regulated upon toxin exposure. The expression levels of several of the genes were confirmed with quantitative reverse transcriptase real-time PCR (qRT-PCR) using gene-specific primers and Taqman probes. In-vitro transcription was used to generate full-length transcripts of the cloned genes of interest; these transcripts were used as seven-point internal standard curves to allow for absolute quantification. Expression was normalized to gene copies/ng total RNA. CRS5, a copper-binding metallothionein, was shown to be significantly upregulated 2-fold or greater in all treatments excluding 5 mg-l 90min. Other genes being examined based on the results of the microarrays include FRE1, which functions as a ferric and cupric reductase, CUP1, a metallothionein that mediates resistance to high concentrations of copper and cadmium, and SSA4, a stress-response protein. These findings are a first step in identifying molecular targets or fingerprint molecular biomarkers for saxitoxin in natural planktonic communities.

RP5 Development of ecological soil screening method based on collembolan optimal reproduction; case study on metal-contaminated mine soil in Korea. J. Son, K. Cho, Environmental Science and Ecological Engineering, Korea University, Seoul, South Korea; K. Shin, Statistics, Hankuk University of Foreign Studies, Yonin, South Korea. Ecological soil screening levels (Eco-SSLs) for ecological risk assessment (ERA) of contaminated soils are very useful in a screening tool in the early steps of ERAs and protecting terrestrial ecosystems from unacceptable harmful effects. However, not only the environmental variables (e.g. CEC, clay type etc.) other than organic matter and pH (soil properties required for Eco-SSLs) but also other variables (aging) are key factors affecting the bioavailability in soils, resulting in different toxicity. Moreover, these soil physicochemical properties themselves also can act as stressor factors. Therefore, to ascertain the potential effect of contaminated soil, we must distinctly separate the adverse effects associated with soil physicochemical properties from the adverse effects of contaminants in the soil. In this study, we developed a 'distance index' as an integrated term of adverse effect of contaminant to set risk-based ecological soil screening for metal-contaminated mine soil in Korea using collembolan species (*Paronychiurus kimi*). To describe the natural performance (esp. 28-d reproduction) of *P. kimi* without contaminant, we constructed statistical experiment design, central composite design (CCD), as functions of soil physicochemical properties. The predicted response curve was used as reference values to predict the optimal reproduction at a certain soil physicochemical properties. Reproduction test with metal-contaminated mine soils were also conducted and especially, soil physicochemical properties of these mine soils were analyzed. The relationship between distance index, which were calculated by dividing the difference (predicted optimal reproduction - observed optimal reproduction) into observed

optimal reproduction at a certain soil physicochemical properties, and soil physicochemical properties and soil metal fractions were analyzed using multiple regression model. Our approach will be considerable steps to increase our understanding for the potential effect of contaminated field soil in risk-based soil screening. *Funded by Korea Institute of Environmental Science and Technology (No. 2007-09001-0043-0)

RP6 Spatial and temporal trends of metals in San Francisco Bay: have metals in bed sediments decreased since the Clean Water Act of 1972? J.L. Dyke, M.I. Hornberger, S.N. Luoma, USGS, Menlo Park, CA. San Francisco Bay (SFB) has historically been a receptacle of pollution from industrial point source discharges and non-point sources such as urban and agricultural runoff. Metals in aquatic systems bind with sediment particles leaving a legacy of past and present inputs in the sediment record. Temporal trends in metal concentrations in SFB sediments since the 1972 Clean Water Act were evaluated using data from long-term (1977-1997) monthly monitoring of surface sediments in North SFB (San Pablo Bay and Suisun Bay). Historic and regional background concentrations were determined from published sediment core data. Average Cu and Zn concentrations ($53.4 \pm 7.9 \mu\text{g/g}$ and $118.1 \pm 20.0 \mu\text{g/g}$, respectively) remain nearly two-fold higher than regional background concentrations. Average Pb concentrations ($18.9 \pm 3.8 \mu\text{g/g}$) are nearly four-fold higher than regional background, probably due to residual inputs from historical lead smelting activities. Average concentrations of Cu, Pb, and Zn were not significantly different between wet and dry periods. In contrast, V concentrations are generally higher during the wet winter season than the dry summers. The positive correlation between V concentrations and delta outflow ($r^2=0.34$, $p<0.01$) suggests that freshwater inputs contribute to the seasonal fluctuation of V in SFB. While temporal data from North SFB monthly monitoring sites indicate that Cu, Pb, and Zn have decreased from the historically high concentrations of the 1960s and 1970s (as determined from published sediment core data), concentrations have not returned to pre-industrial levels. This may be due to either continued trace metal loading to SFB or redistribution of sediments within the system.

RP7 Monitoring of Organochlorine Compounds and Alkylphenols in Sediment and Oyster Collected from Marsh/Estuarine Savannah, GA. K.S. Sajwan, S.K. Kurunthachalam, J.P. Richardson, Department of Natural Sciences and Mathematics, Savannah State University, Savannah, GA; K. Kannan, Department of Health, Wadsworth Center, Albany, NY; B.G. Loganathan, Department of Chemistry, Murray State University, Murray, KY. Sediment and oyster (*Crassostrea virginica*) tissue collected from nine different marsh/estuarine ecosystem in Savannah GA USA, were analyzed for contamination profiles of organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs), and alkylphenols (APs). OCPs such as chlordanes, DDTs (except DDE), HCHs, HCB were not detected ($<2 \text{ ng/g}$) whereas, DDE was 5.5-78 (in sediment) and 176-645 (in oyster) on pg/g dw . Total PCBs were less than detection limit ($<10 \text{ ng/g}$) in 30 sediment and oyster while, few samples collected in 2001 showed 5.0-11 (sediment) and 10-15 (oyster) on ng/g dw (when detection limit set to 1.5 ng/g). Among APs, butylphenol was <0.3 -5.7 (sediment), and <0.6 -1.5 (oyster), octylphenol was <0.3 -6.9 (sediment) and <0.6 -10 (oyster) and nonylphenol was <0.3 -18 (sediment) and <0.6 -20 (oyster) on ng/g dw . Greater concentrations of DDE, PCBs, and APs in oyster tissue than sediment suggests their efficient bioaccumulation potential. There is no significant ($P<0.5$) contamination variation in target analytes in between nine estuarine sites. Observed DDE, PCBs and APs in oyster were well below the United States Food and Drug Administration (USFDA) threshold limit for human consumption. Overall, the baseline data can be used for regular ecological monitoring, considering the domestic and industrial growth around this important marsh/estuarine ecosystem.

RP8 Relationships between Sediment Profile Imagery (SPI) and environmental variables. W.S. Boothman, L. Coiro, B.J. Bergen, W.G. Nelson, Natl. Health and Env Effects Laboratory, U.S. Environmental Protection Agency, Narragansett, RI. Sediment profile imagery (SPI) is increasingly being used to provide rapid, cost-effective spatial assessment of benthic communities, as well as short- and long-term recovery after disruptive activities such as dredging or capping. This poster relates effects of both direct (toxic contaminants), and indirect stressors (low dissolved oxygen (DO)), on SPI metrics of benthic condition/health. Sediment profile images and core samples were collected from five stations in Greenwich Bay (RI, USA) along anticipated gradients of contamination and DO. Hydrolabs® were deployed at the sites from early summer into autumn, providing a continuous temporal record of DO concentrations. The SPI images were analyzed for

both abiotic and biotic features (e.g., depth of apparent redox potential discontinuity (RPD), presence/absence of organisms and burrows), which vary among stations; the extent of variation differs among types of metrics. Analyses of toxic and crustal metals in the sediment cores show gradients of both contaminant metals and authigenic Mo. The latter reflects exposure to low oxygen conditions over a longer term relative to direct measurements. In these sediments, authigenic Mo concentrations reflect a long-term DO record that is similar to short-term trends shown by the Hydrolab® data, that is, more frequent/severe occurrences at sites near the head of the Bay than at the mouth. Mo concentrations also increase sharply with depth in some cores, indicating hypoxia has been more prevalent in the past than recently. Radiometric dating (i.e., ^{210}Pb , ^{137}Cs) was performed on selected sediment core horizons to estimate sediment ages and accumulation rates of sediment and molybdenum (Mo). Spatial variations of concentrations of contaminants and long- and short-term hypoxia in bottom waters will be compared against variation of SPI metrics to determine which may be indicative of the environmental stressors assessed. Examining the relationships between SPI metrics and environmental stressors may help to determine which environmental stressors are dominant causes of impairment of those communities.

RP9 Sediment contamination in the tidal freshwater Potomac and Anacostia River: A pollution history of Washington, D.C. M. Schafer, D. Velinsky, L. Zaoudeh, J. Ashley, Patrick Center for Environmental Research, Academy of Natural Sciences, Philadelphia, PA; D. Butera, G. Riedel, Smithsonian Estuarine Research Center, Edgewater, MD; J. Ashley, Philadelphia University, Philadelphia, PA; J. Cornwell, Horn Point Laboratory, University of Maryland Center for Environmental Science, Cambridge, MD. Sediment cores (up to 5 m in length) and surface sediments, were collected in 2005 from the tidal freshwater Potomac River within Washington DC to explore historical changes in contaminant levels, and assess the effectiveness of pollution controls. One core was collected near the largest wastewater treatment facility in the Chesapeake Bay. Analyses of cores and surface sediments from this study were compared to data from cores collected in 2003 from the lower tidal Anacostia River. Both rivers bisect substantial urban landscapes that historically (and currently) contributed large inputs of trace metals and organic contaminants. Despite decades of inputs, concentrations of chemical contaminants were, in most cases, low and variable among cores collected from the tidal Potomac River. Total PCBs ranged from 1.5 to 180 ng/g dw with depth (compared to 3000 ng/g dw in Anacostia River cores) and exhibited little sub-surface structure. The homolog distribution was dominated by congeners with three to five chlorine groups. In contrast, PCB, PAH and DDT profiles in the tidal Anacostia River cores showed distinct subsurface maximum concentrations in the 1960s to 1970s, decreasing in more recently deposited sediments. Total Pb concentrations ranged from 10 to 150 $\mu\text{g/g dw}$ with highest concentrations nearest the treatment facility. For most metals, there was a slight enrichment in the surface sediments, with levels decreasing with depth. Analyses of ^{210}Pb from Potomac River cores indicate a minimal net deposition in the region due to excessive tidal shear in this portion of the river, and consequently, only one core was datable. These data suggests a net deposition (sink) of contaminants in the tidal Anacostia River while material entering the tidal Potomac River in Washington DC is continually flushed downstream to other depositional areas, most likely in the marshes and embayments of the upper tidal river.

RP10 A Case Study: Remediating Sediment with Hydraulic Dredging. M.M. Wade, URS Corporation, Salem, NH. At a Massachusetts Contingency Plan site more than a century of backfilling and erosion of metals impacted soils into a near shore marina basin resulted in deposition of metals impacted sediments to significant depths across a third of the marina area. Planned maintenance dredging of the marina would resuspend and expose the sediments to ecological receptors. This project was undertaken to achieve sufficient depths to accommodate marina operations and to remove identified impacted sediments from a portion of the marina in accordance with the MCP. The remedial alternatives evaluation concluded that the least intrusive alternative that would provide a permanent remedy was hydraulic dredging of the unimpacted and impacted sediments from the marina, treatment of dredge effluent, dewatering of dredged sediments in Geotubes®, consolidation of these sediments with impacted soils from other upland areas of the site and subsequent capping. Federal, state and local permits restricted dredge operations to occur only between November and February. The sediment dredging was accomplished utilizing a hydraulic dredge positioned on a barge

platform. The marina was dredged to target depths using a GPS positioned rotary cutter head and a suction pump. The resulting sediment/sea water slurry was pumped through a slurry pipeline and an on shore booster pump to a Smartfeed® effluent processing facility. The Smartfeed system conditioned the dredge effluent with polymer and distributed the treated effluent to designated Geotubes based on predetermined sediment segregation requirements. Dewatering run-off was clean and free of suspended solids and was routed through two temporary infiltration basins. Any overflow was pumped back to the dredge area and discharged inside the silt curtain. This presentation will include project photographs, figures and narrative illustrating the project benefits, roadblocks and modifications required to successfully complete the remediation within the permit required seasonal window. Author & Presenter: Marilyn M. Wade, P.E., LSP Senior Project Manager URS Corporation 5 Industrial Way Salem, NH 03079 (603) 893 0616 marilyn_wade@urscorp.com

RP11 Ecological Risk Assessment, Remediation and Wetlands Restoration at a Small Arms Firing Range. N. Shetty, ENSR, Raleigh, NC; J. Messier, United States Coast Guard Support Center, CEU Cleveland Detached, Elizabeth City, NC; K. Durocher, ENSR, Belmont, NH; R. Holcomb, United States Coast Guard, Integrated Support Command, Portsmouth, VA. The United States Coast Guard (USCG) operates an outdoor small arms firing range (SAFR) at their Integrated Support Command facility in Portsmouth, Virginia. An earthen berm was historically used to contain bullets from the SAFR. A storm sewer, which has been capped and abandoned, located near the former earthen backstop routed stormwater from the range to a palustrine forested wetland and adjacent estuarine intertidal wetland. Site investigations indicated lead and copper in shallow wetland soils in excess of 400 milligrams per kilogram (mg/kg) lead and 310 mg/kg copper, the Tier II Virginia Department of Environmental Quality (VDEQ) Voluntary Remediation Program (VRP) soil screening levels (SSLs) for residential (unrestricted) use. A multiple line-of-evidence ecological risk assessment (ERA) was conducted. Simultaneously extracted metals: acid volatile sulfide (SEM:AVS) analysis in sediment, surface water screening, and food web modeling were included in the ERA. The results indicated it is unlikely that lead and copper in the estuarine marsh pose unacceptable risk to ecological receptors. However, concentrations of total lead in the forested wetland hydric soils indicated potential unacceptable risk to ecological receptors. Site-specific cleanup levels protective of ecological receptors were calculated. The estimated area of lead impacted soils above the Tier II SSLs and site-specific ecological cleanup levels was approximately 3,600 square feet. A total of 96 tons soils impacted with lead and copper above SSLs for residential use were removed from the wetlands. Excavated wetlands were backfilled and restored. Forested wetlands were restored by planting silky dogwood, arrowwood, elderberry and black willow. Salt marsh cordgrass plugs were planted to restore estuarine marsh. The postremediation confirmation samples indicated copper and lead were undetected in surface water and SEM:AVS in sediment was 0.04, well below the risk threshold of 1. A "No Further Action" has been granted by VDEQ for unrestricted use of the site.

RP12 The Effects of In-Situ Burning on Hydrocarbon Bioavailability in a Louisiana Salt Marsh. L. Lockard, J. Baker, Chesapeake Biological Laboratory, Solomons, MD; A. Merten, NOAA Office of Response and Restoration, Seattle, WA; U. Ghosh, Civil and Environmental Engineering, University of Maryland Baltimore County, Baltimore, MD. In-situ burning is a common remediation practice for treating petroleum-contaminated marsh sediments. Although above-ground vegetation recovers rapidly once this technique has been properly applied, the long-term effects of burning on PAH bioavailability and marsh sediment chemistry have not been thoroughly investigated. Combustion of partially-weathered petroleum and marsh biomass changes the alkane and PAH composition of the sediments and creates reduced carbon phases that may alter the bioavailability of the remaining PAHs. This study examines PAH bioavailability along three transects in a Louisiana intermediate salt-marsh contaminated with crude oil following Hurricanes Katrina and Rita in late August/early September of 2005 and subsequently burned in October of that year. Oiled sediments that were burned and allowed to recover are compared with unburned but oiled sediments and reference sediments. PAH partitioning between solid phases, pore water, and soot particles is measured by solid-phase microextraction (SPME) and GC/MS methods, and soot concentrations in the sediments by thermal- and chemical-oxidation techniques. Total petroleum hydrocarbon (TPH) levels in oiled and burned sediment decreased 63% over the eight

months following the burn, while TPH levels in oiled and unburned sediments dropped approximately 91%. Alkane and polycyclic aromatic hydrocarbon measurements, however, suggest that in-situ burning reduced concentrations of these hydrocarbons within burnt sediment. An increase in soot content, produced by pyrolysis, may have increased the hydrocarbon sorption capacity of the burnt sediments. Increased sorption may partially explain the results of TPH analyses and is being assessed by measuring the dissolved hydrocarbon content in pore water using SPME. Additional sediments collected from these transects during Summer 2007 will allow us to follow changes in PAH bioavailability more than a year and a half post-burn. We expect that burning of oiled sediments causes a decrease in petrogenic hydrocarbon bioavailability, providing important information in determining whether to use in-situ burning as a method of remediation.

RP13 A Mass Balance for Dioxins and PCBs in Sediments of the Lower Passaic River. S. Gbondo-Tugbawa, E.A. Garvey, A. Juliana, Malcolm Pirnie Inc, Fair Lawn, NJ; S. McDonald, Malcolm Pirnie, Inc, King of Prussia, PA; A. Accardi-Dey, Malcolm Pirnie, Inc, White Plains, NY. Polychlorinated biphenyls (PCBs), and polychlorinated dibenzo-dioxins and furans (dioxins) are two hydrophobic organic compounds of concern in the sediments of the Lower Passaic River in northern New Jersey. The Lower Passaic River is a 17-mile tidally influenced stretch of the river from the Dundee Dam to the river's confluence with Newark Bay. For two centuries, urban and industrial development has resulted in a significant environmental impact on the Lower Passaic River and adjacent waterbodies in northern New Jersey. Contamination of PCBs and dioxins in the Lower Passaic River extends more than 15 ft feet in depth into the river bed. An empirical mass balance model using a receptor-type modeling approach was developed to understand the fate and transport of sediment-bound contaminants and for an early action remedial investigation in the Lower Passaic River. The model quantifies the relative contaminant and solids contributions to the river's recently deposited surface sediments from the following sources: the upper Passaic River, the tributaries, combined sewer overflows (CSO) and storm water outfalls (SWO), tidal input from Newark Bay and in-river sediment resuspension. The model results indicate that the external sources alone cannot account for the observed chemical concentrations of PCB and dioxins in the lower Passaic surface sediments; an internal source, specifically sediment resuspension, is contributing to the contaminant burden of recently deposited surface sediments in the river. As a fraction of the total solids flux to the Lower Passaic River, resuspension of legacy sediments (i.e., the historical inventory) comprises about 10 percent of the total annual deposition. For dioxins, the sediment concentrations in external sources are two orders of magnitude lower than current concentration in the surface of the Passaic River, resulting in resuspension accounting for over 95 percent of the dioxin burden in the river. The fate and transport of PCB congeners showed a sliding scale with lighter PCB congeners more influenced by resuspension of historical inventory and the heavier PCB congeners impacted by solids originating from the Upper Passaic River. Finally, CSO/SWOs, Newark Bay, and the tributaries may represent only minor inputs for both dioxin and PCB.

RP14 A Mass Balance for PAHs, Pesticides and Heavy Metals in Sediments of the Lower Passaic River. S. Gbondo-Tugbawa, E.A. Garvey, J. Atmadja, Malcolm Pirnie Inc, Fair Lawn, NJ; A. Accardi-Dey, Malcolm Pirnie, Inc, White Plains, NY; S. McDonald, Malcolm Pirnie, Inc, King of Prussia, PA. Polycyclic aromatic hydrocarbons (PAHs), pesticides and heavy metals are three significant classes of contaminants in the sediments of the Lower Passaic River in northern New Jersey. The Lower Passaic is a 17-mile tidally influenced stretch of the river extending from the Dundee Dam to the river's confluence with Newark Bay. Over the past two centuries, urban and industrial development has resulted in a significant environmental impact on the lower Passaic and adjacent waterbodies in northern New Jersey. Contamination of PAHs, pesticides and metals in the lower Passaic extends more than 15 ft feet in depth into the river bed and is deeper than dioxins and PCBs. An empirical mass balance model using a receptor-type modeling approach was developed to understand the fate and transport of sediment-bound contaminants and for an early action remedial investigation in the Lower Passaic River. The model quantifies the relative contaminant and solids contributions to the river's recently deposited surface sediments from the following sources: the upper Passaic River, the tributaries, combined sewer overflows (CSO) and storm water outfalls (SWO), tidal input from Newark Bay and in-river sediment resuspension. Model results indicate that PAHs originate primarily from the upper Passaic River with resuspension only contributing 10 to 15 percent

of the PAH burden in the lower river. About 50 percent of the mercury and DDE (a derivative of DDT) burden can be explained by internal resuspension of legacy contamination in the sediments of the lower river. Suspended solids delivery by tidal exchange with Newark Bay may represent 25 percent of the mercury burden but plays a less important role for all other contaminants examined. Finally, CSO/SWOs and the tributaries may represent about a third of the total flux for contaminants like lead, copper, dieldrin, and chlordane. The results of this mass balance model illustrate the importance of accurately quantifying the relative importance of both external and internal sources to understanding the fate and transport of contaminants in the Lower Passaic River.

RP15 A Comprehensive Examination of Dioxin Distribution and Fate in the Newark Bay Estuary Complex, NJ. S. McDonald, Malcolm Pirnie, Inc., King of Prussia, PA; S. Gbondo-Tugbawa, E. Garvey, J. Atmadja, B. Fidler, Malcolm Pirnie, Inc., Fairlawn, NJ; A. Accardi-Dey, Malcolm Pirnie, Inc., White Plains, NY. The Newark Bay estuary complex is a series of interconnected tidal water bodies located in one of the nations most urbanized and industrialized regions. This dynamic estuary complex includes the Lower Passaic River, the Hackensack River, Newark Bay and the proximal ends of Kill Van Kull and the Arthur Kill. Environmentally persistent compounds such as polychlorinated dibenzo-dioxins and furans (dioxins) were loaded to this system from the 1940s until the 1970s after the enactment of the Clean Water Act. Although there is a suite of dioxin congeners, the major dioxin source to the estuary was unusually rich in the dioxin congener, 2,3,7,8 tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). This compound served as an excellent geochemical tracer in the estuary. Using the ratio of 2,3,7,8 TCDD to Total TCDD as a characteristic source identifier, spatial and temporal variations in this ratio were examined. Two end members of the ratio were identified: about 0.7 for the Lower Passaic River and about 0.05 for urban background. These variations were used to study the complex's intricate hydrodynamic and sediment-transport processes. The ratio was used as part of two mass balance calculations, one for the lower Passaic River and one for Newark Bay and to estimate the Lower Passaic River contribution of dioxin to the NY/NJ harbor. To round out the analysis, data from radiodated sediment cores, historical sediment cores, CSO/SWO discharges and water column samples were examined to build a comprehensive understanding of dioxin sources, fate and transport in the estuary. The results show the contaminated lower Passaic River sediments to be the primary dioxin source to the entire complex, representing more than 95 percent of the annual budget within the lower Passaic, 80 percent of the load to Newark Bay and at least two-thirds of the load in the NY-NJ harbor. Potentially significant external sources are essentially ruled out by the analysis. Estimates of the mass of contaminants within the lower Passaic combined with the reworking of the sediment bed by tidal movements and flood events indicate the potential for continued dioxin release from the sediments. The analysis also supports projecting dioxin concentrations in the estuary's surface sediments into the future.

RP16 Sediment recontamination following dredging and capping at an early action site within the Lower Duwamish Waterway Superfund Site. D. Williston, J. Stern, B. Tiffany, DNRP, King County, Seattle, WA; B. Schmoyer, Seattle Public Utilities/City of Seattle, Seattle, WA. The Lower Duwamish Waterway (LDW), located in Seattle, Washington, was listed as a federal Superfund Site in 2001. Following a Phase 1 Remedial Investigation, several early action sites were identified in the waterway. King County, as a member of the Elliott Bay Duwamish Restoration Project, led the removal action of contaminated sediments from one of these early action sites. Sediments in front of and adjacent to a combined sewer overflow and storm drain (CSO/SD) outfall was removed from approximately a 7 acres area to an average depth of five feet. Prior to dredging, major contaminants of concern included polychlorinated biphenyls (PCBs), phthalates, and mercury. Monitoring of the surface sediments was conducted prior to the dredging and after capping on both the cap and the surrounding sediments. Chemical analyses of the surface sediments include metals, PCBs as Aroclors, semivolatile organic compounds including phthalates and PAHs, and conventional parameters. Within one year, sediment recontamination to levels above Washington State Sediment Management Standards was observed for phthalates and within two years for PCBs. Source control efforts by King County and the City of Seattle within the drainage basin did not reveal any significant point sources; however, source control investigations have shown phthalates and PCBs to be ubiquitous at low levels in the urban watershed. Monitoring continues of the surface sediments as does source control efforts to reduce the chemical load

to the outfall. Factors contributing to the observed recontamination include air deposition, low-level sources within the drainage basin and surrounding sediments in the waterway contaminated with PCBs and phthalates.

RP17 Monitoring of Polycyclic Aromatic Hydrocarbons in Sediment and Oyster Collected in Estuarine Ecosystem Savannah, GA. S.K. Kurunthachalam, K.S. Sajwan, J.P. Richardson, Department of Natural Sciences and Mathematics, Savannah State University, Savannah, GA; K. Kurunthachalam, Department of Health, Wadsworth Center, Albany, NY; B.G. Loganathan, Chemistry, Murray State University, Murray, KY. Sediment and oyster tissue collected from nine different marshes/estuarine ecosystem in Savannah GA USA, were analyzed for 16 predominant polycyclic aromatic hydrocarbons (PAHs). Total concentrations of PAHs were 7.5-48 (sediment) and 4.0-264 (oyster) on ng/g dw. There was no significant ($P < 0.5$) contamination variation in target analytes in between nine estuarine sites. Observed PAHs were lower than ERL-ERM guidelines. Overall, this baseline data can be used for regular ecological monitoring, considering the domestic and industrial growth around this important marsh/estuarine ecosystem.

RP18 PAHs in the Lake Michigan Aquatic Ecosystem. J.D. Fernandez, L.P. Burkhard, M.T. Lukaszewicz, P.M. Cook, J.W. Nichols, MED, USEPA, Duluth, MN. In this study, we are investigating the accumulation of PAHs in the Lake Michigan food web. Focusing on EPA's 16 "Priority Pollutant" PAHs and the methyl- and dimethyl-analogs of several of these PAHs, chemical analyses were performed on archived samples of water, sediment, invertebrates (Mysis spp. and Diporeia spp.) and fish species representing different trophic levels (alewives, chubs, sculpins, smelt and multiple age classes of lake trout) which were collected in conjunction with U.S.EPA's Lake Michigan Mass Balance Study (LMMBS). Because PAHs are metabolized by aquatic species and some of the subject fish species have high lipid contents, e.g., >20%, sample preparation techniques were optimized for low detection levels using GC/MS in tissues with high lipid content. These data will be used to calculate bioaccumulation factors (BAFs) and biota sediment accumulation factors (BSAFs). The BAFs and BSAFs will be compared to values determined from mechanistic models and a suite of compounds with differing metabolism rates ranging from recalcitrant PCBs to the more metabolizable PAHs. These data will augment efforts to reduce large uncertainties in risk assessments and water quality criteria developed for PAHs. This abstract does not necessarily reflect EPA policy.

RP19 Effect of sediment aging on the toxicity and bioavailability of fipronil and selected metabolites, sulfone and sulfide, to *Chironomus tentans* larvae. A.A. Brennan, M.J. Lydy, Fisheries and Illinois Aquaculture Center and Department of Zoology, Southern Illinois University Carbondale, Carbondale, IL. Fipronil is a member of a relatively new pesticide class known as phenylpyrazoles. This insecticide is the active ingredient in many well known pesticide preparations, including Frontline®, Termidor®, and MaxForce® for the eradication of fleas and ticks, termites, and fire ants, respectively. Fipronil partitions to sediments in aquatic ecosystems, thus having the potential for adverse effects to aquatic invertebrates that reside or utilize its resources. In sediment, fipronil degrades into fipronil sulfone and fipronil sulfide, with fipronil sulfone being more toxic to the benthic invertebrate, *Chironomus tentans*, than the parent compound or fipronil sulfide. Since fipronil and its degradation products can remain in the sediment for months after their initial release, hazard assessments of these compounds are necessary in order to determine how their bioavailability and toxicity changes with respect to time. Simulations of these conditions are being conducted with a six-month aging study using laboratory-spiked sediments. With residence time in sediment, a decrease in concentration and bioavailability of the insecticides should be seen as a result of abiotic and biotic degradation processes as well as sorption to organic components in the sediment. These parameters are being measured with sediment analysis, standard 10-d toxicity tests with *C. tentans* and Solid Phase Microextraction. In separate aging experiments for each compound, fipronil toxicity is expected to increase as a result of a more toxic degradate, whereas toxicity will decrease for fipronil sulfone and fipronil sulfide.

RP20 The energetic costs of reproduction in mayflies deduced by lipid depletion and a novel method of correction for individual variation in lipids using PCB tracers. J.M. Daley, K. Drouillard, GLIER, Windsor, Windsor, Ontario, Canada. Mayflies (*Hexagenia* spp.) have been shown to be effective monitors of organochlorines, such as polychlorinated biphenyls (PCBs). All of their growth and feeding occurs in the aquatic nymphal stage, and when

they emerge onto shore they undergo a transformation from subimago to imago. The purpose of this study was to test the hypothesis that male mayflies build up higher energy reserves in order to sustain higher reproductive costs associated with flight. The concentration of PCBs in mayflies was determined in order to demonstrate that the elevated rate of lipid loss can be detected by an increase in lipid normalized PCB concentrations. Nymphs were collected by Ponar sampling near Middle Sister Island and adults were collected using light traps. They were separated by sex into four life stages and analyzed for their lipid content and PCB concentration. There was a two-fold difference in lipid dry weight concentration between male subimagos and imagos (18.2% to 9.2% respectively). In contrast, females did not show a significant depletion in lipid between the two life stages (11.2% to 9.6%). The males showed pronounced increases in the PCB 153 concentration between subimagos to imagos, increasing from 0.50 to 2.00 ng/g lipid. The females showed a modest increase in concentration with a change from 0.81 to 1.35 ng/g lipid across the same lifestages. This research demonstrates that using PCBs as a surrogate measure of lipid change across different life stages is a more sensitive indicator of their energetic costs and thus PCBs could be used as effective energetic tracers. Finally, mayflies should be separated based on their life stage and sex for their continued use in biomonitoring.

RP21 Influence of Organic Matter Source on the Bioavailability of Sediment-Bound Pcb's to *Lumbriculus variegatus*. J. Gallagher, S. Klaine, Biological Sciences, Clemson University, Pendleton, SC; W. Bridges, Applied Economics and Statistics, Clemson University, Clemson, SC. The Sangamo-Weston capacitor manufacturer (Pickens County, South Carolina) discharged approximately 400,000 pounds of polychlorinated biphenyls (PCBs) into the 12-Mile Creek arm of Lake Hartwell from 1955 to 1978. Because PCBs are resistant to degradation in the environment and since PCBs may cause adverse effects to benthic organisms, this research characterized the influence of various organic matter sources (hydrilla [*Hydrilla verticillata*], pine needles [*Pinus* sp.], grass clippings [*Agrostis* sp.], and maple leaves [*Acer rubrum*]) on the availability of the Lake Hartwell sediment-bound PCBs in oligochaete worms (*Lumbriculus variegatus* Müller) in 28-day bioaccumulation experiments. Pulverized organic matter was amended to PCB-contaminated Lake Hartwell sediment prior to experiment initiation. Bioavailability of PCBs to *L. variegatus* decreased by approximately 50% in all of the organic matter-amended treatments compared to an un-amended sediment control for six sequential bioaccumulation experiments. This data implies that organic matter source may significantly influence bioavailability of sediment-bound PCBs to lower aquatic trophic levels. In addition, changes in sediment and worm chiral chemistry were observed, using enantiomeric fractions (EF), for chiral PCB congeners 95 (non-racemic) and 149 (racemic) throughout the bioaccumulation experiments.

RP22 Tenax-extraction – Does it measure bioavailability of sediment-associated contaminants? J.V. Kukkonen, J. Akkanen, A.J. Sormunen, M. Lyytikäinen, S. Pehkonen, M.T. Leppanen, Faculty of Biosciences, University of Joensuu, Joensuu, FINLAND. Tenax-resin has been originally developed for adsorbing volatile organic from gases. The resin is a porous polymer and it has low affinity for water (floats on the surface). It has high affinity for hydrophobic organic chemicals (HOCs), thus capturing efficiently freely dissolved HOCs also in aquatic media. On the other hand, the HOCs can be quite easily extracted from Tenax for analysis. Due to these properties Tenax has been applied for studies of availability of HOCs in sediment- (and soil-) water systems. The Tenax extraction has indicated that desorption of sediment associated HOCs can be modeled from 2 or more compartments having its own rate of desorption. In many studies three compartments model has been used (rapid, slow and very slow fractions). Following this it has been anticipated that mainly the rapidly desorbing fraction, obviously containing also the freely dissolved fraction, would be bioavailable. Several studies have been conducted to determine if Tenax extraction based desorption could be used to predict bioavailable fraction in sediments. In many cases the laboratory studies indicated that there is a relationship between the size of rapidly desorbing fraction and bioavailability measures or between desorption rate constant of the rapid fraction and bioaccumulation rates. However, there are some issues that we must be aware when using Tenax extraction. For example, it appears that ecological factors, such as species and feeding habits affect the bioavailability in ways that cannot be detected by Tenax extraction.

RP23 Analysis of In-Situ Sediment Pore Water to Support a Wetland Ecological Risk Assessment at a Brownfield Site in New Jersey. L. Judd, S. Peterson, B. Rabe, ERM, Exton, PA. Collection of in-situ sediment pore water

for chemical analysis is increasingly being used as a method for evaluating the bioavailable fraction of sediment-bound contaminants. For this study, passive diffusion devices were used to collect in-situ sediment pore water for chemical analyses to evaluate groundwater flux to sediment and aqueous partitioning of metals and organics. These investigations were used in conjunction with sediment toxicity testing and other data to support an ecological risk assessment for a Brownfield site located in a large urbanized watershed in New Jersey. The site, a former chemical manufacturing plant being considered for industrial re-development, contains a diverse complex of estuarine and freshwater wetland/open water habitats. Contaminants of concern at the site include chlorotoluenes in ground water from former chemical manufacturing activities, and metals in sediment as a result of the historical placement of river dredge spoils. An initial data screening showed that a variety of metals and organics in sediment were present at concentrations exceeding benchmarks. In a phased approach, analysis of in-situ sediment pore water samples was conducted along with sediment toxicity tests, bulk sediment analyses (including AVS/SEM), benthic macroinvertebrate surveys, fish tissue analyses, and food chain modeling to determine whether sediments posed an unacceptable risk to ecological receptors, and to inform risk management decision-making in the context of site re-development plans. Results of in-situ sediment pore water analyses, in conjunction with other weight-of-evidence data, will be discussed.

RP24 Autumnal Sediment Quality Assessment of Mississippi Delta Oxbow Lakes. R.E. Lizotte, S.S. Knight, S. Smith, C.T. Bryant, USDA-ARS NSL, Oxford, MS. A sediment quality assessment conducted during autumn 2004 examined agricultural pesticide contamination, biological effects, and bioavailability from five Mississippi Delta oxbow lakes during autumn. Three reference oxbow lakes were located in the White River National Wildlife Refuge (NWR), Arkansas, and two impaired lakes, according to USEPA section 303d Clean Water Act (303d), were located in Mississippi. Surficial sediment (top 5 cm) was collected at three sites within each water body from September to October 2004 and analyzed for 17 current-use and legacy pesticides and metabolites. Twenty-eight-day toxicity assessments and pesticide body residues using *Hyalella azteca* exposed to oxbow lake sediments were completed to determine the degree of biological impairment and bioavailability. Pesticides were detected in approximately 31% of both NWR and 303d sediments with legacy pesticides and metabolites accounting for 51% and 70% of all detections in NWR and 303d sediments, respectively. No significant ($P > 0.05$) mortality occurred in animals exposed to sediments and significant growth impairment was observed in sediment from only one site in a 303d listed lake (Macon Lake). Only 6 of 17 pesticides were bioavailable to test organisms with current-use pesticides occurring in <2% of samples, and legacy pesticides and metabolites occurring in 8%. Associations of a bioavailable legacy pesticide (dieldrin) and metabolite (*p,p'*-DDE) were implicated in observed growth impairment. Results show limited current-use pesticide contamination of sediments and animal body tissues during autumn and that bioavailable legacy pesticides and metabolites are the primary contributors of observed biological impairment.

RP25 Accurate Determination of Bioavailable Metals using Acid Volatile Sulfide Simultaneously Extracted Metals Analysis. M. Christie, J. Iverson, A. Hanson, Pace Analytical, Green Bay, WI. Sediments and the techniques used to analyze them present unique challenges. Accurately determining the concentration of the bioavailable fraction of metals present in sediments is vital to assessing risk and ultimately determining the degree of remedial action necessary. The AVS/SEM analysis requires special handling of sediments in the collection phase as well as the laboratory preparation and analysis phase. Oxygen interferes with the sulfide quantitation, measures need to be taken to avoid oxidative losses. Without precise preparation of the analytical set up and specific attention to detail Data Quality Objectives will not be met. The draft EPA Method 1629 suggests a preferred sample size of 10 grams, and discourages sample sizes less than 1-2 grams due to oxidative losses and sample homogeneity. An innovative procedure allows for sample sizes to remain in the 7-10 gram range for all samples regardless of the amount of sulfide present. This assures that the sample is representative of the actual site values. Development of unique sample handling techniques and analysis execution assuring data quality and comparability will be discussed.

RP26 Bioaccumulation of Chlorophenolic Contaminants by Estuarine Clams in the St. Johns River, Florida. J.C. Higman, St. Johns River Water Management District, Palatka, FL; L.B. Sonnenberg, Millar Wilson Laboratory for Chemical Research, Jacksonville University,

Jacksonville, FL. Previous research reported at SETAC 2006 described the widespread chlorophenolic contamination (chlorophenols, chloroguaiacols, chlorocatechols, chlorovanillins, chlorosyringols) found in the riverbed sediments of the St. Johns River, along with chlorobenzenes and other organic and metals contaminants (Higman et al, 2006; Durell et al, 2004). No chlorophenolic tissue information was available, but chlorobenzene tissue concentrations and chlorophenolic equilibrium partitioning estimates indicated a high potential for chlorophenolic bioaccumulation and possible toxic effects (Sonnenberg and Higman, 2001; Higman et al., 2006). Research has continued and recent results have shown that estuarine clams are accumulating some chlorophenolic compounds. Sediment samples were collected at thirteen sites but live clams were collected currently at only three of these sites. All sediment and tissue samples were analyzed for thirty chlorophenolic compounds. Nineteen of the thirty analytes were detected in sediments and the chlorocatechols occurred most frequently. Chlorophenols, chloroguaiacols and chlorovanillins were also detected in sediment samples. The total chlorophenolic concentrations in the sediment ranged from 1.4 to 113.3 ppb (dry weight). In contrast, the total chlorophenolic concentrations in clam tissue, from the three sites, ranged from nondetect to 11 ppb (wet weight). Pentachlorophenol and chloroguaiacols were the main chlorophenolic compounds found in the clam tissue. The relative distribution and quantities of chlorophenolic contaminants in the sediments were not reflected in the clam tissues, which could be due to the varying hydrophobicity of the different compounds and general bioavailability. Estimates of bioaccumulation using equilibrium partitioning equations and bio-sediment accumulation factors will be presented. Additional research is currently in progress to determine if organisms closer to the probable sources of chlorophenolic contamination are bioaccumulating higher concentrations than those living farther downstream in the St. Johns River.

RP27 Use of empirically-based and mechanistically-based sediment quality guidelines (SQGs) to predict toxicity of metal-contaminated sediments. C. Ingersoll, J.M. Besser, W.G. Brumbaugh, N.E. Kemble, N. Wang, USGS, Columbia, MO; D.D. MacDonald, D.E. Smorong, J.J. Jackson, MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia, Canada. The objective of this study was to evaluate the predictive ability of empirically-derived SQGs (PEC-Q@1%TOC: probable effect concentration quotients for metals normalized to 1% total organic carbon) and mechanistically-derived SQGs (ΣSEM-AVS/foc: Simultaneously-extracted metals, acid-volatile sulfide, and fraction organic carbon). Matching sediment toxicity and chemistry data were compiled for 8 studies totaling 140 sediment samples collect from sites primarily contaminated with metals. These data were then used to evaluate the ability of mean or maximum metal PEC-Q@1%TOC and ΣSEM-AVS/foc to predict the toxicity of metals in these freshwater sediment samples to sediment-dwelling organisms in laboratory toxicity tests with midge or amphipods or in mussel surveys in the field at sites with metal-contaminated sediments. Results of the analyses indicate that both metal PEC-Qs@1%TOC and ΣSEM-AVS/foc can reliably predict toxicity of sediments on both a regional and national basis. Specifically, >50% incidence in toxicity was observed in sediments at: (1) mean metal PEC-Q@1%TOC of >1.3, (2) maximum metal PEC-Q@1%TOC of >2.3, or (3) of ΣSEM-AVS/foc >170 μmole/goc. The proportion of freshwater sediment samples that were correctly classified as toxic or non toxic was similar when either metal PEC-Qs@1%TOC or ΣSEM-AVS/foc were used. The strong correspondence between PEC-Q@1%TOC and ΣSEM-AVS/foc in this evaluation was likely the result of two factors: (1) normalizing both SQGs to total organic carbon in the sediment samples; and, (2) a relatively low concentration of AVS in most of the sediment samples. In sediments with elevated concentrations of AVS, use of PEC-Q@1%TOC to predict toxicity may over estimate the toxicity of metals in sediment compared to predictions using ΣSEM-AVS/foc.

RP28 Exposure and impact of a veterinary antibiotic to sediment invertebrates. K. Henderson, J. Coats, Entomology, Iowa State University, Ames, IA; T. Moorman, USDA-ARS, National Soil Tilth Laboratory, Ames, IA. The antibiotic sulfamethazine can be transported from manured fields to surface water bodies. We investigated the degradation and fate of sulfamethazine in small pond water microcosms using ¹⁴C-phenyl-sulfamethazine, and found significant binding of sulfamethazine to sediment over a 63-day period. Greater than 40% of the applied radiolabel was bound to the sediment at the end of the study, indicating a potential route of exposure for benthic organisms. Sulfamethazine uptake by *Lumbriculus variegatus*

was measured during the study. The noted exposure of *L. variegatus* to sulfamethazine led to the examination of potential effects on gut microflora.

RP29 Use of Site-Specific Equilibrium Partitioning Sediment Benchmarks for Polycyclic Aromatic Hydrocarbon Mixtures to Predict Toxicity of Sediments at Former Manufactured Gas Plants. S.B. Kane Driscoll, B. Amos, M.E. McArdle, C.A. Menzie, Exponent Inc., Maynard, MA; A.J. Coleman, EPRI, Palo Alto, CA. This study was conducted to examine the application of site-specific Equilibrium Partitioning Sediment Benchmarks (ESBs) for assessing the toxicity of polycyclic aromatic hydrocarbons (PAHs) in sediments at former Manufactured Gas Plant (MGP) sites. Samples of freshwater sediment from four MGP sites in the Northeast and Midwest U.S. were analyzed for 34 individual PAHs, non-pyrogenic organic carbon, "black" carbon (potentially comprised of pitch, soot, and other forms of pyrogenic carbon), and sediment toxicity (28-day Hyalella azteca toxicity test). The sum of the ESB toxic units (Sum-TU) for the 34 PAHs in sediment was calculated based on a one-phase model that accounted for adsorption of PAHs to total sediment organic carbon, or a two-phase model that accounted for adsorption to non-pyrogenic organic carbon and black carbon. The one-phase model accurately predicted lack of toxicity in sediments with Sum-TU less than 1.0 and concentrations of total PAHs as high as 21 mg/kg. The two-phase model was in closest agreement with results of sediment toxicity tests, accurately predicting lack of toxicity for samples with Sum-TU less than 1.0 and concentrations of total PAHs as high as 52 mg/kg. This work demonstrates that both models are conservative, since significant toxicity was not generally observed for samples with up to 15 Sum-TU and concentrations of PAHs up to 325 mg/kg.

RP30 Contamination Status and Accumulation Profiles of Organotins in Sea Otters (*Enhydra lutris*) Found Dead along the Coasts of California, Washington, Alaska (USA), and Kamchatka (Russia). S. Murata, S. Takahashi, T. Agusa, S. Tanabe, Center for Marine Environmental Studies, Ehime University, Matsuyama, Japan; N.J. Thomas, US Geological Survey-Biological Resources Division, National Wildlife Health Center, Madison, WI; K. Kannan, Wadsworth Center, New York State Department of Health and Department of Environmental Health Sciences, School of Public Health, State of University of New York at Albany, Albany, NY. The decrease in the population of southern sea otters (*Enhydra lutris nereis*) in the late 1990s was attributed to high adult mortality rates citing same infectious diseases as the major cause of death (Thomas and Cole, 1996). High prevalence of diseases in this animal has been hypothesized as due to their weakened immune systems resulting from exposure to toxic chemical contaminants. In this study, to examine the authenticity of this hypothesis, mono- to tri-butyltins (MBT, DBT, TBT), -phenyltins (DPT, TPT) and -octyltins (MOcT, DOcT, TOcT) were determined in the liver of adult female specimens died along the California coast during 1992-2002. In addition, sea otters found dead along the coasts of Washington State, Alaska and Russia were also analyzed for comparison. OTs were detected in all the liver samples analyzed. Total concentrations of OTs in specimens of California ranged from 43 to 8200 ng/g on a wet wt basis. The order of the percentage of OTs were total butyltins (BTs) > total octyltins (OcTs) • total phenyltins (PTs). Very high concentrations of BTs were found in some specimens which were affected by infectious diseases. Total BTs concentrations in sea otters significantly decreased since the 1990s. The half-life of TBT and Total BTs estimated from the hepatic concentrations of sea otter were 3.02 years and 3.15 years, respectively. BTs concentrations in sea otters from California were significantly higher than those in same species from Kamchatka Peninsula and in California sea lions and harbor seals collected along the California coast. Percentage of BTs (average 79%) in ΣSn concentrations in sea otters were similar to those of cetaceans, but higher than those of pinipeds. Moreover, concentrations of TBT and DBT found in few infected specimens were close to or even exceeded the threshold levels of toxic effects reported from in vivo (Ueno et al, 1998) and in vitro (Nakata et al, 2000) studies.

RP31 Understanding watershed and land use-based sources of fecal indicator bacteria in urban stormwater. L.L. Tiefenthaler, E.D. Stein, K.C. Schiff, Watersheds, Southern CA Coastal Water Research Project, Costa Mesa, CA. Land-based stormwater runoff is increasingly recognized as a source of fecal indicator bacteria (FIB) and a public health concern at recreational bathing waters. Routine stormwater monitoring programs focus on quantification of average concentration or fluxes at the terminal watershed discharge point. While important for overall status and trends assessment and compliance, such monitoring provides little insight into the mechanisms and

processes that influence FIB concentrations in stormwater. The goal of this study was to quantify the sources, patterns of concentrations and fluxes of three FIB (i.e. *Escherichia coli* (*E. coli*), enterococci, and total coliforms) from representative land use (LU) types in both urban and non-urban watersheds within the greater Los Angeles, California region. In addition, within storm and within season patterns were investigated in order to identify mechanisms that influence patterns of FIB concentrations. Finally, we compared the estimates of storm water FIB concentrations to data from point and non-point sources and to existing water quality standards to provide context for the magnitude of importance of storm water to overall FIB concentrations for the region. To achieve these goals, bacterial concentrations were measured over the entire storm duration from eight different LU types over 13 storm events in five southern California watersheds during the 2000-01 through 2004-05 storm seasons. In addition, runoff samples were collected from twelve mass emission (ME) sites during 13 different storm events. Recreational (horse) LU sites contributed significantly higher storm (EMCs) for *E. coli* bacteria than other LU types. Agricultural LU sites contributed substantially higher fluxes for both enterococci and total coliforms. Stormwater runoff contributed a similar range of median *E. coli* EMCs when compared with the rest of the nation and has improved over time. FIB concentrations exceeded the State of California single-sample bacteriological water quality standards for marine recreational water in almost all samples at both ME and LU sites. Early-season storms (October-December) repeatedly produced higher bacterial EMCs than comparably sized late-season (April-May) storms. For most storms sampled, the highest bacterial concentrations occurred during the early phases of stormwater runoff with peak concentrations usually preceding peak flow.

RP32 Comparison of IDEXX and membrane filtration for tracking concentration of fecal indicator bacteria (FIB) at an enclosed beach in Southern California. K. Mika, J. Jay, C. Lee, G. Imamura, R. Moreno, C. Chang, C. Lin, Civil & Environmental Engineering, UCLA, Los Angeles, CA. Coastal sediments are increasingly recognized as important reservoirs for pathogens, pathogen indicators, and fecal indicator bacteria (FIB). Contaminated sands and beach aquifers are sources of FIB, and surf zone sediments at enclosed beaches often harbor drastically higher levels of FIB than sediments at exposed beaches. Reduced wave action at enclosed beaches results in a high percentage of children playing in the surf. Thus, enclosed beaches are an important area to monitor, as they create a scenario where a population that is naturally more susceptible to illness (children) is exposed to possibly elevated levels of FIB. Throughout the wet season (Jan to May), we sampled water and sediment at Mother's Beach, an enclosed beach in Marina del Rey, using both IDEXX substrate technology and membrane filtration (MF), for *E. coli* (EC) and enterococci (ENT). In samples taken the day after rainfall, IDEXX values from sand samples for EC ranged from 200-6,300MPN/ 100 dry grams sediment (DGS), and for total coliforms from 300-22,000MPN/ 100DGS. Background samples taken during dry weeks showed respective concentrations of 100-400MPN/100DGS and 200-600MPN/100DGS. ENT, however, showed less correlation with seasonality, showing levels ranging from 60-5000MPN/100DGS throughout the sampling period. For MF, wet weather samples provided values of 600-1,000cells/100mL for ENT, and 240-4,150cells/100mL for EC while dry weather samples were 10-500cells/100mL and 50-1,100cells/100mL, respectively. We have begun analyzing frozen extracted DNA from the same samples for human-specific indicators (HSI) such as the *esp*-gene on enterococci or human-specific *Bacteroides* to determine their correlation with FIB. Throughout the high-use season (June-Sept), we will continue tracking FIB and HSI concentrations at Mother's Beach. In addition, we are sampling at an open beach in Orange County, Doheny Beach, in collaboration with Southern California Coastal Water Research Project. With dna extracted from sand samples, we will be able to compare levels of HSI at Mother's Beach throughout the high and low use seasons. These correlations will provide a deeper insight into the extent to which traditional FIB reflect levels of anthropogenic fecal pollution at enclosed and open beaches, and a deeper understanding of seasonal effects on bacterial populations in saline water away from the circulation caused by crashing surf.

RP33 Near real-time detection of pathogen indicators in coastal waters. C. Lee, ucla, Los Angeles, CA. We are adapting for use in marine waters a recently developed method for near real-time *E. coli* and enterococci detection based on immunomagnetic separation and quantification of ATP using luciferin/luciferase. We have documented relative light units, measurements using a micro luminometer, for *E. coli* in freshwater and also informally for a

SCCWRP study in 2005 comparing several methods for rapid detection. Our current work consists of devising a new sensor system to monitor and study light emissions that arise from the metabolism of bacterial ATP (in particular, of FIB), and testing the selection method for both *E. coli* and enterococci. Presented are preliminary tests evaluating the ability of the system to detect extremely low light levels (photons per unit time) against ATP standard concentrations and *E. coli* concentrations. There will also be discussions regarding the efficiency of attachment mechanisms of the antibody-magnetic bead complex (the selective agent that binds the target organisms).

RP34 Contaminant Transport Prediction in Sediment Caps: Analytical Modeling and Uncertainty Analysis. D. Lampert, D. Reible, Civil, Architectural, and Environmental Engineering, The University of Texas at Austin, Austin, TX. An analytical model is developed to predict performance of a cap for containment of contaminated sediments. Transient conditions within a cap can be modeled by advection, diffusion and reaction within the typically homogeneous chemical containment layer for which numerous analytical models exist. After contaminant penetration of the chemical containment layer, a steady state model is proposed that incorporates pore water advection and diffusion, sediment re-working and pore water pumping via bioturbation, sorption and reaction. The steady state model allows layers of different physical and chemical properties while maintaining an analytical form for convenient and rapid evaluation, for example for repeated evaluations to evaluate the influence of site heterogeneity or uncertainty. The applicability of this model and the potential effectiveness of capping in the face of site variability or uncertainty are demonstrated in this discussion.

RP35 Dioxins and Furans (D/F) in Bivalve Samples from the NOAA National Status and Trends Project. T.L. Wade, S.T. Sweet, Geochemical and Environmental Research Group, Texas A&M University, College Station, TX. Dioxins and Furans (D/F) are assessed as being some of most toxic man-made compounds. They are unwanted byproducts of chemical processes that include chlorine. They are also found in ball clays and therefore could be expected to have some natural formation mechanisms. D/F are ubiquitous in the environment at low concentrations (pg/g), but can be elevated near some input sources. This study reports on the concentration and toxicity equivalents of 152 bivalves samples analyzed as part on the NOAA National Status and Trends Project. The samples were collected from 1995 to 1998. The concentration of total dioxin/furans ranged from not detected to 2,246 pg/g dry weight (DW) of tissue. The toxicity equivalents (compared to 2,3,7,8-TCDD) ranged from not detected to 8.99 pg TEQ/g dry weight. OCDD had a concentration range from not detected to 2,090 pg/g DW and a mean concentration of 85.7 pg/g DW. OCDD normally is the dominant of any D/F compounds detected accounting for, on average, over 70% of the total D/F present. If background TEQ for bivalves is assumed to be at approximately 7 pg TEQ/g DW, elevated TEQ are concentrated in marine and Great Lake locations with large population and/or industrial activities (e.g. Boston Harbor, Long Island Sound, Galveston Bay, Los Angeles, San Francisco, Reno Beach on Lake Erie, etc.). These areas typically have higher concentrations of other contaminants, especially PAH, which have been shown to be the major contributors to the toxicity associated with bivalves with D/F only responsible for 10% of the total estimated inducible toxicity.

RP36 A comparison of biomarker responses in striped mullet and mummichog from the lower Sampit River, Georgetown, SC. P. van den Hurk, A. Revotskie, Biological Sciences, Clemson University, Clemson, SC. The Sampit River is located in the coastal plain of South Carolina and discharges into the upper Winyah Bay estuary. Sediments in the lower part of the river are heavily contaminated, supposedly by industrial activities in Georgetown, SC, which is located on the river. Very little is known about the biological effects of the environmental pollution in this location. We started an investigation using a suite of biochemical biomarkers to measure exposure and biological effects in two abundant fish species in the area: the mummichog (*Fundulus heteroclitus*) and striped mullet (*Mugil cephalus*). Biomarkers measured were bile fluorescence and biliverdin content, and induction of specific xenobiotic metabolizing enzymes: cytochrome P450-1A, glucuronosyltransferase, glutathione S-transferase, and sulfotransferase. The results showed consistent differences between animals from the contaminated and the control site, with the mullet being the more sensitive, or more exposed species. Significant increases were found in almost all biomarkers, indicating exposure to aromatic hydrocarbons and/or compounds inducing oxidative stress. The collected mummichogs showed significant differences between males and females, supposedly related to spawning status of the females.

The results of this study demonstrate that the use of biomarkers is a valuable approach to assess exposure and effects in an estuarine system like the lower Sampit River.

RP37 A new genome scan technology for microbial source tracking. C.C. Tseng, Purdue University, Hammond, IN. Microbial source tracking (MST) is an important issue for improving water quality. Current approaches such as DNA profiling and PCR assays for 16S rDNA or toxin genes (library independent) are not ideal for MST due to the lack of sufficient markers. To generate more markers, a microarray-based approach has been pursued. However, neither new sequences nor specific sequence variations can be detected by microarrays. We developed a the ditag genome scan (DGS) technology for studying *E. coli* genome variation to generate markers for MST. The whole genome was fragmented by a restriction enzyme. All the genomic DNA fragments were cloned to create an *E. coli* genomic library. A second restriction enzyme was then used to remove most parts of the cloned fragments except about 17-base tags from each end of the fragments. The two tags retained in the vector were re-ligated to form a new ditag library. The newly formed ditags were released from the vector by restriction enzyme digestion and connected to each other to form concatemers. These concatemers were cloned to form a concatemer library. After sequencing of concatemers, the resulting ditag sequences from the isolates of original wild-type and pathogenic *E. coli* were mapped in sense and antisense orientations to the ditag reference databases (*E. coli* K12 and *E. coli* O157:H7). Matching percentage and genome coverage percentage were calculated to assess the stability of the genomes among different testers. Partial-matched and unmatched ditags may represent genomic variation from the reference databases or artifacts. The latter can be eliminated through PCR assays. For PCR verification, a primer design program was developed to extend the single tag sequence to a 20 base primer by adding extra bases to the 5' end (prefix sequence). All PCR verified primer sets can be used for mass screening of *E. coli* genomic DNA from a large number of isolates of known sources. These will include isolates from different geographical locations. After suitable host-specific primers are identified, the next step is to develop a simple, low cost kit for MST. DGS allows identification of different types of genomic variations: deletion, insertion, inversion, and translocation. The application of this technology is unlimited, including microbial typing and subtyping.

RP38 Detecting Sublethal Effects of Pesticides in Embryos and Early Larval Stages of 3 Bivalves. K.D. Perry, J. Lynn, Biological Sciences, Louisiana State University, Baton Rouge, LA. Embryonic and early larval stages exhibit increased sensitivity to stressors in the environment in comparison to their adult cohorts. Many aquatic species are exposed to pesticides released in runoff or used to control nuisance populations. Bivalve larvae often are not able to avoid exposure causing deleterious effects at early stages and later generations. By testing for sublethal effects in early life stages, stress to a population can be monitored for species conservation, chemical control of invasive species, and as a biomarker of pollution. One approach to invasive species controls and reducing environmental impacts is to detect sublethal concentrations that may impair recruitment to the population and the continuation of the life cycle. In this study, we present sublethal effects in early life stages of 2 invasive species, *Dreissena polymorpha* and *Mytilus galloprovincialis*, and 1 indigenous bivalve, *Crassostrea virginica*. The 3 bivalves tested for apoptotic cells exhibited variations in the normal and stress induced apoptotic index (API) despite having the same life stage transitions. API was quantified using a TUNEL assay for detection of fragmented DNA. Normal apoptosis was measured at 4h intervals for the initial 24h and stress induced apoptosis was measured in embryos and 24h-old larvae after 4h and 24h exposures to a molluscicide, Bayluscide. *C. virginica* and *M. galloprovincialis* cleavage stage embryos displayed normal and stress-induced apoptosis; however *D. polymorpha* had no apoptotic cells in this stage. There was a significant increase in the API during the blastula to trochophore transition in all species. An exposure to 1.0 ppb Bayluscide produced significant increases in trochophore APIs in both *M. galloprovincialis* (24h exposure) and *D. polymorpha* (4h pulsed exposure). A decrease in API was observed in the higher concentrations of all exposures suggesting that with excessive numbers of damaged cells, the embryo can not provide defensive cell deletion to maintain development. An ELISA was also performed for detecting mono- and oligonucleosides in the cells signifying apoptosis. Expression of stress-inducible proteins (hsp-70 and caspase-9) is currently being evaluated with Western Blots. Using this data, it may be possible to monitor apoptosis and protein expression in bivalve larvae as a consequence of environmental stress, signifying susceptibility in an ecosystem.

RP39 Characterization of dimethylsulfoniopropionate (DMSP) production, antioxidant and oxidative stress endpoints in marine *Symbiodinium* sp. cultures. D. Yost, C. Mitchelmore, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, Solomons, MD. *Symbiodinium* sp. are one group of marine algae (dinoflagellates) known to produce high amounts of dimethylsulfoniopropionate (DMSP). These algae are important components of healthy symbiotic corals, but may promote oxidative stress conditions in their coral hosts due to excessive photosynthetic oxygen production. DMSP and its breakdown products dimethylsulfide (DMS), dimethylsulfoxide (DMSO), methane sulfinic acid (MSNA) and acrylate have been shown to have antioxidant capabilities in other algal cells. We investigated several different marine algal cultures, including a variety of *Symbiodinium* sp. for background levels of DMSP, DMS and DMSO production and measured algal DMSP in response to various treatments eliciting oxidative stress. In parallel, we measured several antioxidant system and oxidative stress endpoints. Our results indicate that *Symbiodinium* sp. produce DMSP at different background concentrations and that, under conditions of oxidative stress, DMSP is regulated according to species-specific physiology. To characterize DMSP production further, we measured DMSP lyase activity (responsible for enzymatic cleavage of DMSP) in each of the algal cultures investigated. Taken together, the above data suggest that regulation and function of DMSP in cnidarian-algal symbioses plays a crucial role in alleviating oxidative stress and may therefore impact overall coral health.

RP40 Gene Expression Profiles as Molecular Indicators of Dissolved Oxygen Stress in Grass Shrimp *Palaemonetes pugio* Holthuis 1949. T. Li, M. Brouwer, Department of Coastal Sciences, University of Southern Mississippi, Ocean Springs, MS. Occurrence of hypoxia in estuarine waters is increasing, and recovery of impacted estuaries is slow. Detection of early effects of hypoxia is needed for timely remedial action to be taken. The aim of this project is to evaluate the potential importance of gene expression in grass shrimp, *Palaemonetes pugio* as indicators of hypoxic-related stress. Suppression subtractive hybridization (SSH) was performed by EcoArray to generate libraries of DNA fragments, which include hypoxia inducible genes, and clones from SSH libraries prepared from copper- and pyrene-treated grass shrimp and shrimp in different stages of the molt cycle. Seven hundred clones were chosen for PCR amplification. Purified cDNA and control clones were spotted in duplicate arrays on UltraGAPS coated slides using the VersArray ChipWriter. Total RNA was extracted from normoxic shrimp and hypoxic shrimp in both chronic (1.5ppm DO, Day0, Day 5, and Day 10, Hour6, Hour12, Hour24, and Hour48) and cyclic (1.5→8ppm DO, Day0, Day1, Day2, Day5, and Day10) hypoxia treatments at different time points. During cyclic exposure, shrimps were collect at high and low concentrations of DO. The DNase-treated RNA was labeled with Amino-Allyl-dUTP. A loop design combining direct and indirect comparisons was used as the microarray experimental design. Cy3 and Cy5 were coupled to labeled cDNA from controls and experimental shrimp, respectively. Slides were hybridized overnight using a-Hyb station with equimolar mixtures of Cy3/Cy5 cDNA from normoxic and hypoxic shrimps. The arrays were then scanned with the VersArray ChipReader and used GenePix Pro for initial spot finding. Raw data was imported into different microarray tools (such as Acuity and R) for data analysis. Normalized data were used for clustering, visualization, classification, statistical analysis and biological theme discovery. Gene expression profiles of gene arrays will help us to determine if the expressions of HIF and hypoxia related stress genes in grass shrimp can be used as ecoindicator tools to monitor hypoxia-related stress in the marine environment. Supported by NOAA NA05NOS4261163.

RP41 Effects of Hexabromocyclododecane (HBCD) diastereoisomers on the thyroid axis of Juvenile Rainbow trout (*Oncorhynchus mykiss*). V.P. Palace, K. Pleskach, K. Wautier, G. Tomy, Fisheries and Oceans, Freshwater Institute, Winnipeg, Manitoba, Canada. Brominated flame retardants are widely used and increasingly detected in abiotic and biotic compartments globally. Tetrabromobisphenol, polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecane (HBCD) are most ubiquitous. HBCD is the principle fire retardant in polystyrene foams that are used as insulation in the building industry and for upholstering furniture. The technical HBCD mixture consists of three diastereoisomers, α , β and γ with the γ isomer most often detected. Differences in the proportions of HBCD isomers in food webs are known, but the relative potency of the diastereoisomers to induce biological effects is not known. In particular, disruption of the thyroid axis

is of most concern but little is known of the diastereoisomer specific abilities to affect the thyroid axis. In fish, the ability to convert the inactive form of thyroid hormone (T₄) to the active form (T₃) is mediated by T₄ outer ring deiodinase (T₄ORD) enzyme activity outside the thyroid glandular tissue. To address the deficiency regarding HBCD diastereoisomer specific effects on the thyroid system, effects of environmentally relevant concentrations of α , β and γ HBCD on rainbow trout T₄ORD were examined using an in vitro system.

RP42 Development of a high-throughput method for quantitating thyroid gland follicular cell hyperplasia in amphibian model species *Xenopus laevis*. J.T. Haselman, J.E. Tietge, M.W. Hornung, S.J. Degitz, EPA, Duluth, MN. The US EPA has developed an amphibian based screening assay for detecting disruption of the hypothalamic-pituitary-thyroid (HPT) axis. Thyroid gland histopathology has proven to be a sensitive and reliable diagnostic endpoint. However, the effort and cost associated with thyroid gland histopathology may ultimately limit its use. One of the hallmark changes observed in the thyroid gland following inhibition of the (HPT) is follicular cell hyperplasia. In an effort to reduce costs and improve throughput, we are exploring new approaches to quantify hyperplasia. In these experiments we are exploiting the relationship between cell number and DNA content. Thyroid DNA was quantified using a nucleic acid-specific green fluorescent dye (CyQUANT GR) and fluorescence values were converted to cell number based on reference standard curves. Cell number standard curves were created by trypsinizing excised glands, quantifying cell number via hemacytometer, and measuring DNA content using Invitrogen's CyQUANT kit. DNA standard curves used for assay calibration were generated using a λ DNA standard solution provided by the CyQUANT kit. In order to quantify follicular cell number throughout the metamorphic process, thyroid glands were collected from *X. laevis* larvae at stages 52, 54, 56, 58, 60, 62, 64. Additionally, stage 54 tadpoles were exposed to three model thyroid active agents, methimazole, 6-propylthiouracil, and perchlorate at concentrations of 100 mg/L, 20mg/L and 4mg/L respectively. Thyroid glands were sampled at 48, 96, 144 hours of exposure. The sensitivity of this technique shows promise for making reliable and routine measurements of follicular cell number in paired glands from a single larva and will aid in screening for chemical effects.

RP43 Phototoxicity of fluoranthene and benzo[a]pyrene on *Artemia franciscana* evaluated with the comet assay. M. Guzman-Martinez, P. Ramirez-Romero, Hidrobiologia, Universidad Autonoma Metropolitana, Mexico, D. F., Mexico; K. Davalos de la Cruz, M. Aguilar-Santamaria, Ciencias de la Salud, Universidad Autonoma Metropolitana, Mexico, D.F., Mexico. The comet assay or single cell gel electrophoresis is a sensitive and quick technique to evaluate DNA damage caused by exposure to physical and chemical agents. PAH's are ubiquitous contaminants that can cause oxidative stress and also DNA damage, these effects are increased exponentially by the presence of solar UV radiation. The objective of this work was to evaluate the phototoxic effects of two PAHs (fluoranthene and benzo[a]pyrene) on metanauplii of *Artemia franciscana* using the comet assay as an indicator of DNA damage. 48 hrs metanauplii were exposed either to fluoranthene or benzo[a]pyrene at two different sub-lethal concentrations (24 and 48 μ g/L; 4.8 y 9.6 μ g/L respectively). Four replicates of 100 organisms were used for the control and the solvent control groups and eight replicates for each of the PAHs concentrations. Each test was done twice. The exposure to PAHs and simulated ultraviolet radiation lasted 24 hrs with a 12:12 photoperiod after which the organisms were processed using Singh's modified technique. Damage was categorized in 5 classes: no damage, low, medium, high and total. All cells of all treatments presented damage. Control organisms presented an average tail length of $17.09 \mu + 0.82$ (SE) and solvent control of $26.2 \mu + 0.11$. Fluoranthene and benzo[a]pyrene exposed nauplii average tail length were two times ($35.95 \mu + 1.32$ and $37.97 \mu + 1.42$) and three times ($56.25 \mu + 1.24$ and $58.96 \mu + 0.99$) longer than controls respectively ($p < 0.05$). Exposure of *Artemia franciscana* to sublethal concentrations of fluoranthene and benzo[a]pyrene and UV radiation caused DNA chain breaks which can be assessed through the comet assay method. The next step on this research will be the application of this experience to mesocosm and *in situ* assays in PAHs polluted areas so that a clear link between this biomarker and its possible ecological implications can be known.

RP44 Determination of estradiol in fecal samples from rainbow trout (*Oncorhynchus mykiss*) using LC-MS. L. Peters, G.T. Tomy, K. Pleskach, Department of Fisheries and Oceans, Winnipeg, Manitoba, Canada; L. Peters, G.T. Tomy, University of Manitoba, Winnipeg, Manitoba, Canada. Environmental monitoring programs typically evaluate fish on the basis of

growth, metabolism and reproduction at exposed and reference collection locations. Measures of reproductive health including gonad size, reproductive steroid profiles, and steroidogenic capacity are most meaningful because they relate to population recruitment; however, most of these measures require lethal sampling. There is an increasing trend to move towards non-lethal methods of evaluation which has been driven by concerns regarding impacts of sampling in situations where fish populations are small or contain species at risk. Mammalian researchers have long used steroid measure from fecal samples to determine reproductive stages. Here we describe the development and optimization of extraction and LC/MS detection procedures of estradiol and related compounds from rainbow trout fecal samples. Application of these techniques may provide a measure of reproductive stage in fishes to be included in future monitoring programs.

RP45 Comparison of Various Metals on the Effects of Oxidative Stress Using 8-Hydroxy,2-Deoxyguanosine as a Biomarker. E. Gibbs, Chemistry, Texas Southern University, Houston, TX. In the recent years of scientific investigation, the role of DNA in disease pathology has become increasingly important. In attempts to understand the effects of foreign materials and energies on DNA structures and interactions, several types of genetic damage have been characterized. One type of genetic malfunction that is of interest to this laboratory is oxidative damage to DNA. Oxidative damage can result when cells are exposed to stimuli such as metallic cations, creating free radicals from metabolic processes that can attack and damage vital cellular components such as DNA. This, in return, leads to elevated levels of oxidative stress. The objective of this investigation is to examine the effects of various metals on oxidative damage to DNA. The investigation into the effects of various metals on oxidative stress shall be monitored and assessed by means of HPLC-UV analysis of 8-Hydroxy,2-deoxyguanosine, a specific biomarker of oxidative stress.

RP46 Oxidative Burst and Phagocytosis as Biomarkers of Contamination Exposure in Estuarine Fish: A Methodological Approach. I.S. Chaves, Pós-Graduação em Oceanografia Biológica, Fundação Universidade Federal do Rio Grande, Rio Grande, RS, Brazil; A. Bianchini, P.E. Martínez, Departamento de Ciências Fisiológicas, Fundação Universidade Federal do Rio Grande, Rio Grande, RS, Brazil. The innate immune response is the first line of defense against pathogens and consists of a variety of immune defense mechanisms, including the respiratory burst and phagocytosis. These mechanisms have been used to investigate the biological effects after exposure to several environmental toxicants, including metals. Quantitative measurements of the respiratory burst have been difficult to be performed because conventional analyses are complicated and laborious. In the present study, we describe methodologies for respiratory burst and phagocytosis measurements adapted from flow cytometric assessments. These methodologies were applied in blood leukocytes from a estuarine fish, the white croaker *Micropogonias furnieri*, using a fluorimetric assay. Peripheral blood erythrocytes were disrupted using an ammonium chloride solution and leukocytes suspended in HBSS were used for respiratory burst and phagocytosis assays. For respiratory burst assay, phorbol myristate acetate (PMA) was used as an inducible reactive oxygen species (ROS), which is detected following the oxidation of the non-fluorescent dye 2',7'-dihydrodichlorofluorescein diacetate (H₂DCFDA) to a fluorescent product, the dichlorofluorescein (DCF). For phagocytosis assay, a *Escherichia coli* (K-12 strain) fluorescein conjugate was used. Since the respiratory burst and phagocytosis are indicative of immune health, they provide an important integrated response of a multitude of molecular indicators to environmental stimuli.

RP47 An in vivo bioassay approach for testing sediment extracts in fish gill and liver (*Gasterosteus aculeatus* L.) for dioxin-like activity. J.C. Otte, A. Abrahamson, C. Andersson, B. Brunström, Department of Environmental Toxicology, Uppsala University, Uppsala, Sweden; J.C. Otte, S. Keiter, H. Hollert, Institute of Zoology, University of Heidelberg, Heidelberg, Germany; M. Engwall, H. Olsman, MTM Research Centre, Örebro University, Örebro, Sweden. To investigate the potential Ah receptor-mediated toxicity of sediment-borne compounds to fish, the gill EROD-assay was developed further for sediment toxicity investigation in the three-spined stickleback (*Gasterosteus aculeatus* L.) in combination with the measurement of EROD-induction in the liver. Sediments from four different sites along the upper Danube River in Germany were Soxhlet-extracted with acetone and finally dissolved in DMSO. Sticklebacks were exposed for 48h to various concentrations of the extracts, to the positive control β -naphthoflavone or to the solvent. Measurements of EROD-activity in gill filaments and liver

microsomes followed the exposure. A concentration-dependent induction of EROD in gill and liver of sticklebacks was found for all sediment extracts. The inducing potential of the dioxin-like compounds in the sediments is site-specific and the EROD-activities in gill and liver correlated properly. A comparison of in vitro results of previous investigations vs. ex vivo results in gill and liver showed good correlations. Chemical analysis of PAHs, PCBs and PCDD/Fs of the sediment samples obtained in previous investigations corresponded with EROD-activity in the gill as well as the liver. In conclusion, determination of EROD in gill filaments of the three-spined stickleback and the gill EROD-assay in combination with EROD-measurement in the liver is a suitable tool in vertebrate-based sediment toxicity assessment.

RP48 Catalase and Peroxidase as Biomarkers of Stress in *Spartina alterniflora* in the Galveston Bay Estuary System. T.L. Randall, J. Unruh, C.L. Howard, University of Houston-Clear Lake, Houston, TX. The Galveston Bay Plan (1995) states that the highest priority is to protect and restore coastal wetland habitats and several million dollars have been spent on creating or restoring *Spartina alterniflora* marshes in the Galveston Bay system. Marsh density and expansion are monitored but little is known about the fundamental health of these salt marsh communities and how they tolerate or adapt to environmental and pollutant stressors. This study evaluated peroxidase and catalase activities as indicators of stress from nine sites representative of unimpacted native, restored and pollutant impacted coastal salt marshes in Galveston Bay. Both catalase and peroxidase serve to detoxify free radicals in plants and elevated levels of these enzymes are indicative of oxidative stress on the marsh system. Restored sites showed significantly elevated levels of catalase in *S. alterniflora* compared to those in the native sites. Peroxidase exhibited a similar relationship with levels significantly higher in impacted and restored marshes. Variations in these markers demonstrate a complex combination of environmental, physical and genetic factors which may relate to whether the *S. alterniflora* marshes were naturally established, pollutant impacted or restored marshes.

RP49 Effects of 17 alpha-methyltestosterone on secondary sex characteristics and vitellogenin induction in the female western mosquitofish, *Gambusia affinis*. S. Raut, R.A. Angus, University of Alabama at Birmingham, Birmingham, AL. Numerous studies, both in the field and laboratory, have demonstrated that a variety of anthropogenic compounds can act as endocrine disruptors. Most of the studies to date have focused on estrogens. However, reports of androgenic endocrine disruptors continue to increase. We are currently investigating the effects of androgens, anti-androgens and aromatase inhibitors on secondary sex characteristic and vitellogenin induction in female western mosquitofish, *Gambusia affinis*. In this study, we examined the effects of the potent synthetic androgen 17 alpha-methyltestosterone (MT). Females were exposed for five weeks to MT at four concentrations: nominal 10, 100, 1000, and 10000 ng/L, via water using the static renewal method. Morphological masculinization, as evidenced by development of an elongated and modified anal fin, was observed in the three highest exposure groups. The expression of VTG mRNA was significantly inhibited in the three highest exposure groups as compared to the vehicle treated controls. These results support the use of anal fin ray elongation and VTG mRNA expression as useful biomarkers for androgen exposure in mosquitofish. Future studies will investigate and compare the response of these biomarkers to other androgens by utilizing MT as a positive control.

RP50 Chemiluminescence of the Catalase Reaction and its Use as an Indicator of Metals in Water. F. Forouzan, T. Byl, L. Sharpe, Environmental Engineering, Tennessee State University, Nashville, TN; T. Byl, Water Resources, USGS, Nashville, TN. Biomarkers or enzyme activity are often used to assess the quality of an environment. These indicators are useful because they represent a biological endpoint to toxicity. The objective of this research was to determine if the chemiluminescence from the catalase reaction could be used as a monitor of environmental quality. The primary task was to determine whether microbial or plant sources of oxidase enzymes were better. The second task was to evaluate the cause of the chemiluminescence when hydrogen peroxide was added. And, the third task was to run assays to determine how water quality parameters affect the chemiluminescence response. This would include tests for optimum pH, optimum temperature, and dose-response tests for various environmental toxins. First, we achieved a chemiluminescent response with a bacterium catalase isolated from *Orfelia fultoni*. This was tested against other sources of catalase, such as potato and horse radish. It was determined the potato gave the most reliable chemiluminescent response. Next, the mechanism of the chemiluminescence was determined to be the

oxidation of organic ring structures (phenol) in the plant tissue by the oxygen radical. The experiment shifted to dose-response tests using metals and organic compounds. Dissolved cationic metals (Pb2+, Cu2+, Mg2+, Ag2+, Ni2+) had varying effects on the chemiluminescence. Lead had the most detrimental affect and iron 3+ had a positive affect, but Fe2+ had a negative affect. The optimum conditions were pH above 6 and below 9. Aliphatic organic compounds had no effect on the chemiluminescence.

RP51 Determination of phthalate metabolites in Korean children's urine by high-performance liquid chromatography with triple quadrupole tandem mass spectrometry. Y. Kho, School of Human & Environment, Eulji University, Seongnam, South Korea; P. Kim, J. Jeong, Dept. Occupational & Environmental Health, Yonsei University, Yonsei, South Korea; K. Choi, School of Public Health, Seoul National University, Seoul, South Korea; C. Park, Department of Air, Institute of Health & Environment, Seoul, South Korea. Dialkylated phthalates have been commonly used as plasticizers and a variety of applications. Phthalate diesters have been shown to be developmental and reproductive toxicants. Di-(2-ethylhexyl) phthalate (DEHP), diethyl phthalate (DEP) and dibutyl phthalate (DBP) are important because of their production and application. It is very difficult to exactly estimate the dose of dialkylated phthalates taken up by the general population because of environmental contamination. Urinary metabolites of phthalates enabled to estimate internal exposure. We employed LC/MS/MS with on-line enrichment and column-switching techniques for this biological monitoring. Metabolites determined were 4 primary metabolites; mono(2-ethylhexyl) phthalate (MEHP), mono(n-butyl)phthalate (MnBP), mono(iso-butyl) phthalate (MiBP), mono-ethylphthalate (MEP) and 2 secondary metabolites of DEHP; mono(2-ethyl-5-hydroxyhexyl)phthalate (5OH-MEHP), mono(2-ethyl-5-oxo-hexyl)phthalate (5oxo-MEHP). The limits of detection (LOD) were in the range of 5-50 ng/L, and actual limits of quantification (LOQ) were in the range of 10-100 ng/L. In all urine samples, six metabolites of phthalates were detectable. Study subjects (n = 38) were aged 3-5 yr children of several kindergartens in Chungcheong province, Korea. The subjects of this age were not occupationally exposed to phthalates. Concentrations were found to vary extremely as the compound and child. Median concentrations for metabolites of phthalates were 9.8 ng/mL for MEHP, 19.3 ng/mL for MnBP, 18.5 ng/mL for MiBP, 38.5 ng/mL for MEP, 49.3 ng/mL for 5OH-MEHP, 41.2 ng/mL for 5oxo-MEHP, respectively.

RP52 Comparison of Productivity Among Native, Restored and Pollutant-Impacted *Spartina alterniflora* Marshes in Galveston Bay, Texas. C.L. Gauthier, A. Mitchum, C.L. Howard, Environmental Science, University of Houston Clear Lake, Houston, TX. Coastal wetland habitats in the Galveston Bay estuary system provide many services, including nurseries for juvenile finfish and shellfish, bird sanctuaries, and storm buffers. Over twenty *Spartina alterniflora* marshes in this area have been created and/or restored over the past several years. The fundamental health of these salt marsh grass communities and how they tolerate or adapt to environmental and pollution stresses, is still largely unknown. As part of a larger study on biomarkers of stress in *S. alterniflora*, data on three ecological metrics (leaf dimensions, biomass, and stand density) and chlorophyll were evaluated at nine sites representing native, restored and pollutant-impacted coastal salt marshes in Galveston Bay. At each station, *S. alterniflora* shoots and roots were collected from 1/16m² plots for biomass determination, and ten individual plants were sampled for chlorophyll (SPAD 1500) and the other metrics. Leaf chlorophyll concentrations were significantly higher in plants from the restored and impacted marshes than in the native marshes. Chlorophyll exhibited significant, although moderate correlation with some of the sediment and/or shoot heavy metals. The impacted marshes contained longer and larger shoots than the other marshes. The stand density was highest among the native marshes. The results from this study indicate that the ultimate productivity was highest among the restored/created sites.

RP53 Biomarkers of Oxidative Stress in Leber's Hereditary Optic Neuropathy. S.J. Kroes, J.T. Eells, Health Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI; A. Berezovsky, S. Salomao, Ophthalmology, Sao Paulo Federal University, Sao Paulo, Brazil; F. Ross-Cisneros, A. Sadun, Ophthalmology, University of Southern California, Los Angeles, CA; V. Carelli, Neurological Sciences, University of Bologna, Bologna, Italy. Lebers hereditary optic neuropathy (LHON) is a mitochondrial genetic disease that causes permanent, bilateral loss of central vision. It has been associated with mitochondrial DNA (mtDNA) point mutations affecting the genes encoding subunits of complex I of the respiratory chain. Although, the primary

etiologic factor in LHON is a mutation in the mitochondrial genome, the presence of this mutation does not necessarily lead to central blindness. The optic neuropathy in LHON exhibits incomplete penetrance and additional environmental and genetic factors influence the onset of the disease. This study was conducted to test the hypothesis that biomarkers of oxidative stress and neuronal damage may be used as predictive indicators in determining the risk of blindness from LHON. Blood samples were collected from patients blinded by the 11778 mtDNA LHON mutation, asymptomatic maternal relatives and unrelated normal control subjects in Colatina, Brazil (Protocol approved by IRB at Sao Paulo Federal University and University of Wisconsin-Milwaukee). Plasma and leukocyte fractions were isolated from each sample. Oxidative damage to DNA and protein was assessed by measuring 8-hydroxy-2-deoxyguanosine (8-OHdG) and nitrotyrosine (NT), two widely used biomarkers of oxidative stress. Leukocyte DNA 8-OHdG concentrations were 3.2-fold and 2.8-fold greater in affected and carrier subjects, respectively than those measured in control subjects. Plasma NT concentrations were increased 5 fold in affected subjects and 2 fold in carrier subjects relative to control subjects. Both biomarkers of oxidative stress were significantly greater in subjects blinded by the 11778 LHON mutation than in unaffected carriers and controls. These data support our hypothesis that biomarkers of oxidative stress, neuronal damage and neuronal repair may be used as predictive indicators in determining the risk of blindness from LHON. (Supported by IFOND)

RP54 Attenuation of Oxidative Stress by 670 nm Photobiomodulation in a Rodent Model of Diabetes Mellitus. J. Lim, D. Henshel, School of Public and Environmental Affairs, Indiana University, Bloomington, IN; R. Sanders, J. Watkins, School of Medicine, Indiana University, Bloomington, IN; R. Wilson, A.C. Snyder, S. Gopalakrishnan, J.T. Eells, Health Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI. Chronic hyperglycemia causes oxidative stress in the kidney, liver and other tissues prone to complications in patients with diabetes. Diabetes has reached epidemic proportions in developed countries. In the United States, 16 million people are diabetic and the number is increasing at a rate of 5% per year. Photobiomodulation by light in the far-red to near-infrared range (630-1000 nm) has been shown to accelerate diabetic wound healing, improve recovery from ischemic injury in the heart and attenuate degeneration in the injured retina and optic nerve. The therapeutic effects of far-red light result, in part, from intracellular signaling mechanisms triggered by the interaction of the light with the mitochondrial photoacceptor molecule, cytochrome oxidase. The present studies were undertaken to test the hypothesis that 670 nm photobiomodulation would attenuate oxidative stress in the liver and kidney in a rodent model of type I diabetes, the streptozotocin-treated rat. Male Wistar rats were made diabetic with streptozotocin (50 mg/kg, ip), then exposed to 670 nm LED photobiomodulation at a dose of 6 J/cm² once per day for 18 days. Animals were euthanized on day 18 and muscle and organs were harvested and flash frozen. Liver and kidneys were assayed for markers of oxidative and energy stress, including glutathione reductase, glutathione peroxidase, superoxide dismutase, catalase, glutathione-S-transferase, and ATP. Enzyme activity and available ATP were significantly decreased in diabetic animals. Both antioxidant enzyme activities and ATP concentrations were normalized to control levels by 670 nm photobiomodulation in diabetic animals. The results of this study suggest that 670nm photobiomodulation augments mitochondrial function and stimulates antioxidant protective pathways in the diabetes-induced rat model. This non-invasive treatment may be of significant benefit in alleviating the complications of chronic diabetes and in other diseases that disrupt mitochondrial function and produce oxidative stress. (Supported by a grant from the Biomedical Technology Alliance).

RP55 Development of markers of exposure to copper, nonylphenol and atrazine in *Daphnia pulex* using subtractive hybridization. R. Flick, J. Lazorchak, National Exposure Research Laboratory, US EPA, Cincinnati, OH. *Daphnia* have been among the most commonly used test organisms for aquatic toxicity studies due to their sensitivity to contaminants. This sensitivity makes them excellent candidates for development as sentinels to monitor the occurrence of chemicals in the environment. The sequencing of the *Daphnia pulex* genome provides an opportunity to develop gene expression assays as indicators of exposure to sublethal concentrations of environmental stressors. In order to gauge the utility of such assays, we have produced subtraction libraries from *Daphnia* exposed to three chemicals that are commonly found in the environment: copper, nonylphenol and atrazine. For each of these three subtractions at least 480 clones from the forward subtraction and 480 clones

from the reverse subtraction were selected for differential screening by reverse northern analyses. Based on the results of these analyses, 50 to 85 clones from each subtraction were identified as differentially expressed. Clones that exhibited the greatest differences in spot intensity were chosen for sequencing. The resulting sequences were compared to the *Daphnia pulex* genome database using the BLAST algorithm. A small number of candidate genes were identified for further analysis. We are in the process of generating quantitative real time PCR primers from these sequences, which we will use to verify differential expression in an independent set of exposed and control *Daphnia*. The development of a suite of these gene expression markers will enable us to use deployed *Daphnia* to diagnose the presence of contaminants in aquatic environments.

RP56 Integrating Oxygen Flux And Genomics Into The Development Of Real-Time Biomarkers Of Fish Egg Contaminant Exposure. B. Sanchez, M.S. Sepúlveda, Forestry and Natural Resources, Purdue University, West Lafayette, IN; H.G. Ochoa-Acuña, M.S. Sepúlveda, Civil Engineering, Purdue University, West Lafayette, IN; H.G. Ochoa-Acuña, Veterinary Pathobiology, Purdue University, West Lafayette, IN; D.M. Porterfield, Agricultural and Biological Engineering, Purdue University, West Lafayette, IN; D.M. Porterfield, Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN; J. Adamec, M.D. Kane, Bindley Bioscience Center, Purdue University, West Lafayette, IN. The detection of harmful chemical and biological agents in real-time is a critical need for protecting freshwater ecosystems. Currently, there are few practical and sensitive enough techniques available to identify immediate physiological effects in representative aquatic organisms. We studied the real-time effects of five environmental contaminants with differing modes of action (malathion, cadmium chloride, atrazine, pentachlorophenol or PCP, and potassium cyanide) on the oxygen flux of 2-day post fertilization fathead minnow (*Pimephales promelas*) eggs. Our objectives were twofold. First, we wanted to see whether our technique is sensitive enough to detect instantaneous changes after brief (i.e. minutes) exposures to low concentrations of contaminants. Second, we aimed at determining if there is a correlation between these responses and physiological modifications realized through changes in gene expression. Oxygen flux data indicated that the technique is indeed sensitive enough to reliably detect physiological alterations induced by four of the five contaminants. After 60 minutes of exposure, we identified significant increases in oxygen flux upon exposure to PCP (1000 and 100 µg/L) and cadmium chloride (0.002 and 0.0002 µg/L). We saw a significant decrease in oxygen flux after exposure to potassium cyanide (44 and 66 µg/L) and mixed and no effect after exposure to atrazine (1500 and 150 µg/L) and malathion (340 and 200 µg/L), respectively. Data on gene expression profiles of 2-day post-fertilization eggs exposed to the same chemicals at concentrations and times similar to those mentioned above were also collected. We have generated a "developmental" microarray consisting of three different, non-overlapping oligo-probes for over 400 genes specific to larval fathead minnows. Our work establishes this technique for the detection of real-time physiological changes as a sensitive and reliable tool ripe for development and eventual application.

RP57 Modeling relations between and among contaminant concentrations and biological endpoints in freshwater fish. J. Hinck, C. Schmitt, D. Tillitt, USGS-CERC, Columbia, MO. The Biomonitoring of Environmental Status and Trends (BEST) Program of the U.S. Geological Survey has one of the largest chemical and biological datasets for freshwater fish in the U.S. The Program has assessed chemical contaminants and biological endpoints in piscivorous (n = 1608) and benthivorous (n = 1909) fish from nine U.S. river basins from 1995 to 2004. Black bass (*Micropterus* spp.) and common carp (*Cyprinus carpio*) were the primary target species because of their widespread distribution and the abundant contaminant, health indicator, and reproductive biomarker data available. Contaminant concentrations (31 organochlorine residues, 16 elemental contaminants, and 2,3,7,8-tetrachlorodibenzo-p-dioxin-like activity) were measured in whole-body composite samples (by site, gender, and species). Biological endpoints including length, weight, age, hepatic ethoxyresorufin O-deethylase (EROD) activity, condition factor, somatic indices (hepatosomatic and splenosomatic index) macrophage aggregate (MA) parameters (MA density, MA size, percent tissue occupied by MAs), health assessment index, and reproductive biomarkers (gonadosomatic index, plasma vitellogenin, 17b-estradiol, 11-ketotestosterone, and oocyte atresia) were measured in individual fish. Our objectives were 1) to determine the distribution functions of contaminant concentrations and biological endpoints and 2) to examine correlations and

relationships between and among contaminant concentrations and biological endpoints. Distribution functions were described using summary statistics and cumulative frequency distribution. We achieved the later objective by using stepwise multiple linear regression and principal component analysis. Statistically significant relationships explained up to 81% of the variation in the models.

RP58 Screening study for repeated dose and reproductive and developmental toxicity of the nitrophenolic herbicide dinoseb in rats. M. Ema, M. Matsumoto, National Institute of Health Sciences, Tokyo, Japan; T. Furuhashi, Nihon Bioresearch Inc., Hashima, Japan; C. Poncipe, SafePharm Laboratories Ltd., Derby, United Kingdom. Dinoseb, 2-sec-butyl-4,6-dinitrophenol, was approved for sale as a herbicide in the US in 1948. The US EPA banned dinoseb from use as a pesticide in 1986 based on the potential risk of birth defects and other adverse effects in humans. However, dinoseb is a high volume chemical with production or importation exceeding 1,000 tons per year in OECD member countries and still widely used. Dinoseb and dinoseb salts are banned in Japan but consented to import. The volume of dinoseb imported into Japan is 110 tons in 2005-2006. Although many studies had been conducted for reproductive and developmental toxicity of dinoseb, these reports could be determined to be inadequate for the hazard assessment of dinoseb. Therefore, a combined repeated dose toxicity study with reproduction and developmental toxicity screening test (OECD Test Guideline 422) was performed under GLP condition in order to obtain reliable data on the toxicity. Rats were given once daily by gavage with dinoseb at 0, 0.78, 2.33 or 7.0 mg per kg. Males were dosed for a total of 42 days beginning 14 days before mating. Females were dosed for a total of 44-48 days beginning 14 days before mating to day 6 of lactation throughout mating and gestation. No deaths were observed in males. At 7.0 mg per kg, eight females died and two females were moribund during late pregnancy, and a significant decrease in body weight gain was found in both sexes. Hematocrit was significantly increased at 0.78 mg per kg and higher in males. Reduction in extramedullary hematopoiesis in the spleen was significant at 2.33 mg per kg in females. A significant decrease in sperm motility and increase in the rates of abnormal sperm, abnormal tail and abnormal head were noted at 7.0 mg per kg. Only two females delivered their pups at 7.0 mg per kg, and the gestation index was significantly lowered. Based on these findings, the LOAEL for males and NOAEL for females were considered to be 0.78 mg per kg per day, and the NOAEL for reproductive and developmental toxicity was considered to be 2.33 mg per kg per day. This study was supported by the Ministry of Health, Labour Welfare, Japan.

RP59 Environmental contaminants and congenital heart defects: fish as environmental integrators. D. Arndt, R. Klaper, Great Lakes WATER Institute, UW-Milwaukee, Milwaukee, WI; K. Hanson-Morris, A. Pelech, Children's Hospital-Cardiology, Medical College of Wisconsin, Milwaukee, WI; S. Corsi, USGS, Middleton, WI. Congenital heart defects are some of the most common birth defects of humans and are thought to be involved in 10% or more of early miscarriages. Factors that have been suspected to contribute to heart defects include exposure of the mother to environmental contaminants such as heavy metals, PCB's, and TCE. An initial study by the Wisconsin Pediatric Cardiac Registry (WPCR) group at the Medical College of Wisconsin has found a greater than expected number of children born with cardiac defects in several counties surrounding the Fox River watershed in Wisconsin. This river system is an Area of Concern by the Environmental Protection Agency. Rivers and lakes integrate the activities of the land within a watershed. Studying these water systems and the freshwater organisms found in the watershed provides an indication of the cumulative environmental factors that may be affecting human populations that also reside in the watershed. Fish are particularly useful as model organisms for toxicological models as they are sensitive to some of the same contaminants as humans and are models for vertebrate development and physiology. Conservation of cardiac genes across vertebrates allows for comparisons between fish and humans. We have used fathead minnows to study the impact on environmental contaminants on cardiac defects and function. Our aims are to: 1) examine the potential links between exposure to environmental contaminants and congenital cardiac defects 2) develop genomic indicators of physiological alterations in cardiac function that occur in relation to contaminant exposures. Pairs of fathead minnows were placed in cages within watersheds that have been identified as hotspots for human cardiac defects. Fatheads were allowed to mate and reproduce and eggs were collected daily. Cardiac defects were measured in addition to changes in gene expression in cardiac tissues. We

found significant defects in fish that were similar to those found in human embryos. Incidence of defect and association with contaminants and genomic markers will be discussed.

RP60 Cell Cycle Analysis of Atrazine-Treated Human Cells Using Flow Cytometry. K.R. Dhanwada, A.L. Austin, Biology, University of Northern Iowa, Cedar Falls, IA; S. Musah, Environmental Programs, University of Northern Iowa, Cedar Falls, IA. Atrazine is one of the most commonly used herbicides in the United States. Many studies have shown an association between herbicide exposure to increased levels of DNA damage, reproductive and endocrine problems as well as a higher risk for certain cancers. Previous work from our lab showed a decrease in cell proliferation after low-level atrazine exposure (0.8-100 ppb) in normal human fibroblasts with no increase in apoptosis or necrosis. The objective of the current study was to determine a mechanism for the decrease in cell number. Flow cytometric analysis was used to see if atrazine-treated cells progressed through the cell cycle differently than control cells thus resulting in fewer cells after herbicide exposure. We exposed synchronized and unsynchronized normal human fibroblasts to increasing concentrations of atrazine (0-300 ppb) for 24 and 48 hours. Flow cytometric analysis was performed on control vs. treated cells. Results suggest a G1 block in unsynchronized and synchronized atrazine-treated cells after a 24 and 48-hour exposure. However, the block may be dependent on the concentration of atrazine used. The percentage of apoptotic cells was low, supporting previous growth study results.

RP61 Effects of TNT or RDX Freshly Amended or Weathered-and-Aged in Different Soils to *Folsomia candida*. C.T. Phillips, R.T. Checkai, R.G. Kuperman, M. Simini, J.E. Kolakowski, C.W. Kurnas, Environmental Toxicology, US Army RDECOM, ECBC, Aberdeen Proving Ground, MD. We investigated the toxicity of 2,4,6-trinitrotoluene (TNT) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) to the soil invertebrate *Folsomia candida* in five soils with varying characteristics: Teller sandy loam (TSL), Sassafras sandy loam (SSL), Kirkland clay loam, (KCL), Webster clay loam (WCL), and Richfield clay loam (RCL). The qualitative "relative bioavailability scores" for these two organic explosives in natural soils were considered "very high" for TSL and SSL; "medium" for KCL and WCL; and "low" for RCL soil; according to the Ecological Soil Screening Level (Eco-SSL) criteria (USEPA 2005). Studies were performed separately and independently using TNT or RDX, either freshly amended, or weathered-and-aged in soil to more closely approximate the exposure effects on soil biota in the field. The production of juveniles by *F. candida* was assessed using replicated multiple treatment concentrations and appropriate controls, TNT or RDX concentrations in soils determined using USEPA Method 8330A, and data analyzed using nonlinear regression models. Provisional EC₂₀:EC₅₀ toxicity values [mg/kg] for freshly amended TNT, based on production of juveniles in these soils, were: 7:17 (TSL), 17:25 (SSL), 20:38 (KCL), 170:260 (WCL), 4:23 (RCL); and for freshly amended RDX: 20:50 (TSL), 30:90 (SSL), 30:110 (KCL), 40:140 (WCL), 70:400 (RCL). Provisional EC₂₀:EC₅₀ values [mg/kg] for TNT weathered-and-aged in these soils were: 20:27 (TSL), 50:61 (SSL), 0.5:3 (KCL), 20:50 (WCL), 40:90 (RCL); and for RDX weathered-and-aged in these soils: 20:90 (TSL), 110:800 (SSL), 40:130 (KCL), 40:60 (WCL), 7:12 (RCL). Weathering-and-aging of TNT in all soils significantly altered TNT toxicity based on the EC₅₀ values and corresponding 95% confidence intervals for the production of juveniles, compared with the toxicity in freshly amended soils; and significantly altered toxicity of TNT in these soils (except TSL) based on EC₂₀ values. Toxicity of RDX was significantly altered by weathering-and-aging only in the SSL and RCL soils and only on the basis of EC₅₀ values. Correlation analyses of test data showed relatively weak relationships overall among the soil properties and toxicity endpoints for TNT or RDX.

RP62 Acute and Chronic Effects of Different Classes of Nanoparticles to Freshwater, Marine, and Soil Dwelling Organisms. S. Chan-Remillard, S. Goudey, HydroQual Laboratories Ltd., Calgary, Alberta, Canada; L. Kapustka, Golder Associates Ltd, Calgary, Alberta, Canada. The rapidly developing nanotechnology industry promises to spawn many exciting products in the field of medicine, manufacturing, and various environmental fields such as bio-control agents. What are the environmental risks associated with the development, commercialization, and ultimate disposal of these different nanotechnologies and associated waste products? There are roughly 7 to 10 broad classes of nanoparticles from carbon based materials to metals and polymers. We have subjected one representative nanoparticle from each class to a series of routine freshwater, marine and soil toxicity tests. The freshwater and marine tests were done with species representative of each major trophic level

(bacteria, plant, invertebrate and fish). The soil tests were done on one plant and invertebrate species. The objective was to determine if acute and chronic effects were obtained at environmentally realistic concentrations. The results will also be discussed within a risk based, life cycle assessment framework.

RP63 Acute exposure to stearate-coated titanium dioxide nanoparticles has minimal effect on gene expression in fathead minnows (*Pimephales promelas*). B.J. Carter, J.B. Rogers, EcoArray, Inc., Alachua, FL; D.E. Tillitt, Columbia Environmental Research Center, US Geological Survey, Columbia, MO; D. Rejeski, Woodrow Wilson International Center for Scholars, Washington, DC; D.J. Caldwell, Johnson & Johnson Worldwide Environment, Health & Safety, New Brunswick, NJ. Evaluation of the potential for exposure and adverse effects of nanoparticles on fish and wildlife has been extremely limited. The concerns regarding the release of nanomaterials into the environment and their potential effects on fish and wildlife have begun to be addressed only recently through toxicological testing. This project utilized state-of-the-art oligonucleotide microarrays to examine gene expression patterns in male fathead minnows (*Pimephales promelas*) exposed to one of the common nanomaterials, titanium dioxide (MT-100TV[®] stearate-coated particles, TiO₂). Adult male fathead minnows were exposed for 96 hr to five doses (0-10 mg/L nominal) of TiO₂ under static renewal conditions. Measured concentrations of TiO₂ were 0.09 in the control group and 0.15, 0.48, 0.67, 1.00, and 1.11 mg/L in treatment groups. Treatment concentrations correspond to 150, 96, 67, 50, and 11% of the nominal doses, respectively. Mortality and histology of the gills were evaluated. No dose-related mortality was observed in any of the treatment groups and histology of the gills was unaffected by the treatment. Additionally, gene expression analysis was conducted on gill, liver and brain tissues of selected fish (control, 1, and 10 mg TiO₂/L). We measured gene expression with a 22K feature fathead minnow microarray following standard protocols. The data were normalized and examined for significance using standard software. Gene expression profiles were not significantly changed by exposure to TiO₂ in any tissue or at any of these treatments of TiO₂ when the analysis was performed with the recommended multiple testing corrections (MTC). However, when the criterion for inclusion was reduced (no MTC was applied), there were several genes in each organ that responded to the TiO₂. It is possible that some of the genes represent biomarkers for TiO₂. Our study indicates that surface treatment of TiO₂ nanoparticles can severely alter the toxicological properties of the particles.

RP64 Assessment of Health Risks Associated with Exposure to Polychlorinated Biphenyls (PCBs) for Consumers of Fish in Ontario, Canada. H. Wei, A. Li, S. Erdal, School of Public Health, University of Illinois at Chicago, Chicago, IL. Although large scale production of polychlorinated biphenyls (PCBs) was banned in the United States in 1977, PCB releases into the environment continue to occur due to PCBs' existence in electrical transformers and capacitors that are still in use and their continuous releases to land and water bodies. PCBs are linked to a variety of adverse health effects and classified by USEPA as probable human carcinogens. PCB concentration can be high in fish due to bioaccumulation. Thus, consumption of PCB-contaminated fish is a human health concern. In this study, we used the USEPA model to estimate the average daily intake of PCBs via adult and child consumption of fish in Ontario Province of Canada from 1996 to 2004. We also estimated hazard index (HI) as a benchmark for adverse health effects other than cancer and excess cancer risk (ECR). Conventional USEPA and toxic equivalency (TEQ) approaches were used in estimation of health risks and compared, the latter of which treated dioxin-like and non-dioxin-like PCBs separately. The HI estimates for children and adults were 26 and 17, respectively. Total ECR estimates were 9.0×10^{-5} for children and 3.0×10^{-4} for adults when USEPA-recommended Cancer Slope Factor for PCBs is used. However, when TEQ values were used, these estimates were 3.3×10^{-4} for children and 1.1×10^{-3} for adults. The results from the TEQ-based approach demonstrated that the majority of total ECR was attributable to dioxin-like PCBs, and about half of the contribution was from the most toxic congener, PCB-126. The application of TEQs to the total ECR calculation yielded a more conservative estimate. In this study, we highlight strengths and limitation of conventional USEPA approach and TEQ approach to PCB ECR analysis. In addition, we propose fish consumption advisories to protect local consumers of fish in Ontario, Canada from potential adverse health effects due to consumption of PCB-contaminated fish.

RP65 Sun Light enhances Toxicity of Fullerene (C60) to Freshwater Invertebrates *Daphnia magna* and *Moina macrocopa*. K. Ji, J. Kim, H.

Jung, K. Choi, Seoul National University, Seoul, South Korea. Manufactured nanomaterials (NMs) have been extensively used for various purposes. Concerns about the potential ecotoxicological effects of NMs are increasing in part because they have different chemical characteristics from their larger counterparts. Fullerene is one of the compounds that are of special interest because of their potential ecological impact. Stable colloidal suspensions of fullerene aggregates in water (aqu/nC60) were created by extended mixing method for 2 wk. We evaluated toxicity of fullerene aqueous suspensions filtered through 0.2 μ m and 0.45 μ m filters using two freshwater macroinvertebrates, i.e., *Daphnia magna* and an indigenous water flea species in Korea, *Moina macrocopa*. We also investigated whether fullerene phototoxicity would be affected by environmental level of ultraviolet (UV) lights, i.e., exposure to 4 hr/d sunlight. Changes in catalase activity were determined in *D. magna* juveniles after being exposed to sublethal levels of aqu/nC60 and environmental level of UV lights. *M. macrocopa* exhibited greater sensitivity toward aqu/nC60 compared to *D. magna*. Greater toxicities were observed with aqu/nC60 filtered through 0.2 μ m filter, and under sun light on both species. Antioxidant enzyme activities were increased by co-exposure to aqu/nC60 and to sun light. The results of this study show that exposure to fullerene leads to oxidative damage to *D. magna* and it is aggravated by natural sun light. Further assessment for sublethal effects of fullerene under environmentally relevant conditions may be needed.

RP66 Interactions and Effects of Titanium Dioxide Nanoparticles in Planktonic and Biofilm *Pseudomonas putida*. A. Horst, P.A. Holden, Mechanical Engineering, UCSB, Goleta, CA; A. Horst, P.A. Holden, Donald Bren School of Environmental Science and Management, UCSB, Santa Barbara, CA. The introduction of synthetic nanoparticles into the environment as a result of manufacturing processes and consumer waste is of concern due, in part, to potential adverse effects on soil microorganisms. Titanium dioxide nanoparticles (nano-TiO₂) are widely produced and are already found in a range of mainstream products. When released into the environment, these nanoparticles will interact with microbes in virtually every environmental niche. However, little is known about these interactions and how nano-TiO₂ may affect bacterial processes. A better understanding of these interactions could offer insight into both potential toxicity and fate of nano-TiO₂ in the environment. This research presents initial findings on the toxicity of nano-TiO₂ to planktonic and biofilm *Pseudomonas putida*, an environmentally widespread and metabolically versatile bacteria. Toxicity of nano-TiO₂ in both light and dark conditions is studied by quantifying bacterial growth characteristics (lag time, growth rate, and cell yield) over a range of nanoparticle concentrations and primary particle sizes. In initial planktonic studies, a decrease in growth rate and cell yield was observed in dark conditions. This is in contrast to previous research using non-nanoscale TiO₂ in which particles were found to be biologically inert in the absence of UV light. This data suggests that nanoparticle characteristics (i.e. size, surface area, etc.) may cause them to have different toxicity mechanisms than larger (>100nm) TiO₂ particles. Environmental scanning electron microscopy (ESEM) is used to observe effects of nano-TiO₂ on cell morphology as well as metal association with cells and surrounding EPS. Understanding nanoparticle-bacterial interactions will be essential in predicting and potentially alleviating adverse environmental effects of nanoparticulate contamination.

RP67 Spectroscopic Speciation of Water-Soluble Quantum Dot Nanoparticles : Their Photostability and Cytotoxic Mechanisms on Microorganisms. C. Park, D. Kim, J. Kim, T. Yoon, Dept. of Chemistry, Hanyang University, Seoul, South Korea. Engineered nanomaterials typically have unique physicochemical properties attributable to their small sizes and are already being extensively used in many areas of application, such as cosmetics, electronics and medicine. However, these novel properties of engineered nanomaterials also raise concerns about their adverse effects on environmental and biological systems. Therefore, for further advancements in nanotechnologies and related industries, strong attention to the safety issues of engineered nanomaterials and science-based approach to solve these concerns are prerequisite. Of particular importances, chemical speciations of water-soluble engineered nanomaterials within the biological system and their interactions at the cellular or subcellular level may have important roles related to their bioavailability and cytotoxic mechanisms. In this presentation, we will present our recent spectroscopic (ATR-FTIR, Raman and XANES) speciation study on the photostability changes and related chemical speciation of quantum dot nanoparticles (i.e., CdSe/ZnSe/ZnS and etc.) under the exposure of UV light and their cytotoxic mechanisms on a simplest biological system,

(i.e., microorganisms : E. coli as a gram negative bacteria and B. Sublitis as a gram positive bacteria).

RP68 Partitioning and Toxicity of Nanotubes Relative to Carbon Reference Material in the Aquatic Environment. A.J. Kennedy, J.A. Steevens, K.M. Dontsova, C.A. Weiss, US Army Engineer Research and Development Center, Vicksburg, MS; M.S. Hull, Luna Innovations, Blacksburg, VA. Nanotubes (NTs) are purported to have endless potential to enhance materials science, with applications spawning from their unique properties (e.g., conductivity, strength). Potential Army applications include enhanced weaponry, armor, obscurants and next generation sensing. If NTs meet a fraction of their projected applications, the environmental implications must be understood to promote green engineering and proper management. Before conducting biological exposures, it is important to (1) determine how to characterize NT in complex environmental media, (2) understand partitioning between media, (3) discriminate agglomeration, fate and toxicity between different NT modifications and (4) properly spike laboratory media with NT. In addition to raw NTs, commercially-relevant surface modifications of NT should be tested. In this study, multi-walled nanotubes (MWNT) were used rather than single-walled tubes due their lower propensity to agglomerate, lower cost and greater production. We investigated the behavior (e.g., agglomeration, partitioning) of raw and modified MWNT suspensions (e.g., hydroxylated, carboxylated, surfactant dispersed) in conditions and media relevant to aquatic bioassays. In laboratory reconstituted waters, MWNTs agglomerated and settled more rapidly than reference particles (e.g., carbon black, activated carbon), suggesting relevance for sediment bioassays. Colloidal stability of MWNT suspensions was influenced less by salinity than reference particles. However, other controlling factors such as functionality and dispersion media (e.g., surfactants, organic matter) were critical in determining stability, and thus water column exposure potential; these findings warrant further investigation. Since our preliminary findings and the known properties (i.e., hydrophobicity, van der Waals attractions) of raw MWNT suggest sediment as a repository, sediment bioassays (*Leptocheirus plumulosus*) were conducted to compare the toxicity of raw MWNTs to a size gradient of reference particles. Our findings suggest MWNT and reference particles are toxic to *L. plumulosus* at high concentrations (g/L range); enhanced mass-standardized dosimetry must be investigated to advance the science of nanoeotoxicology by integrating NT-specific variables (e.g., aspect ratio, surface area, particle size, morphology).

RP69 Aqueous and Sediment Toxicity of C60 Nanoparticles to Several Freshwater Species. D. Huggert, University of North Texas, Denton, TX; A.J. Kennedy, J.A. Steevens, US Army Engineer Research and Development Center, Vicksburg, MS. Carbon and metal based nanoparticles are receiving considerable attention for their applicability to enhance consumer and health related industries. However, less attention has been given to the ecological consequences of these particles if released in the environment; very few published studies provide concrete toxicity reference values for nanoparticles making risk estimates and informed regulation impossible. In an attempt to better understand the environmental fate and potential ecotoxicity associated with carbon-based nanoparticles in the freshwater, *Hyalella azteca*, *Tubifex tubifex* and *Daphnia magna* were exposed to fullerene (C60) nanoparticles. The C60 particles were pre-dispersed into aqueous solution by magnetic stirring for at least 21 days. These suspensions were used in three different exposure scenarios: (1) aqueous-only, (2) sediment-only and (3) aqueous to sediment partitioning bioassays. Aqueous exposures used C60 suspensions that were allowed to stabilize based on UV-vis photospectrometry while sediment exposures involved C60 agglomerates spiked into the overlying water and allowed to settle over the duration of the bioassay. Preliminary data indicate that the aqueous 48hr EC50 for *H.azteca* is > 2 mg/L. Based on these experiments, it is hypothesized that dispersed agglomerates of C60 nanoparticles resulting from this preparation method will partition to some extent to sediments within a typical 7-day exposure period under static conditions. Data will be presented highlighting the partitioning of C60 nanoparticles from water to sediment, with the associated *H.azteca* and *T. tubifex* toxicity data.

RP70 Quantitative Analysis of Fullerenes by LC-ESI/MS and its Application to Zebrafish Developmental Toxicity Assays. C.W. Isaacson, J.A. Field, Chemistry, Oregon State University, Corvallis, OR; C.Y. Usenko, R. Tanguay, J.A. Field, Environmental Toxicology and Chemistry, Oregon State University, Corvallis, OR. With increasing production and use of nanomaterials, there is increasing interest in better understanding the impact

of nanomaterials on human and environmental health. Toxicology and the fate and transport studies of nanomaterials are hindered by the lack of readily-available, quantitative analytical methods for nanomaterials. A quantitative analytical method based on liquid chromatography/electrospray ionization mass spectrometry (LC-ESI-MS) was developed for members (C60 – C98) of the fullerene class of nanomaterials. The method utilizes the stable-isotope, ¹³C60, as an internal standard. To validate the method for the analysis of C60 in aqueous exposure solutions and zebrafish embryo homogenates, spike and recovery experiments were performed. The validated method was then applied during the course of toxicological assays based on embryonic zebrafish as model organisms. The actual exposure concentration of C60 and the uptake of C60 by the zebrafish embryos were determined over time. The accuracy of the method for exposure solutions and zebrafish embryos, as indicated by average C60 recovery, was 90% and 93% recovery, respectively. Precision, as indicated by relative standard deviation, was 2% and 7%, respectively. The method limit of detection and limit of quantitation were 20 ng/L and 40 ng/L, respectively, for both exposure water and embryo homogenate. Over the course of a 12 hrs exposure study, concentrations of C60 decreased to 40% of the initial concentrations. Loss from solution was due to sorption to the styrene divinylbenzene plates. The uptake of C60 by embryonic zebrafish increased with concentration and time and comprised less than 1% of the C60 in the exposure solution. A lethal concentration resulting in 50% mortality, LC50, was determined to be $130 \pm 6 \mu\text{g/L}$ and corresponded to a lethal dose of $0.1 \pm 0.09 \mu\text{g C60/g embryonic zebrafish}$. A partition coefficient of $0.47 \pm 0.35 \text{ mL/g}$ was calculated from the exposure concentration (in 1% DMSO in water) and zebrafish embryo concentration. The method presented herein is uniquely suited for quantifying fullerenes in aqueous exposure solutions and in biological homogenates. Therefore, it can be used to address the basic analytical needs of the toxicological and risk assessment communities.

RP71 Influential Relationships of Industrial Metal Oxide Nanoparticles and Pseudomonas aeruginosa. A.C. Neal, J.H. Priester, P.A. Holden, Bren School of Environmental Science, UCSB, Santa Barbara, CA; W.H. Suh, G.D. Stucky, 2Department of Chemistry and Biochemistry, UCSB, Santa Barbara, CA; R.E. Mielke, Center for Life Detection, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA. Many everyday items from facial cosmetics to batteries incorporate nanostructured materials. Here lies the importance of understanding the environmental impact of nanoparticulate waste. Sub-100 nm nanoparticles can have unique chemical, electronic, magnetic, and physical properties due to their size and high surface area. In addition to these characteristics, nanoparticles can have diverse surface chemistry and physics which can lead to various types of aggregate formation. These new physicochemical properties allow metal oxide nanoparticles to have novel interactions with biological organisms and have substantial impact on their biological processes. *Pseudomonas aeruginosa* is a gram negative bacterium that is an opportunistic human pathogen and important to biodegradation. *P. aeruginosa* can survive in many different environmental conditions and habitats that can range from soil, marshes, coastal marine habitats, mammals and plants, as well as on surfaces of rocks and soil in the form of biofilms. In recent years, rates of infection by *P. aeruginosa* have increased due to the organism's resistance to many antibiotics and lack of competition with other bacteria. The diversity, vigor, and virulence of *P. aeruginosa* make it a likely candidate to come in contact with bioavailable metal oxide nanomaterials and have an impact on human and environmental health. Here, we characterized the complex reactions of four metal oxide nanoparticles; lithium titanate, titanium dioxide (anatase), lanthanum oxide carbonate, and yttrium zirconate (crystallite size less than 100 nm) supplied by industry incubated with planktonic and biofilm cultures of *P. aeruginosa*. Size, morphology, and crystallite analyses were done by TEM, SEM, and XRD. Several areas of biological activity were studied; impact of growth in dark and light conditions, ESEM visual characterization of physical interaction with particles, and indicators of virulence. We have found novel correlations between; *P.aeruginosa* and metal oxide nanoparticle aggregate formations and metal oxide nanoparticle and virulence factors of *P.aeruginosa*. These studies may have an impact on metal oxide nanoparticle waste management and handling protocols.

RP72 Investigating the fate and effects of nanoparticles. H.E. David, J. Roberts, D. Gore, S. Marshall, SEAC, Unilever, Bedford, Bedfordshire, United Kingdom; K. Tiede, A. Boxall, EcoChemistry, Central Sciences Laboratory, York, Yorkshire, United Kingdom. Nanoparticles can be defined as a particle with one or more dimension at the nanoscale, between 1 and

100nm. There are many potential commercial applications of nanoparticles, including health and environmental benefits. However, there is also a need to understand the fate and persistence of nanoparticles in environment, and their potential ecotoxicity. Hence a number of commercially available nanoparticles have been tested using standard algal and *Daphnia* OECD studies. Results from a chronic *daphnia* study with nano-TiO₂ will also be analysed and data investigating whether nano-TiO₂ dispersion is causing an indirect effect due to light attenuation on the growth of the single-celled algae, *Pseudokirchneriella subcapitata*. In addition, the potential fate of the nanoparticles has been investigated using sludge adsorption studies. The results of these studies will be presented and discussed.

RP74 The Effects of Mixtures of Single-Walled Carbon Nanotubes and Copper on *Daphnia magna*. K.T. Kim, S.D. Kim, Dept. Environmental Science and Engineering, Gwangju Institute of Science and Technology (GIST), Gwangju, South Korea; S.J. Klaine, Dept. Biological Science, Clemson university, Clemson, SC; P.C. Ke, Dept. Physics and Astronomy, Clemson university, Clemson, SC. Since the discovery of single-walled carbon nanotubes (SWNTs), their unique physical, chemical, mechanical, thermal, electrical properties lead them to be one of the most importantly noted carbon-based nanomaterials. But, the intrinsic hydrophobicity of SWNTs is an obstacle for biological applications and even for nanotoxicology. Recently, SWNTs suspensions have been stabilized with lysophosphatidylcholine (LPC) facilitating their use in aqueous applications. Further, this would enable researchers to assess the aquatic toxicity of nano-sized SWNTs and to elucidate the fate of them in the environment. The aim of this study was to investigate the potential of these stabilized SWNT suspensions to interact with other aquatic contaminants and influence their bioavailability. We exposed *Daphnia magna* to mixtures of copper concentrations (5, 10, 20 µg/L) and LPC-stabilized SWNTs concentrations (0.5 and 1.0 mg/L). The tests were conducted for 96 h in static renewal system. We changed test solutions and recorded mortality of *D. magna* daily. The mean mortality of *D. magna* exposed to copper and SWNTs mixtures was significantly greater than when exposed to only copper solution over all test duration (96 h) ($p < 0.05$). Treated *D. magna* were analyzed for copper burden to determine if the SWNT enhanced copper uptake. This study implies that if nanomaterials are released into environment as nano-scaled particles, they may increase the bioavailability of pollutants pre-existed in the environment.

RP75 Microbial toxicity of nanosized copper oxide. Y. An, Y. Baek, Department of Environmental Science, Konkuk University, Seoul, South Korea; H. Yoon, Department of Environmental Science, Konkuk University, Seoul, South Korea. There are increasing concerns about unintentional environmental impact of nanosized materials with particle size from a few nm to 100 nm. Metal oxide nanoparticles are widely used in industrial and commercial applications, and also served many functions in polymers. We have studied the microbial toxicity of nanosized copper oxide (CuO) for gram-negative bacteria (*Escherichia coli* DH5α) in laboratory experiments. *E. coli* culture was prepared at 37°C overnight using Luria-Bertani (LB) broth. The copper oxide nanoparticles were well dispersed in a culture medium and the *E. coli* was grown on solid agar plates with different concentrations of CuO nanoparticles. The number of bacteria was determined by colony forming units (CFU) counting. The CFU was reduced in a CuO-containing culture medium, and dose-response relationship was found. Our results indicate that a nanosized CuO released into environment may have adverse effects to even beneficial microorganisms.

RP76 Studies for Cytotoxicity of Titanium Dioxide as Manufactured Nanomaterial into the Cultivated Cell Lines. H. Tokunaga, T. Uchino, Y. Ikarashi, T. Nishimura, Division of Environmental Chemistry, National Institute of Health Sciences, Tokyo, Japan. Manufactured nanomaterials have dramatically increased in recent years in commercial and industrial applications worldwide due to the unique physical and chemical properties imparted by their small size. In order to establish the in vitro risk assessment of titanium dioxide, the cellular toxicity were examined using two kinds of titanium dioxides at the average particle size of 20 nm (LU 175) and 250 nm (LU 205) and the presence of titanium dioxide into the cellular membrane, cytosol and mitochondria were checked using 6 kinds of monolayer cell lines (CHO cells, NHEK cells, RBL-2H3 cells, A431 cells and NHEK cells). After putting 5×10³ cells/0.1 ml of suspension of each cells into the 96-well microplate, the cells were incubated for several days at 37 degree Celsius in CO₂ incubator. Suspensions of 0.1 ml ranged from 0.01 % to 1.0 % of LU 175 and LU 205 were inserted onto the microplate. After 24 hours, the microplate

was washed with 0.2 ml of PBS and then the cell viabilities were measured at 490 nm by the microplate reader. Put 1 ml of suspensions including 5×10⁴ cells/1 ml of each cells into 60-mm dish and then incubate for several days at 37 degree Celsius in CO₂ incubator. Add 1 ml of suspension at 0.2 % of LU 175 or LU 205 and stand for 24 hours. After rinsing the dish with 5 ml of PBS due to elimination of deposited titanium dioxide on the cell wall, treat the dish with the trypsin solution. After making the suspension of cells, transfer it to the centrifuging tube and centrifuge for 5 minutes at 1400 rpm. After ultra-sonicating the cells into 1.5 ml of PBS to break the cell wall, the tube was centrifuged for 60 minutes at 9,000 g and sequentially 100,000 g for getting the cellular membrane, mitochondria and cytosol fractions. After digesting their fractions with the microwave oven using the concentrated nitric acid, dilute the reaction mixture with water and determine the titanium ion by ICP/MS. Cytotoxicities of LU 175 differed between 6 kinds of cell lines but those of LU 205 were small against the cell lines. The amounts of LU 175 were larger than that of LU 205 in cytosol and mitochondria fractions.

RP77 Acute Toxicity of Metal Oxide Nanoparticles (ZnO, TiO₂, Fe₂O₃, and CuO) in *Xenopus laevis*. S. Nations, M. Wages, G.P. Cobb, Environmental Toxicology, Texas Tech University The Institute of Environmental and Human Health, Lubbock, TX; C. Theodorakis, Biology, Southern Illinois University Edwardsville, Edwardsville, IL; X. Xu, E. Carraway, Environmental Engineering and Science, Clemson University, Anderson, SC. The nanotechnology industry is growing and offering possibilities of many advances in electrical engineering, chemistry, material science, and medicine. Toxicological testing is necessary because the size of nanoparticles may introduce new toxicological issues for compounds that may be relatively inert at larger sizes. Metal oxide nanoparticle toxicity was evaluated using the standardized FETAX assay. Preliminary tests used metal oxide concentrations that ranged from 1µg/L to 1000mg/L at log dose intervals, and a control (0mg/L). *Xenopus laevis* embryos were exposed to nanoparticles for 96 h and then euthanized. Mortality was not significant for any of the nanoparticles. Initial results for ZnO and CuO suggest a hormetic trend in growth at doses below 1mg/L. Malformation were observed in ZnO exposures above 10mg/L.

RP78 In Vitro Toxicity Analysis of Nano Sized Aluminum: Particle Size and Shape Effects. M. Palazuelos, Center for Bio-Nano Sensors, University of Florida, Gainesville, FL; M. Palazuelos, K.W. Powers, B.M. Moudgil, Particle Engineering Research Center, University of Florida, Gainesville, FL. Nanostructured materials promise to revolutionize many key areas of science and technology. As our ability to manipulate matter at the nanoscale increases, there is a need to assess the effects of these materials on human health and the environment. These unique properties that make nanomaterials interesting and useful can make toxicological profiles very different from those of the same materials on a different scale. Toxicity analysis of nanomaterials should start from a thorough physicochemical characterization in order to establish a proper correlation between the nanoparticles characteristics and their effects and behavior in physiological environments. This research is a clear example of the necessity of comprehensive studies when investigating the toxicity of nanomaterials. Aluminum nanoparticles are being extensively used for their very unique energetic properties. These materials offer a very promising market that is fostering many startup companies which are expected to consolidate on strong technological positions. Aluminum is generally recognized as a non-toxic material to humans and it is widely used for applications which imply direct human contact. The effect of aluminum nanoparticles in human health is still an unknown. This research consisted of an in vitro toxicity screening of aluminum materials from nano to micron size, including spherical irregularly shaped particles. Several issues relating to size, shape, detection and characterization of nanoparticles in the different environments relevant to in vitro toxicity analysis were addressed and suitable protocols were developed. Lung human epithelial cells were exposed to different concentrations of these materials and the effects were analyzed by means of various toxicity tests. Some of the materials investigated caused elevated in vitro toxicity. Cells endocytosed the particles and a clear correlation between the particle size, shape and the effects observed was established. The hypothesized toxicity mechanism was explored using different analytical techniques. The detected toxicity of aluminum nanoparticles was demonstrated to be a direct effect of their reactivity inside the cells.

RP79 Toxicity of silver nanoparticles to *Daphnia magna*. C. Impellitteri, J. Allen, U.S. EPA, Cincinnati, OH; D. Macke, L. Heckman, Shaw E&I, Cincinnati, OH. Investigation of the toxicity of metallic ions

has a long history. Also, the effect of organic and other materials on metal toxicity is well established. Relatively little is known regarding toxicity of metallic nanoparticles in the environment. Presented here are the results of *Daphnia magna* bioassays describing the toxicity of organically coated silver nanoparticles (<100nm) and the effect of organic additions. Experiments were performed using standard EPA test methodologies (48Hr static and 96Hr static-renewal) with and without the addition of organic material (algae, cerophyll, and algae+cerophyll). Organically coated silver nanoparticles were obtained from commercial sources. Stock suspensions were sonicated and filtered through 100nm filters. Stock suspension were digested via microwave digester (EPA Method 3015) and analyzed by inductively coupled argon plasma-optical emission spectroscopy (ICP) or graphite furnace-atomic absorption spectroscopy (GFAA). A stock suspension was diluted (with stirring) to create working suspensions and transferred to digestion vessels/organism exposure vessels. It is crucial to tightly control and repeat dilution and transfer techniques from experiment to experiment. A clear effect on LC50 concentration was observed: $11 \pm 5 \mu\text{g/L}$ without food addition (48Hr), $40 \pm 8 \mu\text{g/L}$ with food addition (96Hr). These values are similar to *D. magna* LC50 values found in the literature for ionic silver. These results suggest that toxicity of organically-coated silver nanoparticles is in the same range as their metallic ions.

RP80 Surface Chemistry of Quantum Dots Affects Their Developmental Toxicity in Zebrafish. T.C. King Heiden, P. Wicinski, J.A. Pedersen, W. Heideman, R.E. Peterson, Molecular and Environmental Toxicology Center, UW-Madison, Madison, WI; T.C. King Heiden, D. Nesbit, W. Heideman, R.E. Peterson, School of Pharmacy, UW-Madison, Madison, WI; A. Mangham, R.J. Hamers, Chemistry, UW-Madison, Madison, WI; K.M. Metz, J.A. Pedersen, Environmental Toxicology and Technology Program, UW-Madison, Madison, WI. Quantum Dots (QDs) have received national attention due to their prospective applications in the biomedical and life sciences. Their unique optical properties make them ideal fluorophores for use in biomedical imaging, and their superior electrical properties show great potential for use in the electronics industry. While QDs promise to significantly benefit society, most QDs are heavy metal chalcogenides (e.g., CdSe, PbS), raising concern about the potential risk to human health, wildlife, and the environment. Little information currently exists regarding the effect of alterations in surface chemistry on the toxicity of QDs in whole animal models. We used embryonic zebrafish to assess the developmental toxicity of waterborne QDs, and the physiochemical properties influencing their toxicity. Embryos were exposed to poly-L-lysine wrapped CdSe quantum dots with and without a ZnS shell, as well as CdSe/ZnS core-shell QDs functionalized with polyethylene glycol of two molecular weights (PEG350 and PEG5000) and different terminal groups (PEG5000-OCH₃, -COOH and -NH₃). We demonstrate that the ZnS shell protects embryos from Cd-like sublethal toxicity, and that the wrapping polymer contributes to their overt toxicity. Observed sublethal toxicity correlated with increased expression of metallothionein, supporting the hypothesis that QD toxicity results in part from exposure to Cd²⁺. We are using fluorescent microscopy to visualize QD uptake, and measuring Cd levels in larvae to assess QD bioavailability following waterborne exposure. While the stability of QD suspensions did not appear to be altered under our experimental conditions, the physiochemical properties of the different capping groups appear to influence their overall stability in aquatic environments. Our work illustrates the utility of the zebrafish embryo as a medium-throughput and low-cost, whole-animal vertebrate model to screen nanomaterials for developmental toxicity. Results from this assay can be used to extrapolate adverse effects to other vertebrates, including humans. (Supported by NSF and NIEHS).

RP81 The Cytotoxicity and Genotoxicity of Silver Nanoparticles in Sperm Whale Cells. S.S. Wise, H. Xie, J.P. Wise, J.P. Wise, Wise Laboratory of Environmental and Genetic Toxicology, University of Southern Maine, Portland, ME; S.S. Wise, H. Xie, J.P. Wise, J.P. Wise, Maine Center for Toxicology and Environmental Health, University of Southern Maine, Portland, ME; M.D. Mason, G. Craig, The Department of Chemical and Biological Engineering, Institute for Molecular Biophysics, University of Maine, Orono, ME; R. Payne, I.A. Kerr, Ocean Alliance, Lincoln, MA. In recent years nanoparticles have shown great promise with a broad range of applications, one of the current applications is due to the antimicrobial effects of silver. Silver nanoparticles are currently in wide use in consumer products. However, while silver nanoparticles have a powerful ability to kill bacteria and viruses their effects on mammalian cells remains unclear. These products are

already on the market thus environmental exposure is inevitable. To address this issue we investigated the cytotoxicity of 15 nm silver nanoparticles in cells derived from sperm whale skin. We found that silver nanoparticles induced a concentration-dependent cytotoxicity at relatively low concentrations. At 0.3, 0.5, 3 and 5 $\mu\text{g/cm}^2$, there was 85, 82, 5, and 0 percent relative survival in sperm whale skin cells respectively. There was no induction of chromosome damage in the cell lines. However an increase in the incidence of aneuploid cells was observed. Aneuploidy is an indication of aberrant cellular division and a precursor to chromosome instability which can lead to tumorigenesis. Further work will characterize the development and progression of aneuploid cells and determine if transformation of cells due to silver nanoparticle exposure is possible.

RP82 Methods for the Prediction of Nanoparticle Fate and Transport in Gaseous and Aqueous Environments. C. Mackay, AMEC, Portland, ME; K. Sellers, AMEC, Westford, MA. The development and applications of nanomaterials have presented a unique problem to environmental scientists and risk assessors. Until now, the models and paradigms used to predict the behavior of chemicals in the environment and thereby the potential for exposure and effect have been firmly rooted in the principals of solution chemistry such as molarity, partition, fugacity, etc. However, to evaluate and predict the behavior of nanomaterials in the environment, new considerations that take into account conditions of surface chemistry need to be added to the standard model. These include environmental and material properties such as buoyancy, surface area, viscosity, charge accumulation, steric factors, and Hakman forces. Recently, we presented a method for predicting the mass transport and stability of nanomaterials in the environment using competitive probability kinetics. Furthering on this research, this work looks at predictive methods of determining the probability of reaction (P) given projected rates of interaction. This is placed in the context of likely modes of receptor exposure. With consideration of bioavailability and toxicological potency and efficacy, this will permit the direct risk evaluation of potential environmental impacts within the paradigm currently in use.

RP83 Predicting the Potential for Nanomaterials and Macromolecules to Bioaccumulate in Ecological Receptors. C. Mackay, K. Reinert, AMEC, Portland, ME. Compounds with high lipophilicity possess the potential to bioaccumulate in environmental organisms. This is usually modeled as a passive process whereby the equilibrium for a given compound predicts high concentrations in lipid environments relative to the concentration in the aqueous environment. While this model holds for small molecules that are able to easily cross membranes and achieve rapid equilibrium, larger molecules and nanoparticles face a rate-limiting condition related to the probability that a particle will cross a lipid bilayer and thereby be capable of achieving equilibrium. Conceptually, the energy gradient for bioaccumulation is the initial disequilibrium. However, in order for a substance to enter a bilayer, there must be a gap in the membrane sufficient to accommodate it. Such gaps require free energy and contrary to the partition gradient, the larger the gap, the less likely it is to occur. Using quantitative structure activity relations (QSARs), a probability model was developed that predicts the rate of passage of a molecule or particle relative to its size and lipophilicity based on the probability of a sufficient gap manifesting in the lipid bilayer. This model was then applied to predict the time necessary for the concentration of a particle in the endogenous lipid environment to exceed that in the aqueous phase. By comparing this rate to either the duration of exposure or the lifetime of the organism, it is possible to determine the size-dependent potential for the substance to bioaccumulate. Studies indicate that even highly lipophilic molecules with sizes greater than 1,000 daltons show little potential to bioaccumulate. Smaller molecules potential vary with lipophilicity. This approach permits for rapid screening of compounds and reduces the need for expensive bioaccumulation studies.

RP84 Pharmacokinetic Approach to Developing Occupational Exposure Guidelines for Single and Multiwall Carbon Nanotubes. C. Mackay, J. Hamblin, AMEC, Portland, ME. Nanotubes are becoming a more common feedstock in the manufacture of a host of products. The current occupational standard in the United States is based on synthetic graphite with a permissible exposure limit of 5 mg/m³. Recent installation studies show that exposure to high concentrations of single-walled carbon nanotubes resulted in the manifestation of acute fibrosis and associated granulomas. In our investigation, the potential risk for an adverse impact based on inhalation of single and multiwall carbon nanotubes is assessed using currently available animal studies. Unlike the current standard, this risk assessment

was standardized on fiber exposure rates rather than on a mass standard. The model consisted of two subcomponents. The first modeled the behavior of the carbon nanotubes in the ambient air in order to characterize the time-course changes in the distribution of fiber size and structure. This subcomponent was used as the exposure term for a combined computational fluid dynamics and pharmacokinetic simulations to develop an exposure rate that would result in a minimal inflammation response. Discussion includes evaluation of the appropriateness of the current information base and how the model can be modified and applied as more data on the toxicology of carbon nanotubes become available.

RP85 Genotoxic effects of engineered nanoparticles and the effect of sorption to nanoparticles on estrogenic activity of commonly detected EDCs. L. Moffatt, S. Pacheco, R. Putnam, K. Arcaro, Veterinary and Animal Sciences, University of Massachusetts, Amherst, MA; B. Xing, Plant, Soil, and Insect Sciences, University of Massachusetts, Amherst, MA. Nanoparticles are defined as inorganic materials and biopolymers that are between 1nm and 100nm in size. Engineered nanoparticles are being used in commercial products, manufacturing and other industries. With widespread use, nanomaterials are being released into the aquatic environment, thus leading to the potential exposure of humans and wildlife. Currently, little is known about the non-target effects of environmental nanoparticles. However, studies suggest that nanoparticles may not be entirely benign and rather, they may trigger harmful human and animal health effects. This is mainly because they can readily travel throughout the body, deposit in target organs, and penetrate cell membranes, all while potentially transporting other compounds that readily sorb to them. In this work, the effects of two types of nanoparticles (colloidal silica and C60 fullerenes) were examined on DNA damage in the human breast cancer cell line, MCF-7. Stable aqueous suspensions of nanoparticles were prepared and their genotoxicity was evaluated using the single-cell gel electrophoresis assay (Comet assay). The Comet assay demonstrated genotoxicity for both types of suspensions. The mean Olive tail moments (OTM) for the C60 fullerene suspensions (.70 mg/L and 1.36 mg/L) were 6.17 and 8.23, respectively, which in comparison to the negative control OTM of 1.23 are statistically significant ($p < 0.05$). The mean OTM for the colloidal silica suspensions (4 mg/L and 40 mg/L) were 4.87 and 5.26, respectively, which in comparison to the negative control OTM 1.23 are statistically significant ($p < 0.05$). Treatment with each of the suspensions resulted in a level of DNA damage similar to that caused by 1 μ M benzo-a-pyrene (B[a]P). Work is underway to determine if a third type of nanoparticles (multi-walled nanotubes, MWNTs), which allow commonly detected estrogenic pollutants (endosulfan, 17 α -ethynyl estradiol, and 4-tert-octylphenol) to sorb onto them, can affect the estrogenic activity of these known contaminants. The stably transfected human cell line, MVLN is being used for cell-based ER reporter assays in this evaluation of MWNTs loaded with estrogenic contaminants.

RP86 The immunomodulatory effects of nanosilica upon in vitro exposure. C. Perkins, Center for Environmental Sciences and Engineering, University of Connecticut, Storrs, CT; C. Perkins, M. Levin, S. De Guise, Department of Pathobiology and Veterinary Science, University of Connecticut, Storrs, CT. There is limited research to date related to the toxicity, fate, and exposure of engineered nanomaterials (NMs) on human and ecosystem health, therefore there is a recognized need to examine systemic effects as well as exposure pathways. However, the available data have shown that it is difficult to extrapolate toxic effects of nanomaterials from existing data on similarly composed particles of a much larger size and mass. Experimental data and the physico-chemical properties of nanomaterials and their resulting translocation to target organs such as blood and lymph nodes, lend credibility to the theory that the immune system will also be a sensitive receptor to nanomaterials. Preliminary results in our lab have demonstrated the potential to use routine functional immune assays to assess the immunotoxicity of NMs. Exposure of U-937, a human monocyte cell line, to silica particles (40nm) resulted in a statistically significant 21% increase (1 ppm) and statistically significant 38% decrease (100 ppm) in phagocytosis upon in vitro exposure. Coating the same particles with norbornene, an aliphatic compound, resulted in a statistically significant 26% decrease in phagocytosis only at the highest dose (100 ppm). We are in the process of conducting a more detailed assessment to determine if immunotoxicity can be predicted by the physico-chemical properties of nanosilica, including size, surface area, and coatings. Since many NM appear to promote a pro-inflammatory response, we are investigating the ability of immune cells to

secrete common pro-inflammatory cytokines (IL-1 β , TNF- α , IL-6 and IL-8) upon in vitro exposure, in addition to effects on immune function such as phagocytosis, respiratory burst, and cell viability. Overall, the preliminary results suggest that nanosilica has immunotoxic potential, which is influenced by surface coating. The preliminary and ongoing analysis will likely provide data to help assess if the immunotoxicity of NM at the cell level can be predicted from their physico-chemical structure, which, combined with dosimetry at the cellular level, can provide a new approach for risk assessment.

RP87 The Effects of Functionalized and Non-Functionalized Carbon Nanotubes on Root Elongation of Selected Crop Species. M.K. Long, S. Nations, R. Vadan, J. Cañas, The Institute of Environmental and Human Health Department of Environmental Toxicology, Texas Tech University, Lubbock, TX; D. Olszyk, H. Lee, US EPA, National Health and Environmental Effects Research Laboratory, Western Ecology Division, Corvallis, OR; R. Ambikapathi, Greater Research Opportunities Fellow, US EPA, Western Ecology Division, Corvallis, OR; M. Luo, L. Dai, Department of Chemical Engineering, Texas Tech University, Lubbock, TX. Single-walled carbon nanotubes (SWNT) have many potential beneficial uses with additional applications constantly being investigated. However, these unique properties create a potential cause for concern of toxicity, not only in humans and animals, but also in plants. Root elongation, a process that takes place during the beginning phases of germination, has been examined to determine if exposure to functionalized and non-functionalized single walled carbon nanotubes inhibits this process. The effects of SWNTs were examined in six crop species routinely used in phytotoxicity testing. Crop seeds were exposed to varying concentrations of functionalized (p-aminobenzenesulfonic acid added to provide solubility in water) and non-functionalized SWNTs. Inhibition of root elongation was observed in seeds exposed to functionalized nanotubes at the two highest concentrations tested, but the toxicity may be due to the p-aminobenzenesulfonic acid group used to functionalize the nanotubes. Comparisons between functionalized and non-functionalized nanotubes will be discussed.

RP88 Molecular mechanisms of SWCNT-induced toxicity in lung epithelial cells. T. Sabo-Attwood, M. Ariza, E. Beckman, Environmental Health Sciences, University of South Carolina, Columbia, SC; P. Ferguson, Chemistry and Biochemistry, University of South Carolina, Columbia, SC; M. Ramos-Nino, Environmental Pathology, University of Vermont, Burlington, VT. Occupational exposure to airborne contaminants such as particulate matter and asbestos are associated with various types of lung injury and disease including, asthma, bronchitis, and cancer, among others. However, assessment of the potential negative health impacts of nanoparticles have been relatively unexplored. Few studies have investigated the cellular and molecular mechanisms responsible for toxic effects observed in the lung caused by exposure to single walled carbon nanotubes (SWCNT). Synthesis of "as prepared" SWCNT results in the production of intact SWCNT and smaller fractions of nanohorns and fluorescent byproduct material. We chose to observe the toxic effects of SWCNT on pulmonary epithelial cells as they are initial targets of inhaled particles. To assess the toxicity of various fractions, human lung epithelial cells were exposed to various doses (.0021 ng/ul – 210 ng/ul) of "purified" SWCNT, nanohorns, and fluorescent material for 24 hours. Cell viability studies (MTT) revealed that only the "purified" SWCNT had a toxic effect on the lung cells at all of the doses tested, reducing cell viability up to 70% compared to unexposed cells. To assess the possible molecular mechanisms responsible for this observed toxicity we exposed human small airway epithelial cells to 2 doses of purified SWCNT and determined changes in gene expression using Affymetrix microarrays. Initial analysis of the expression profiles revealed multiple gene targets and pathways that are potentially involved in SWCNT-mediated toxicity in lung cells. Further experiments regarding the control and functionality of these genes may shed light on the molecular and physiological events relevant to particle-induced lung disease. Understanding mechanisms of nanoparticle initiated toxicity will offer clues to the potential acute and chronic health effects of these emerging contaminants.

RP89 Studies for Cytotoxicity of Titanium Dioxide as Manufactured Nanomaterial into the Cultivated Cell Lines. H. Tokunaga, T. Uchino, Y. Ikarashi, T. Nishimura, Division of Environmental Chemistry, National Institute of Health Sciences, Tokyo, Japan. Manufactured nanoterials have dramatically increased in recent years in commercial and industrial applications worldwide due to the unique physical and chemical properties imparted by their small size. In order to establish the in vitro risk assessment

of titanium dioxide, the cellular toxicity were examined using two kinds of titanium dioxides at the average particle size of 20 nm (LU 175) and 250 nm (LU 205) and the presence of titanium dioxide into the cellular membrane, cytosol and mitochondria were checked using 6 kinds of monolayer cell lines (CHO cells, NHEK cells, RBL-2H3 cells, A431 cells and N9H5 cells). After putting 5×10^3 cells per 0.1 ml of suspension of each cells into the 96-well microplate, the cells were incubated for several days at 37 degree Celsius in CO₂ incubator. Suspensions of 0.1 ml ranged from 0.01 % to 1.0 % of LU 175 and LU 205 were inserted onto the microplate. After 24 hours, the microplate was washed with 0.2 ml of PBS and then the cell viabilities were measured at 490 nm by the microplate reader. Put 1 ml of suspensions including 5×10^4 cells per 1 ml of each cells into 60-mm dish and then incubate for several days at 37 degree Celsius in CO₂ incubator. Add 1 ml of suspension at 0.2 % of LU 175 or LU 205 and stand for 24 hours. After rinsing the dish with 5 ml of PBS due to elimination of deposited titanium dioxide on the cell wall, treat the dish with the trypsin solution. After making the suspension of cells, transfer it to the centrifuging tube and centrifuge for 5 minutes at 1400 rpm. After ultra-sonicating the cells into 1.5 ml of PBS to break the cell wall, the tube was centrifuged for 60 minutes at 9,000 g and sequentially 100,000 g for getting the cellular membrane, mitochondria and cytosol fractions. After digesting their fractions with the microwave oven using the concentrated nitric acid, dilute the reaction mixture with water and determine the titanium ion by ICP-MS. Cytotoxicities of LU 175 differed between 6 kinds of cell lines but those of LU 205 were small against the cell lines. The amounts of LU 175 were larger than that of LU 205 in cytosol and mitochondria fractions.

RP90 Effect of Synthesis Methods on Metal Oxide Nanoparticles Properties. X. Xu, C. Elizabeth R., Environmental Engineering and Science, Clemson University, Anderson, SC; C. Elizabeth R., Clemson Institute of Environmental Toxicology, Clemson University, Pendleton, SC. Four types of metal oxide nanoparticles (iron oxide (hematite, α -Fe₂O₃), copper oxide (CuO), titanium dioxide (TiO₂), and zinc oxide (ZnO)) have been prepared and characterized for use in acute and developmental toxicity tests on fathead minnows (*Pimephales promelas*) and African clawed frogs (*Xenopus laevis*) in collaboration with researchers at Texas Tech University and Southern Illinois University at Edwardsville. One aspect of nanoparticle characteristics that can lead to ambiguous toxicity test results is the formation of agglomerates of nanosized particles of varying size and stability. Therefore, synthesis method variations were investigated for effects on particle characteristics and stability. The general synthetic approach is the sol-gel method, however, a solid state pyrolytic method was also used for ZnO. Nanoparticle size and morphology changed with temperature, mixing conditions, calcination conditions, precursors, ionic strength, and reaction medium. Nanoparticle purity was determined using acid digestion and AA or ICP. X-ray diffraction (XRD) measurements provided particle crystal structure and confirmation of particle purity results. UV-visible absorption was used as a measure of particle formation, size, and extent of agglomerate formation or disruption. Particle and agglomerate size distributions were measured using laser light scattering. Electron microscopy (SEM and TEM) was used to obtain images of particles and agglomerates. The average particle size were about 20-35 nm for Fe₂O₃; 20-40 nm for CuO; 10-20 nm for TiO₂; and 10-20nm for ZnO; agglomerates were 100 nm or more in diameter. The primary particles were spherical or rod-like in shape. Agglomeration effects were often extensive. In particular, the medium composition in the ZnO sol-gel synthesis had significant influence on the extent of agglomeration. The agglomerates formed by ZnO, CuO and TiO₂ appeared to be random combinations of primary particles, but Fe₂O₃ formed web-like structures. In future work, the agglomeration behavior of the nanoparticles under conditions of toxicity tests and various environmental conditions will be investigated.

RP91 Stability of Aqueous Suspensions of raw Fullerenes (C60): What are the Relevant Exposure Scenarios? A.J. Kennedy, J.A. Stevens, C.A. Weiss, Jr., US Army Engineer Research and Development Center, Vicksburg, MS; M.S. Hull, Luna Innovations, Blacksburg, VA; J.G. Coleman, SpecPro, Inc., Vicksburg, MS. As nanotechnology advances to product development for commercial and military applications (e.g., targeted medical delivery, circuitry, electromagnetic interference shielding), gaining proactive knowledge of nanoparticle behavior, fate and toxicology becomes important. Ecotoxicologists face a steep learning curve related to quantification techniques, dosimetry and presumably unique fate, transport and biological uptake mechanisms; divergent paths of investigation are necessary to discover the most effective methods to study nanoparticle risk. In the emerging field of

nanotoxicology, where the most fundamental questions remain unanswered (e.g., nomenclature, dosimetry, assay procedures), fullerenes (e.g., C60) provide researchers with one of the better understood models for investigating the ecotoxicological effects of manufactured nanomaterials. Although inherently hydrophobic, researchers have applied different dispersion techniques (e.g., solvents, sonication, magnetic stirring) to force C60 into aqueous suspension. Thus, there is obvious need for standard material preparation methods relevant to the environments simulated by laboratory bioassays. Prior to exposing test species, basic information regarding C60 behavior in different environmental media needs investigation to determine the appropriate exposure scenarios (pelagic, epibenthic, infaunal) and corresponding bioassays. One of these questions relates to the colloidal stability of C60 suspensions across gradients of salinity (0-20 ‰), pH (4-10) and organic matter (0 – 100 mg C/L) relevant to different aquatic environments. Preliminary results indicate the stability of pre-dispersed C60 is inversely related to salinity but directly proportional to organic matter concentrations; pH had less influence. These parameters similarly influenced dispersibility of dry C60 powder stirred into solution. Information gained from raw C60 suspension stability, better quantified as zeta potential, in this study will facilitate informed bioassay selection. Further investigation is needed to determine how C60 with commercially relevant surface modifications influence behavior and toxicity in environmental media.

RP92 Comparison of several novel techniques for potential high-throughput in nano-toxicology. H. Yoon, Environmental Materials Research Team, Korea Basic Science Institute, Seoul, South Korea; T. Ko, School of Materials Science & Engineering, Dept. of Ceramic Engineering, Inha University, Incheon, South Korea; Y. An, Department of Environmental Science, Konkuk University, Seoul, South Korea. Nanoparticles are discrete nanometer scale and because of the importance of size-dependent behavior changes in natural medium its properties in many environmental materials have been studied in detail especially for their specific property changes in biological systems. Not only naturally occurring but also manufactured engineered nanoparticles exist in a variety of complex forms. A single crystal with sizes from a few nm up to 100nm often changes their characteristic physical behaviors in living biota through toxic exposure. Microscopic investigations with high resolution techniques such as HR-TEM, Bio-TEM reveals sub-micron sized structures down to nanometer level including agglomeration, dissolution and deformation of original crystals. In this study, the aspects of engineered nanoparticles physical behavior that give rise to specific micro-interaction in living cells are considered. As an initial research, we were focusing on developing electron microscopic technique to detect nanomaterials in biological samples. Research on the absorption of nanomaterials was also proceeded along with to study the availability of the existing in vitro experimental system in order to clarify nanoparticles fate in biota as well as establishing more suitable approaches for nanoscale material characterization, detection, and toxicity evaluations that may emerge with time and experience.

RP93 Toxicity of two major N-nitroso metabolites of RDX. B. Zhang, T.A. Anderson, TIEHH, Texas Tech University, Lubbock, TX; B. Zhang, Department of Biology, East Carolina University, Greenville, NC. A variety of energetic materials are produced and used by the DoD. These explosives can contaminate the environment at munitions testing grounds and at production facilities. While there are many reports describing the effects of the parent compounds, few studies have been concerned with the metabolites of the parent materials. In the environment, RDX can be degraded to metabolites such as TNX and MNX. Although several studies have demonstrated that RDX is toxic to a number of organisms, including humans, the toxicity of MNX and TNX is not known. Acute toxicity and bioavailability of MNX and TNX to *Eisenia fetida* was evaluated. Results indicated that both MNX and TNX had lethal and sublethal effects on earthworms. Exposure to MNX- or TNX-contaminated soil caused a significant concentration-dependent decrease in survival, growth and reproductive success of earthworms. Earthworms were more sensitive to TNX than to MNX. MNX and TNX were more toxic in sandy loam soil than in silt loam soil. The Lowest Observed Lethal Concentration (LOLC) for both MNX and TNX was 100 mg/kg in the sandy loam soil, and 200 mg/kg in the silt loam soil. At 7 days of exposure, the Lowest Observed Effect Concentration (LOEC) for earthworm growth was 50 mg/kg for TNX and 100 mg/kg for MNX in both soil types. MNX and TNX also significantly inhibited earthworm cocoon production and hatching. The LOEC for cocoon production and hatching were 50 mg/kg for both MNX and TNX in sandy loam soil, with cocoon production at about

50% of control values. The LOECs for cocoon hatching were 1 and 10 mg/kg for MNX and TNX in soil, and 10 mg/L in the topical test. At concentrations higher than 100 mg/kg, cocoon hatching was completely inhibited except for 100 mg/kg MNX at which only one of 54 cocoons hatched. Our results suggest that MNX was slightly more toxic than TNX. In sandy loam soil, the EC20 values for MNX were 8.7 and 8.8 mg/kg for cocoon production and juvenile production; for TNX, they were 9.2 and 9.1 mg/kg, respectively. The EC20 values were much lower for cocoon hatching: 3.1 and 4.7 mg/kg for MNX and TNX in sandy loam soil and 4.5 and 3.1 mg/L in topical test. MNX and TNX also caused oxidative stress in earthworm.

RP94 The Chemical Spill Infiltration Potential (C-SIP) Model for Assessing Large Volume Releases. L.E. Barber, J.L. Tunkel, Environmental Science Center, Syracuse Research Corporation, North Syracuse, NY; T.E. Miller, R.M. Garrett, Armed Forces Medical Intelligence Center, Washington, DC. Determining the potential for the contamination of groundwater by industrial chemicals is an important component of assessing potential human health risks. Existing methods for determining the groundwater intrusion potential after a large volume release were found to be either too complex, require data that were not readily available, or were not designed to characterize the complete breadth of structural diversity present in industrial chemicals. As a result, a low resource categorization technique was developed to aid analysts in the rapid identification of industrial materials with the potential to contaminate groundwater after a catastrophic release. These efforts resulted in the development of the Chemical Spill Infiltration Potential (C-SIP) model, a semi-quantitative, kinematic technique that utilizes a variation of Darcy's Law to determine the likelihood that a chemical will migrate to various subsurface depths within a given time period. The C-SIP output provides a three-tiered classification (low, moderate, or high) based on the inherent physical characteristics of the chemical as well as simplified hydrologic equations. Drop-down menus facilitate data entry into the model and a simple, customizable, computerized interface displays the migration potential for multiple scenarios in a format designed to allow direct comparison of the results. The interface allows the user to customize the model scenarios based on geographical location and chemical spill conditions. C-SIP utilizes generic data drawn from an associated database that encompasses the global spectrum of hydrologic and climatologic characteristics and is thus applicable to highly diverse chemicals at a wide range of site conditions. With minimal data requirements, the C-SIP model provides a rapid characterization of a chemical with regard to its subsurface fate.

RP95 Use of Microarrays to Study the Influence of Estrogen and the Mechanisms of Female-Specific Hepatocarcinogens in the Mouse Liver. M.H. Feld, N.R. Drinkwater, School of Medicine and Public Health, McArdle Laboratory for Cancer Research, University of Wisconsin, Madison, WI. Males are much more susceptible than females to hepatocellular carcinoma development. The mouse has been a useful model for understanding these differences. Intact females have reduced tumor multiplicity compared to ovariectomized females. Estrogen has been suggested to be responsible for this protection against liver tumor development. The purpose of these studies is to understand how estrogen influences hepatic gene expression in the C57BL/6J mouse. We are also interested in the role of estrogen receptor- α and estrogen receptor- β in regulating hepatic gene transcription. We have found that estrogen receptor- α , but not - β , is critical in protection against DEN-initiated hepatocarcinogenesis. Since female mice are known to be less susceptible than male mice to development of liver tumors, it was surprising when the National Toxicology Program found that, out of 112 hepatocarcinogens tested, 21 were more hepatocarcinogenic in females than males, and 34 were active in females only. A second set of studies, that we have conducted, look at the effects of the female-specific hepatocarcinogens, safrole, fumonisin B1, and 5,5-diphenylhydantoin, in regulating hepatic gene expression. Humans are exposed to safrole by consumption of spices, such as sassafras, sweet basil and cinnamon. Fumonisin B1 is a mycotoxin and humans are mainly exposed by consumption of contaminated corn products. 5,5-diphenylhydantoin is used clinically as an antiepileptic drug and is known to be teratogenic and associated with lymphoma. Our studies use a toxicogenomics approach to examine the mechanisms of these female-specific hepatocarcinogens in the C57BL/6J mouse model. It is hypothesized that the estrogen-dependent protective pathways will be disrupted by female-specific hepatocarcinogen treatment.

RP96 Exposure to hormonally active substances and prostate carcinogenesis. C. Filiatrault, J. Gomes, Health Science Program, University

of Ottawa, Ottawa, Ontario, Canada. Hormonal etiology of prostate cancer has been suggested as one of the etiological pathways of the cancer of the prostate. Prostate gland is dependent on natural hormones for its functioning; however, hormone mimics could significantly alter the health of the prostate gland. Environmental and occupational exposures to a number of agents with diverse properties have been proposed inconclusively as risk factors. The purpose of this study is to systematically review the literature for environmental and occupational exposures and risk of prostate cancer in aging men. We reviewed Ovid, Scopus, Medline, Toxline, Cancerlit and Embase databases for the period 1980 to 2007 using keywords such as environmental / occupational exposures, risk factors and prostate cancer / prostatitis / prostate hyperplasia / prostate intraepithelial neoplasia. A total of 4840 articles were retrieved after removing the duplicates. All these articles were manually reviewed for relevancy to the research question and 148 articles, original research and review studies, were retained for review. A list of all exposures was identified and the exposures were categorized into agents that exhibit hormonal activity and agents without hormonal activity. Hormonally active agents were further categorized into the following groups: a) general anthropogenic chemicals (dioxins, furans, petroleum products, etc.), b) biocides and derivatives (phenoxy herbicides, triazine, carbamates, etc.) and c) inorganic and organo-metallic complexes (cadmium, copper, zinc, etc.). Non-hormonal agents which increased the risk for prostate cancer included fertilizers, mineral spirits, cobalt and nickel. Environmental and occupational exposures to agents such as organochlorines, polychlorinated biphenyls, polycyclic aromatic hydrocarbons and pyrethroids significantly increased the risk to prostate cancer in aging men. Exposures to certain types of pesticides, combustion products, paints and varnishes, organic and inorganic dusts, metal dusts and pharmaceutical drugs used in agriculture also increased the risk or prostate cancer. The risk is reported to be higher in men with family history or prostate or female breast cancer, certain ethnic origins and advanced age. Exposures in high risk men further increased the risk. It is plausible that most of these agents being hormonally active act through a hormonal pathway to influence the carcinogenesis of the prostate.

RP97 Contamination status of arsenic in groundwater and humans in the Red River and the Mekong River Deltas, Vietnam. T. Agusa, T. Minh, N. Ha, H. Iwata, S. Tanabe, Center for Marine Environmental Studies (CMES), Ehime University, Matsuyama, Japan; T. Kunito, Department of Environmental Sciences, Faculty of Science, Shinshu University, Matsumoto, Japan; S. Inoue, Japan Food Hygiene Association, Tokyo, Japan; T. Minh, P. Trang, P. Viet, Center for Environmental Technology and Sustainable Development (CETASD), Hanoi National University, Hanoi, Viet Nam; N. Tu, Faculty of Agriculture, Ehime University, Matsuyama, Japan; B. Tuyen, Nong Lam University, Hochiminh, Viet Nam. This study summarized our previous studies on arsenic contamination in groundwater and residents from the Red River and the Mekong River Deltas in Vietnam. The investigation and sample (groundwater, human hair and urine) collection were conducted in Gia Lam, Ha Nam, Ha Tay and Than Tri Provinces of the Red River Delta and An Giang, Ben Tre, Can Tho, Dong Thap, Hochiminh, Long An, Soc Trang, Tien Giang and Vinh Long Provinces of the Mekong River Delta during 2001 - 2004. Arsenic concentrations in groundwater were from <0.1 to 486 $\mu\text{g/L}$. Relatively high levels of arsenic in groundwater were observed in Ha Nam in the Red River Delta and Dong Thap in the Mekong River Delta. About 33 % of groundwater samples analyzed in our investigation had arsenic levels more than WHO drinking water guideline of 10 $\mu\text{g/L}$. These results indicate widely spread arsenic contamination in groundwater in certain places of both Red River and Mekong River Deltas and also a risk on public health. Significant positive correlations between arsenic concentrations in groundwater, and human hair and urine were observed, implying that residents in the areas have been exposed to arsenic by consumption of arsenic-contaminated groundwater and, hence, highly potent health risk of arsenic is of great concern for the population.

RP98 Great Lakes Fish Contaminant Laboratory Performance Study. E. Murphy, Great Lakes National Program Office, U.S. EPA, Chicago, IL; S. Backus, Environment Canada, Burlington, Ontario, Canada. Fish consumption advisories and analysis of contaminants in fish are important tools for protection of human and ecological health. U.S. EPA's Great Lakes National Program Office and Environment Canada have organized a three phase interlaboratory comparison study of Great Lakes laboratories to determine the potential causes for within year variability in fish contaminant results reported by the various agencies implementing periodic monitoring

programs. Phase one of the performance study built upon a previous survey conducted by the Michigan Department of Environmental Quality in 2003. Participating agencies were asked to complete an updated survey to identify differences between agencies in program description, program logistics and mechanics, quality control, data analysis, and interpretation of trends between agencies. Phases 2 and 3 consisted of round robin analyses of known injectable PCB and organochlorine (OC) pesticide mixture standards and three homogenized fish tissue certified reference materials (CRM). Results are to be disseminated among participants and used in future planning for individual programs and the Great Lakes Fish contaminant community as a whole.

RP99 A Comparative Study of Analytical Methods for the Determination of Trace Metals in Blood using ICP-MS. M.F. Powell, D. Peterson, Brooks Rand Labs, Seattle, WA. Interest in the determination of trace elements in humans has increased in recent years due to the roles they play in both normal biological function and toxicity. The determination of trace and ultratrace elements in blood has been frequently studied because of accessibility and importance in biological function. The use of inductively coupled plasma mass spectrometry (ICP-MS) has become an important method of analysis for trace elements in biological samples due to the simultaneous multielement measurement capability and low detection levels. Due to the matrix complexity of blood, ICP-MS analysis can lead to spectral and polyatomic interferences. Sample dilution, sample dilution with matrix modification and sample digestion are the most common ways to overcome these interferences. There is no single prescribed technique for any method of preparation, and although most are similar, variations exist. A comparative study was performed evaluating four possible diluants for the determination of As, Cd, Cu, Ni, Se, and Pb by direct-injection ICP-MS. A digestion technique was also performed, and these samples were analyzed as a verification of total metal concentrations. The dilution techniques we employed were: 1) 1:50 dilution in 1% HNO₃ 2) 1:50 dilution in 1% ethyl alcohol and 1% HNO₃ 3) 1:50 dilution in 0.05% disodium ethylene diamine tetraacetate (EDTA), 1% tetramethyl ammonium hydroxide (TMAH), 1% ethyl alcohol, and 0.05% Triton-X 100. 4) 1:50 dilution in 1% ethyl alcohol, 0.05% ammonium pyrolinecarboxylic acid (APDC), 1% TMAH, and 0.05% Triton-X 100. For the digestion method, blood samples were digested in concentrated nitric acid on a hot block digester for 3 hours at 100° C. Results of the comparative study are summarized along with quality control results. Statistical analyses were performed on the data to determine trends and similarity of results.

RP100 Lead Screening Among Pre-school Children in Dhaka, Bangladesh. A.K. Mitra, Community Health Sciences, University of Southern Mississippi, Hattiesburg, MS; F.S. Faruque, University of Mississippi Medical Center, Jackson, MS; K. Bashar, North South University, Dhaka, Bangladesh. Lead poisoning is an alarming public health problem among Bangladeshi children. Several factors may contribute to the problem. Although the government of Bangladesh adopted a policy to ban the sale of leaded gasoline, there is no total control over the use of leaded gasoline in the country. Law enforcement agencies do not monitor lead emissions through industrial waste disposal. Because of lack of a proper waste management system, disposed batteries, potteries and cans, which are good sources of lead, are left near areas where slum children play. There is no monitoring of lead content of pesticides and insecticides available in the market. No routine screening or surveillance system is currently available in the country to monitor the level of lead exposure of the children. In addition, micronutrient malnutrition, which is extremely severe in Bangladesh, may predispose Bangladeshi children to increased lead absorption and toxicity. Our current prospective study among 300 children, aged 3-6 years, recruited from 10 primary schools in the Dhaka Metropolitan Area aims to 1) assess the level of blood levels of lead (BLL) among Bangladeshi children using a portable instrument called LeadCare (ESA Inc., Chelmsford, MA); 2) identify children at risk of high BLL in terms of socio-demographic and anthropometric parameters (weight and height); and 3) correlate sources of lead with identified cases of high BLL by using a geographic information system (GIS). This study will help the government of Bangladesh to develop and sustain a long-term lead surveillance program and take appropriate interventions.

RP100.5 Environmental Illness: Complex Negotiation of the Everyday. Meyer, Sherry A., Geography, University of Wisconsin-Milwaukee, Milwaukee, WI, USA. Multiple Chemical Sensitivity/Environmental Illness ("MCS/EI") is a state in which the human body becomes highly sensitized to, and often debilitated by, the chemicals of everyday life. It impacts a person's access to space and use of resources, thereby altering the relationship with

the places and spaces of daily life. Individuals endeavor to stabilize their health through close management of their environment and surrounds. They create and/or negotiate safer daily spaces through a variety of pragmatic and (socio)political adaptations. Adaptation and accommodation in building construction and maintenance, products, air quality controls, and advance notices of chemical events aid these individuals in their environmental needs with varying degrees of success. The proposed research will examine the complex interaction and achievement of urban individuals, neighbors, scientists, policy makers, governmental entities, communities and others as they engage with MCS/EI. It is anticipated the results may inform further research, decision making and policy discourses surrounding MCS/EI, health and well-being by providing critical, situated spatial analyses of the condition.

RP101 Testicular Toxicity of B-Success Herbal Supplement in Male Albino Rats. E. Obi, J. Afonne, E. Orisakwe, Toxicology Unit, Pharmacology Dept., Nnamdi Azikiwe University, Nnewi, Anambra State, Nigeria; M. Odiaka, Pathology, Ambrose Alli University, College of Health Sciences, Edo State, Ekpoma, Nigeria, Ekpoma, Nigeria. We have investigated the subchronic testicular effects of B success herbal supplement, which has high lead level in male albino rats with a view implicating the heavy metal. The acute toxicity (LD₅₀) and the phytochemical analysis of the herbal supplement were determined. Twenty weight matched male rats were divided into four groups of five rats each namely 0.00, 315, 630, 945mg/kg/day of the herbal product orally for 90 days. Animals had access to deionized water and were fed ad libitum with rat chow for 90 days. The feed and fluid consumption of the animals were measured on daily basis while the body weight was measured weekly. Animals were anaesthetized after 90 days, bled sacrificed, testes excised and weighed, protein, DNA and epididymal sperm count ESC were determined. Testosterone and lead in blood were also determined. There was no increase ($p > 0.05$) in feed and fluid intake in any of the treated groups. There was a significant decrease ($p \leq 0.05$) in absolute and relative weights of the testes in all the treated animals when compared with the control. There were significant ($p \leq 0.05$) decreases in testosterone, ESC, DNA, and protein levels in all the treated animals when compared with the control. The lead content of all the animals treated with the extract of the B success herbal supplement was significantly increased ($p \leq 0.05$) when compared with the control. Testicular tissues of all the treated animals showed dose dependent spermatocytic arrest. The present work suggest that the high lead content of B Success herbal supplement may be responsible for the testicular toxicity of this herbal supplement.

RP102 Molecular mechanism of cadmium-induced renal glucose malabsorption. N.M. Tabatabai, Medical College of Wisconsin, Milwaukee, WI; R.K. Kothinti, A.B. Blodgett, D.H. Petering, Chemistry and Biochemistry, University of Wisconsin-Milwaukee, Milwaukee, WI. Chronic exposure to cadmium (Cd) causes glucosuria. In kidneys, glucose passes freely through glomerulus but later on it is taken back in to blood. Glucose is reabsorbed by passive diffusion through GLUTs and by secondary active uptake by SGLTs. To investigate the mechanism of Cd-induced glucosuria, we study effect of Cd on SGLTs. We have shown that exposure of cultured mouse kidney cells to micromolar levels of Cd resulted in dose-dependent decrease in uptake of glucose and also with decreases in mRNA levels of SGLT1 and 2. To determine the mechanism of transcriptional down-regulations of SGLTs, we analyzed promoter regions of mouse SGLT1 and SGLT2 and found potential binding sites (GC-box) for zinc (Zn) finger protein, Sp1. Electrophoretic Mobility Shift Assay (EMSA) showed that nuclear Sp1 from Cd-treated cells had reduced binding to SGLT1-GC1 probe. In this study, we show that a recombinant human Sp1 (rhSp1) could bind to SGLT2-GC probe. We also show that binding of nuclear Sp1 from kidney cells exposed to 7.5 μ M Cd for 24 hr was 86% lower than those from untreated cells. EMSA with rhSp1 exposed to 0.5-10 μ M Cd for 15 min prior to binding assay showed dose-dependent decreases to 77%-17% and 74%-7.5% of untreated controls to SGLT1-GC1 and SGLT2-GC probes, respectively. To determine the effect of Cd treatment on DNA-bound Sp1, rhSp1 was first allowed to bind to either probe after which the reactions were treated for 15 min with the same concentrations of Cd as above. EMSA showed that binding of rhSp1 to either SGLT1 or SGLT2 probe was not significantly affected by this treatment. To show that replacement of Zn by Cd in rhSp1 reduced its binding, we first co-exposed rhSp1 to constant amount of Cd while increasing the concentration of Zn. DNA binding assays were then performed with the above samples using either SGLT1-GC1 or SGLT2-GC probes. EMSA showed that at equal molar amounts, Zn had no protective role against the inhibitory effect of Cd

on rhSp1. However, 10 folds excess of Zn over Cd restored binding of rhSp1 to SGLT1-GC1 and SGLT2-GC to 94% and 59% of untreated controls, respectively. We conclude that the reduced mRNA levels of SGLT1 and 2 in Cd-exposed kidney cells can be the result of reduced binding of Sp1 to their promoters, which is caused by the replacement of Zn by Cd in DNA binding domain of this transcription factor.

RP103 Potassium dichromate-induced cytotoxicity, genotoxicity, oxidative stress, and in human liver carcinoma (HepG2) cells. A.K. Patlolla, P.B. Tchounwou, Biology/Env.Sci, Jackson state University, Jackson, MS. Chromium is a widespread industrial waste. The soluble hexavalent chromium Cr (VI) is an environmental contaminant widely recognized to act as a carcinogen, mutagen and teratogen towards humans and animals. The fate of chromium in the environment is dependent on its oxidation state. The reduction of Cr (VI) to Cr (III) results in the formation of reactive intermediates together with the oxidative tissue damage and a cascade of cellular events. However, the mechanisms of the toxic action of chromium are not completely understood. The main purpose of this study was to evaluate the occurrence of oxidative stress, genotoxicity and cytotoxicity in the human liver [HepG2] cells exposed to potassium dichromate. HepG2 cells were cultured following standard protocol and exposed to various concentrations [0 – 50 μ M] of potassium dichromate [K₂Cr₂O₇]. Following exposure to the toxic metal, we performed the MTT assay to assess the cytotoxicity, thiobarbituric acid test to evaluate the degree of lipid peroxidation as an indicator of oxidative stress and DNA damage evaluation using alkaline comet assay. Study results indicated that potassium dichromate is cytotoxic to HepG2 cells, showing LD50 values of 8.83 + 0.89 μ g/ml, 6.76 + 0.99 μ g/ml for cell mortality upon 24 and 48 hrs of exposure respectively; indicating a dose- and time-dependent response with regard to cytotoxic effect of potassium dichromate. Statistically significant increase in the concentration of malondialdehyde [MDA], an indicator of lipid peroxidation, was recorded in exposed cells [15.9 – 69.9 μ M] compared to control [13 μ M]. Similarly, a strong dose-response relationship ($p < 0.05$) was also obtained with respect to potassium dichromate induced DNA fragmentation [comet assay] in HepG2 cells exposed [3.16 + 0.70 – 24.84 + 1.86 microns] to potassium dichromate than control [3.07 + 0.26]. Our results demonstrate that potassium dichromate is highly cytotoxic to HepG2 cells, and its cytotoxicity seems to be mediated by oxidative stress and DNA damage.

RP104 Assessment of Human Health Risks of Consumption of Cadmium Contaminated Cultured Oysters. W. Cheng, PWGSC, Public Works and Government Services of Canada, Halifax, Nova Scotia, Canada; F.A. Gobas, School of Resource and Environmental Management, Simon Fraser University, Burnaby, BC, British Columbia, Canada. With farmed British Columbia (BC) oysters containing higher cadmium concentrations than wild oysters, long-term exposure to cadmium through consumption of oysters has the potential to cause health risks. This study reports on a risk assessment for cadmium intake resulting from the consumption of BC-cultured oyster. The study concludes that Health Canada's current recommended BC-cultured oyster consumption rate for Canadians of 12 oysters per month exceeds the Agency for Toxic Substances and Disease Registry chronic oral minimal risk levels (MRL) of 0.2 μ g/kg/day by approximately 4- to 5-fold and reaches the Food and Agriculture Organization/World Health Organization (FAO/WHO) reference dose of 1 μ g/kg/day for cadmium consumption for Canadians. This suggests that although the current recommended maximum oyster consumption rates is consistent with the FAO/WHO and U.S. Environmental Protection Agency limits for acceptable risk, it leaves little or no room for error or uncertainty. This is noteworthy as recent studies demonstrate toxicological effects at cadmium intakes of 0.43 to 0.71 μ g/kg/day. This study indicates that a lower maximum BC-cultured oyster rate should be considered, particularly for high risk groups, including women with low iron stores, people with renal impairment, smokers, children, and indigenous people who consume organ meats of games and wildlife other than shellfish.

RP105 Development of Realistic Risk Assessment Framework Incorporating Desorption-limited Bioavailability. H. Ryu, T. Nam, K. Nam, Dept. of Civil & Environmental Engineering, Seoul National University, Seoul, South Korea. A framework for realistic risk assessment is under developing by incorporating site-specific bioavailability and desorption-limited dilution and attenuation processes in hazardous site. To determine bioavailability of hydrophobic organic compounds in soil a modified Basic Solid Phase Test (mBSPT) provided by Microtox system, which is appropriate

for higher soil-water ratio soil-slurry samples and produces more similar results to solid-phase toxicities, was conducted with four soil samples spiked with phenanthrene ranging from 10 to 6,000 mg/kg-soil. The pristine soil samples were collected with varying organic carbon (OC) content including Soil 1 (loamy sand, OC content 0.078%), Soil 2 (sandy loam, OC content 1.47%), and Soil 3 (clay, OC content 13.2%). The distribution coefficients obtained from batch tests were 146.4, 448.4, and 1022.4 (mg/kg-soil)/(mg/L-water) for Soil 1, 2 and 3 at equilibrium state, respectively. Toxicities of phenanthrene-spiked soils, expressed as 50% Effective Concentration, EC50, reasonably increased as the concentration of phenanthrene increased for all four soil samples. Interestingly, in Soil 3 with high OC content, EC50s were remarkably greater (i.e., lower toxicities) at a certain phenanthrene concentration (i.e., $\leq 2,000$ mg/kg-soil) than in other soil samples. Bioavailability of phenanthrene in soil, calculated simply by dividing concentration of phenanthrene at EC50 in soil-slurry sample with concentration of phenanthrene at EC50 in aqueous phase, was 45.0 and 40.1 for Soil 1 and 2, but only 3.15% for Soil 3. Our data suggest that factors besides organic carbon content and distribution coefficient be involved in determining the bioavailability and hence toxicity of phenanthrene in soil. Further experiments are in progress to characterize which property of soil is responsible for such phenomena. Likewise, two-compartment first-order kinetics from column desorption test will be considered to describe how soil properties including organic matter quality influence on desorption behavior and thus toxicity of phenanthrene in soil.

RP106 Future Land Use Checklists: Tool for Integrating and Weighting Human Health vs. Ecological Risk Assessments. K.G. Keil, M.S. Graham, Environmental Health, U.S. Army Corps of Engineers, Buffalo District, Buffalo, NY. The U.S. Army Corps of Engineers' environmental mission includes addressing sites that are contaminated with residual radioactive materials from activities dating back to the Manhattan Engineer District project. Many of these sites are owned by private industries, both currently active and inactive, while others are owned by the federal government. Land ownership and use at these sites is in flux. As these sites must be evaluated using the CERCLA process, both a human health and ecological risk assessment are performed for each of these sites. However, the land use at and around the site often dictates the relative importance of the human health versus the ecological risk assessment in driving remedial action objectives. Although the future land use of the site is not always well defined, it may drive a cleanup decision. Obtaining agreement from all project stakeholders regarding the reasonable future land use at the site may be contentious. The U.S. Army Corps of Engineers, Buffalo District, has developed a checklist to be filled out in order to document the rationale behind choice of future land use at a site. This checklist compiles all relevant information used to make a defensible decision regarding a site's future land use, including deed information, zoning determinations, master plans, presence or absence of sensitive habitats and species, etc. If completed early enough in the CERCLA process, it can be used to support the development of ecological management goals and the problem formulation of an ecological risk assessment, as well as the choice of receptor groups to evaluate in the baseline human health risk assessment. Use and impact of the future land use checklist will be presented for several hazardous waste sites being evaluated by the U.S. Army Corps of Engineers, Buffalo District.

RP107 The Bioaccumulation of Trace Elements by *Corbicula fluminea* and *Elliptio hopetonensis* in the Altamaha River System. W.A. Wilson, M.C. Black, Environmental Health Science, University of Georgia, Athens, GA; J. Unrine, Savannah River Ecology Laboratory, University of Georgia, Aiken, SC. The Altamaha River and its major tributaries (the Oconee, Ocmulgee, and Ohoopsee Rivers) constitute the second largest watershed in the eastern US. Recent surveys have indicated that native mussel populations in this system are declining. One proposed factor is the increased loads of trace elements associated with human activity. In the summer of 2006, the invasive clam, *Corbicula fluminea*, was collected from twenty-one sites and its tissues analyzed for trace element accumulation using ICP-MS. At seven sites, the endemic native mussel *Elliptio hopetonensis* was also collected and its patterns of bioaccumulation compared to those of *C. fluminea*. The data gathered show many differences in the amount of trace metals accumulated between the two species and between different sites within the river system. *C. fluminea* tended to accumulate higher loads of several trace elements (As, Cd, Cu, Hg, and Pb) than *E. hopetonensis*. However, there were strong relationships between the accumulation of Cu, Cd, Hg, and Pb by *C. fluminea* and *E. hopetonensis*. Spatial trends indicated significantly higher bioaccumulation of As, Cd, Pb,

and Zn at sites downstream of urban areas and in regions with input from surface kaolin mining activities. Some weak correlations between condition index (mass of dried tissue / shell volume) and accumulation of trace elements (As, Cd, Cu, and Hg) by *C. fluminea* were also observed. This study indicates that *C. fluminea* may make a suitable biomonitor species for the exposure of native mussels to various trace elements.

RP108 Copper Accumulation Measurement in Invertebrate Gill Cells Using Different Techniques. C.L. Paganini, Pós-Graduação em Oceanografia Biológica, Fundação Universidade Federal do Rio Grande, Rio Grande, RS, Brazil; J.L. Ruiz, Pós-Graduação em Ciências Fisiológicas - Fisiologia Animal Comparada, Fundação Universidade Federal do Rio Grande, Rio Grande, RS, Brazil; M.M. Souza, Departamento de Ciências Fisiológicas, Universidade Estadual de Londrina, Londrina, PR, Brazil; A. Bianchini, Departamento de Ciências Fisiológicas, Fundação Universidade Federal do Rio Grande, Rio Grande, RS, Brazil. Gill copper accumulation controls toxicity, which is associated with ionoregulatory disturbances in aquatic invertebrates, including crustaceans and molluscs. Copper toxicity is assumed to occur as a result of the free metal ion interaction with the physiologically active binding sites at the site of action, the gills. This study reports data on intracellular copper concentrations in isolated gill cells from the blue crab *Callinectes sapidus* (osmoregulator) and the yellow clam *Mesodesma mactroides* (osmoconformer) using two different techniques: the copper-sensitive fluorescent dye Phen Green and atomic absorption spectrophotometry. Isolated gill cells were exposed to copper (100 μ M), for 1 h. Data obtained show that copper accumulation in gill cells from both species measured by the fluorescent technique was similar to that found when measured by atomic absorption spectrophotometry. Considering the practicality and the amount of biological material needed for analysis, the fluorescence technique is now being used to assess the mechanism involved in the copper accumulation in both crab and clam gill cells.

RP109 Cellular controls of glutathione pools in copper and cadmium exposed algal cells. T.L. Stoiber, M.M. Shafer, D.E. Armstrong, Environmental Chemistry & Technology, University of Wisconsin Madison, Madison, WI; M.M. Shafer, Wisconsin State Laboratory of Hygiene, Madison, WI. Intracellular levels of glutathione may serve as an indicator of an algal cell's health and its ability to resist toxic stressors, and therefore serve as a biomarker of exposure and effect. Recycling of oxidized glutathione (GSSG) to the reduced form (GSH) is mediated by the enzyme glutathione reductase (GR). GR is critical for maintaining high levels of GSH in cells. Copper and cadmium dose-response experiments were conducted with the green algae species *Chlamydomonas reinhardtii*. Levels of GSH, GSSG, and GR were measured following metal exposures after 6 and 24 hours. In response to Cu, GSH pools were depleted and the GSH/GSSG ratio decreased with increasing Cu concentration. Contrasting results were observed in response to Cd exposure with GSH levels increasing almost 8-fold compared to controls. GR levels were observed to fluctuate with the increasing or decreasing GSH levels. The observed response in the glutathione pools may be related to the activity of the GR enzyme.

RP110 Mercury and Index of Biological Integrity for Fish and Benthos on the North Fork Holston River, VA and TN. E. Curtis, A. Shortelle, H. Fogell, N. Ruberti, C. Butcher, M. Bowling, MACTEC Engineering and Consulting, Inc, Kennesaw, GA. The North Fork Holston River (NFHR), located in southwestern Virginia and northeastern Tennessee, is part of the Upper Tennessee River Basin. A former chlorine plant (site) operated on the NFHR from 1950 to 1972 and contributed mercury to the river. Fish and benthic Index of Biotic Integrity (IBI) collections were conducted in 2005 to evaluate the health of fish and benthic communities in the NFHR downstream of the site. Bulk sediment samples were collected from the NFHR for mercury (Hg) and methylmercury (MeHg) analysis in conjunction with the fish and benthic collections. Fish IBI scores calculated using the recently developed Ridge and Valley scoring system ranged from 46 to 54, representing classifications from "Fair/Good" to "Good/Excellent". Comparison of the 2005 data to historical data indicates overall improvement in the fish community. Benthic IBI scores calculated using the Virginia stream condition index (VSCI) rated above the VSCI threshold score of 61.3. Thus, none of the locations are considered impaired based on the VSCI scores. Benthic IBI scores were also calculated using the Rapid Bioassessment Protocol (RBP) II method. Eleven of the 13 benthic IBI locations rated a RBP II classification of "Very Good" and 2 locations rated a RBP II classification of "Fair". Comparison of the 2005 data to historical RBP II data indicates improvement

in the benthic community. Based upon results of regression analyses, benthic IBI scores varied significantly with river mile location, but fish IBI scores did not. Sediment Hg and MeHg concentrations explained little of the observed variation in IBI scores. Overall, the IBI results indicate that fish and benthic communities in the NFHR appear to be sustained, healthy, and continuing to improve over time, and support conclusions of other studies that there has been a steady recovery of fish and benthos in the NFHR since the site closure in 1972.

RP111 Bioaccumulation and biomarker expression in *Corbicula fluminea* from pulsed exposure studies with uranium. A.L. Bunn, R.E. Durham, B.G. Fritz, D.P. Mendoza, A. Stegen, A.L. Miracle, Pacific Northwest National Laboratory, Richland, WA. Flow of groundwater contaminants into surface waters can vary daily or seasonally based on such factors as river stage, groundwater flow and water chemistry. As a result, the exposure of contaminants to benthic organisms at the groundwater/surface water interface changes regularly, in some cases on a daily basis. The continual change in contaminant concentration is not typically studied in laboratory exposure studies. Pulsed exposures of uranium were conducted to evaluate uptake and depuration rates using a sentinel benthic organism, the Asian clam (*Corbicula fluminea*). In addition to assessing the bioaccumulation of uranium, molecular changes in the gill tissue of the exposed organisms was assessed by measuring glutathione S-transferase (GST) and cytochrome oxidase subunit 1 (Cox1) using semi-quantitative real-time polymerase chain reaction. These gene expression endpoint measures were chosen because GST has been shown to participate in oxidative stress reactions and Cox1 has been observed to be upregulated following heavy metal exposure. Initial experiments with a continuous exposure of uranium in river water (at 10 and 100 μ g L⁻¹) indicated that an apparent equilibrium between the soft-tissue and exposure-system concentrations occurred within 48 hours, and that the depuration rate was slower than the uptake rate of uranium. Follow on experiments included short- and long-term studies using a pulsed uranium exposure of 100 μ g L⁻¹ in river water. Short-term uranium exposures consisted of three 24 hr cycles, each followed by 24 hr depuration in un-amended river water. Long-term uranium exposures consisted of two 120 hr cycles, each followed by 240 hr depuration in un-amended river water. The results from this study suggest that Asian clams do not regulate uranium uptake and depuration differently based on exposure periods. However, the soft tissues from the Asian clams are better as bioindicators of the most recent uranium contaminant flux into the riverine environment and not as indicators for long-term exposure. These experiments have been used in the evaluation of biomonitoring programs and in ecological risk assessments at the U.S. Department of Energy's Hanford Site.

RP112 Intraspecific differences in metal bioaccumulation in the Atlantic silverside (*Menidia menidia*): inferences regarding the effects of key biological processes. J. Dutton, N.S. Fisher, Marine Sciences, Stony Brook University, Stony Brook, NY. Understanding the processes governing metal bioaccumulation in marine organisms is essential for evaluating the ultimate effects, including risks, of metals on the organisms themselves or the animals that consume them. Relatively few studies have quantified the rates of accumulation and loss of metals in marine fish, despite the fact that they are known to be important sources of potentially toxic metals for human consumers. Here we present results of experimental studies that used gamma-emitting radioisotopes to assess uptake, release, and tissue distribution of two essential metals (Zn, Se) and three non-essential metals (Am, Cd, Hg) in the Atlantic silverside. We compared two populations of this fish, one from Nova Scotia, with relatively high rates of metabolism, ingestion and growth, and a second from South Carolina, with slower physiological processes. We measured assimilation efficiencies (AEs) from an Artemia diet, absorption from the aqueous phase (ku), and loss rates following either uptake route. AEs ranged from essentially zero for Am to 88% for methylmercury (MeHg). Inorganic Hg, Se, Cd, and Zn all displayed AEs ~ 8-32%. ku values were at least an order of magnitude higher for MeHg than for the other metals. While uptake, retention, and tissue distributions differed among the metals, the two fish populations did not differ significantly in uptake, tissue distribution, or retention of any metals from either diet or from the aqueous phase with the exception of Cd from diet, for which Nova Scotia fish displayed a lower AE. The results suggest that weight-specific rates of metabolism, ingestion, and growth are unlikely to affect metal concentrations in marine fish.

RP113 Uptake and Accumulation of Organic Arsenic Compounds in Various Freshwater Fish Species: Relationship to Feeding Habits and Food Web Exposure. E.S. Dillon, CH2M HILL, Okemos, MI. A variety

of fish species were collected from Franklin D. Roosevelt Lake (Lake Roosevelt), a part of the Upper Columbia River (UCR) and located in north central Washington, and analyzed for both inorganic and organic arsenic compounds. Lake Roosevelt has historically received inputs from mining, milling, and smelting operations. The lake is formed by the Grand Coulee Dam and consists of both a riverine portion upstream and a lake-like portion downstream. Specific aquatic habitats within both the lotic and lentic portions of Lake Roosevelt are dynamic because of the fluctuating surface water elevations due to dam operations. The trophic status of Lake Roosevelt can be characterized as meso-oligotrophic and is phosphorus-limited. Lake Roosevelt and its tributaries support a varied fish community (potentially 18 native fish species and 11 non-native species present). The fish community present represents the full range of feeding guilds expected in a freshwater fish community. Feeding studies show that the fish community is supported by both benthic and pelagic production. Five fish species, Walleye (*Sander vitreus*), largescale sucker (*Catostomus commersoni*), rainbow trout (*Oncorhynchus mykiss*), lake whitefish (*Coregonus clupeaformis*), and burbot (*Lota lota*) were collected from six locations throughout Lake Roosevelt that represent a gradient of contamination and habitat conditions. The results showed that inorganic arsenic comprised up to 30 per cent of the total arsenic in the target species. Burbot had the lowest portion at 3 percent and also showed a unique distribution of organic arsenic species. The effect of feeding habits and food web exposure relative to the observed patterns of uptake will be discussed.

RP114 Total Copper and Cadmium Concentrations of Aquatic Insects in Northern New York and the Adirondack Region. C. Johns, J. Winkowski, Environmental Studies, St. Lawrence University, Canton, NY. Benthic macroinvertebrates have been used to monitor water quality in freshwater ecosystems throughout North America. The Adirondack region has received decades of atmospheric deposition of contaminants, including trace metals. To ascertain whether deposition causes bioaccumulation of metals by stream macroinvertebrates in the northern Adirondacks, we undertook a pilot study to analyze concentrations of copper and cadmium in multiple taxa of aquatic insects from 6 sites. We hypothesized that invertebrates from sites nearer the Adirondacks would bioaccumulate more metals and that metal concentrations would vary by trophic level (e.g. predator vs collector). Samples were collected in September 2006 using kicknets and frozen. Insects were pooled by similar body length for each taxon, dried, weighed, digested by nitric acid reflux and analyzed by flame AAS. Low levels of both metals occurred in all samples collected compared to known polluted freshwater systems. Copper was greatest in samples from the Grasse River in Madrid, NY (2.06 ppm) and lowest in the West Branch of the St Regis River in Parrishville, NY (0.60 ppm). Cadmium was greatest in samples at the outfall of Cranberry Lake, NY (0.18 ppm) and lowest in Cold Creek, Colton, NY (<0.001 ppm). Metal concentrations varied little, regardless of location, taxon, or trophic position. These data can be utilized to establish a benchmark for biomonitoring macroinvertebrates in this region. Although Cu and Cd levels appear to be low at these sites, studies assessing a wider array of species and sites are needed to assess potential contamination and bioaccumulation.

RP115 Further Development of a Marine Biotic Ligand Model for Copper. A.C. Ryan, R.C. Santore, HydroQual, Inc., East Syracuse, NY; P.R. Paquin, HydroQual, Inc., Mahwah, NJ; W. Arnold, Copper Development Association, New York, NY; G. Rosen, I. Rivera-Duarte, D. Chadwick, P. Wang, SSC-San Diego, San Diego, CA. Success of the biotic ligand model (BLM) in freshwater has fueled efforts to develop or calibrate a similar model that reasonably characterizes copper bioavailability and toxicity in marine systems. Since predictions of copper accumulation and toxicity rely on metal speciation, the performance of the speciation portion of the BLM was evaluated. This was accomplished by comparing copper speciation predictions with the results from copper titrations conducted in waters from different marine and estuarine environments including San Diego Bay, San Francisco Bay, and the Cape Fear River Estuary. This analysis indicated that model predictions could be improved by re-characterizing the nature of the interactions between copper and marine organic matter. The toxicity portion of the model was calibrated with copper accumulation and toxicity data for *Mytilus galloprovincialis*, *Strongylocentrotus purpuratus*, and *Dendraster excentricus*. To satisfactorily describe accumulation, a two-site BLM was required. However, toxicity (characterized by a 48-h chronic-estimator test) could be predicted with a one-site BLM, because the high affinity, low capacity biotic ligand is saturated before the median lethal accumulation level is

reached. A model of this type can potentially be used to assess the ecological risk of copper in coastal and marine environments, and also has potential for use in the derivation of saltwater copper criteria.

RP116 A Comparison of the Toxicity of Copper to Marine Invertebrates. R. Arnold, Environmental Sciences, Copper Development Association, New York, NY; J.S. Cotsifas, Pacific EcoRisk, Fairfield, CA. It has been clearly demonstrated in the literature that water chemistry, especially dissolved organic matter, affects the bioavailability and thus toxicity of copper in estuarine and marine ecosystems. Since dissolved organic matter has rarely been reported in historical toxicity tests of marine organisms, it is difficult to establish the relative sensitivity of marine species to copper as the bioavailable copper in these tests may have differed significantly from the reported values. Thus, there is a need to determine the relative sensitivity of marine organisms in tests where factors that affect bioavailability are controlled and quantified. A series of toxicity tests have been performed to determine the relative sensitivity of a variety of marine invertebrate embryos to copper over a range of dissolved organic matter concentrations. The test species included the oyster, *Crassostrea virginica*; the sand dollar, *Dendraster excentricus*; the mussel *Mytilus edulis*; the mussel, *Mytilus galloprovincialis*; and the urchin, *Strongylocentrotus purpuratus*. The mitigative effect of dissolved organic matter was clearly demonstrated and the relative sensitivities determined.

RP117 Influence of flow-through and renewal exposures on the toxicity of copper to rainbow trout. J. Lipton, P.G. Welsh, J.C. Marr, Stratus Consulting Inc., Boulder, CO; C.A. Mebane, US Geological Survey, Boise, ID. We examined changes in water chemistry and copper (Cu) toxicity in three paired renewal and flow-through acute bioassays with rainbow trout (*Oncorhynchus mykiss*). Test exposure methodology influenced both exposure water chemistry and measured Cu toxicity. Ammonia and organic carbon concentrations were higher and the fraction of dissolved Cu lower in renewal tests than in paired flow-through tests. Cu toxicity was also lower in renewal tests; 96-h dissolved Cu LC50 values were 7 to 60% higher than LC50s from matching flow-through tests. LC50 values in both types of tests were related to dissolved organic carbon (DOC) concentrations in exposure tanks. Increases in organic carbon concentrations in renewal tests were associated with reduced Cu toxicity, likely as a result of the lower bioavailability of Cu-organic complexes. The biotic ligand model of acute Cu toxicity tended to underpredict toxicity in the presence of DOC. Model fits between predicted and observed toxicity were improved by assuming that only 50% of the measured DOC was reactive, and that this reactive fraction was present as fulvic acid.

RP118 Copper Accumulation and Toxicity in Gills of the Blue Crab *Callinectes sapidus*. C.M. Martins, Pós-Graduação em Ciências Fisiológicas: Fisiologia Animal Comparada, Fundação Universidade Federal do Rio Grande, Rio Grande, RS, Brazil; C.L. Paganini, Pós-Graduação em Oceanografia Biológica, Fundação Universidade Federal do Rio Grande, Rio Grande, RS, Brazil; A. Bianchini, G.S. Trindade, Departamento de Ciências Fisiológicas, Fundação Universidade Federal do Rio Grande, Rio Grande, RS, Brazil. Copper toxicity seems to be related to the level of metal accumulated in gills, since copper is considered as an osmoregulatory toxicant. In this study, copper accumulation was investigated in vitro using isolated and perfused gills, as well as cultured gill cells from the blue crab *Callinectes sapidus* acclimated to salinity 30 ppt. Isolated gills (anterior and posterior) were perfused and incubated with a saline solution of ionic composition similar to the hemolymph of crabs acclimated to salinity 30 ppt. Different copper concentrations (1, 10, 100 and 1000 μM Cu as CuCl_2) were tested (4 h) in the incubation solution. Cells from primary culture of posterior gill cells were maintained in culture media containing different copper concentrations (1, 10, 100 μM Cu as CuCl_2). Cell viability was significantly reduced after 6 h of exposure to 10 or 100 μM Cu. In perfused anterior gills, a significant copper accumulation was observed at 1000 μM Cu. In posterior gills, a significant accumulation was observed after exposure to 100 or 1000 μM Cu. Copper concentration in isolated cells exposed to 100 μM Cu significantly increased from $0.02 \pm 0.003 \mu\text{g Cu}/10^6$ cells at the beginning of the experiment to $0.12 \pm 0.017 \mu\text{g Cu}/10^6$ cells after 6 h of exposure. Data show that copper is accumulated in both gills and isolated gill cells of *C. sapidus* after acute exposure, inducing toxicity. The differences observed in the copper accumulation patterns between anterior and posterior gills might be associated with their different physiological functions (respiration and osmoregulation, respectively).

RP119 Effects of dissolved organic carbon on copper, cadmium, and zinc toxicity during chronic exposure to a tri-metal mixture. R. MacPhail, C. Kamunde, Biomedical Sciences, Atlantic Veterinary College, Charlottetown, Prince Edward Island, Canada. Although toxicological inferences are largely based on effects of single toxicants, natural waters are usually contaminated with mixtures of toxicants that interact with each other to enhance or reduce the overall toxicity. We studied the effects of dissolved organic carbon (DOC) in moderating bioavailability and toxicity of copper (Cu), cadmium (Cd) and zinc (Zn) from a waterborne mixture of the three metals during a chronic exposure. Juvenile rainbow trout (*Oncorhynchus mykiss*) were exposed to a tri-metal mixture containing (in mg/L: Cu 30, Cd 15, and Zn 115) in hard water (260 mg/L as CaCO₃) with and without 7.5 mg/L DOC for 28 days. Metals accumulation, mortality, growth, ionoregulatory status, and oxidative stress were measured weekly. Whereas no mortality occurred in the control and DOC + metals mixture treatments, the DOC-free metals mixture treatment caused 10% mortality during the first week of the exposure. This mortality was associated with sodium and calcium loss, inhibition of branchial Na⁺-K⁺-ATPase and elevated levels of branchial oxidative stress marker, malondialdehyde. Dissolved organic carbon not only reduced metals accumulation but also conferred significant protection against these early toxicological effects. Surprisingly, appetite and growth were unaffected by the metals mixture, and normal ionoregulatory status was restored by day 14 of the exposure. Based on evidence that similar or higher concentrations of the respective metals in the same water do not cause toxicity individually, we conclude that the toxic effects of these metals are most critical early in the exposure and are, to some extent, additive. Our data also suggest that long-term exposure to a metal mixture causes loss of additivity of effects. Because metals often co-occur in contaminated environments, it is imperative that tools for predicting toxicity and ecological risk assessment take cognisance of the fact that interactive effects among metals may be different for acute and chronic exposures.

RP120 Pulsed exposure effect of mercury, zinc, and copper on *Daphnia magna*: body residue and toxicity. S. Jang, K. Choi, school of public health, seoul national university, Seoul, South Korea; Y. Kho, Eulji University, Gyeonggi, South Korea. Metal contaminants on road and land could reach the river or lake especially during rainfall event and cause undesirable ecological effects on aquatic organisms. In this study the effect of pulsed exposure to such contaminants on *Daphnia magna* was studied. Zinc, copper and mercury were chosen as test metals since they have been detected frequently in urban and rural runoff. Body residue was determined to assess the effect of recovery time and hence on ecological effect. Toxicity of test chemicals tends to decrease with longer recovery time. In pulsed exposure test of mercury, 24 hr recovery test (EC50: 5.5 ug/L) showed more sensitive effect than 72 hr recovery test (EC50: > 10 ug/L). Body residue of mercury was 71.4 mg/kg after 24 hr exposure and decreased down to 26.7 mg/kg after 24 hr of recovery, which was increased to 59.9 mg/kg by another 24 hr exposure, and reduced to 32.6 mg/kg after 24 hr of depuration. To better assess the environmental risk of pulsed metal exposures characteristics of chemicals such as uptake and excretion rate should be considered.

RP121 Silver acute-to-chronic ratios for four freshwater species and the determination of a final acute-to-chronic ratio. R.B. Naddy, ENSR, Fort Collins, CO; J. Gorsuch, Gorsuch Environmental Management Services, Inc., Webster, NY; P. Paquin, HydroQual, Inc., Mahwah, NJ; W. Stubblefield, Parametrix, Inc., Albany, OR. The acute and chronic toxicity of silver, as silver nitrate, was determined for two freshwater aquatic cladoceran species, *Ceriodaphnia dubia* and *Daphnia magna* and two freshwater fish, *Primephales promelas* and *Oncorhynchus mykiss*. These studies were conducted as part of a larger program to generate chronic toxicity values for development of a chronic ambient water quality criterion for silver. In reviewing the historical data, acute-to-chronic ratios (ACR) for invertebrate species were < 1, and were therefore not suitable for use in establishing a final ACR (FACR). The ACRs for the invertebrate species were <1 because acute values were less than the chronic values, a function of the reduced bioavailability and toxicity of silver when food was added. We conducted concurrent acute studies for all four species, with and without food and compared these with chronic values determined from our laboratory. The presence of food reduced the toxicity of silver for all species, although less so in the fish studies. ACRs for *C. dubia* and *D. magna* were 1.33 and 1.22, respectively; while ACRs for *P. promelas* and *O. mykiss* were 10.6 and 35.8, respectively. Using these new values and

values in the literature, we determined a FACR to be used in a revised chronic freshwater ambient criterion for silver.

RP122 *Ceriodaphnia dubia* field and laboratory population responses to nickel concentrations in chronic toxicity tests. K.W. Custer, G. Burton, P. Anderson, Department of Earth and Environmental Sciences, Wright State University, Dayton, OH; C. Schlekert, Nickel Producers Environmental Research Association (NiPERA), Durham, NC. The responses of two field collected and two laboratory populations of *Ceriodaphnia dubia* to nickel were compared. The two field populations were collected near Dayton and Cincinnati, Ohio, USA, and the two laboratory populations were obtained from Columbia, Missouri and Dayton, Ohio, USA. Results showed that both field populations exhibited the same reproduction NOEC and LOEC values of 3.9 µg/L, and 5.6 µg/L, respectively. The two laboratory populations showed a difference in their reproduction NOEC values of <3.9 µg/L, and 3.9 µg/L, and different LOEC's of 3.9 µg/L and 5.6 µg/L, respectively. Both field populations had survival NOEC's of 5.6 µg/L, and LOEC's of 8.8 µg/L. The laboratory populations had different survival NOEC's with one population at 5.6 µg/L, and the other at 8.8 µg/L, and the survival LOEC's were 8.8 µg/L and 29 µg/L. The two field collected *C. dubia* populations appear to be as sensitive (survival NOEC and LOEC) as one laboratory population, but more sensitive than the other laboratory population tested. These values are lower than the other *C. dubia* nickel studies, and may be attributed to the higher pH values during the tests. Further research is needed to determine if there are differences between field populations and the laboratory clone populations which are commonly used in toxicity tests.

RP123 Copper and zinc toxicity in radioactive liquid waste from Ontario CANDU Nuclear Reactors. D. Rodgers, Environmental Technologies Solutions, Kinectrics, Toronto, Ontario, Canada. The radioactive liquid waste (RLW) system in Ontario's CANDU Nuclear Generating Stations collects drainage from a variety of sources ranging from floor drains to laundry waste. Specific toxicity treatment systems incorporated within each station have largely eliminated RLW toxicity (failure > 1%); however, there have been isolated toxic events. In many of these toxic events, the concentrations of copper and zinc in the RLW were at the lower end of the toxic threshold of each metal by itself, suggesting that the observed toxicity related to interaction of copper, zinc, and the generally low hardness and conductivity of the RLW effluent. The present studies investigated the impact of water hardness and pH on toxicity of Cu and Zn in RLW, and evaluated the use of the Biotic Ligand Model for use in predicting RLW toxicity.

RP124 Effect of aluminium on growth and photosynthesis of *Euglena gracilis* and *Chlamydomonas acidophila*. F. Perreault, A. Diallo, R. Popovic, Department of Chemistry and Biochemistry - TOXEN, Université du Québec à Montréal, Montreal, Quebec, Canada; C. Fortin, Institut National de la Recherche Scientifique - Eau, Terre et Environnement - TOXEN, Université du Québec, Montreal, Quebec, Canada; P. Juneau, Dpt of Biological Sciences - TOXEN - CRC on Ecotoxicology of Aquatic Microorganisms, Université du Québec à Montréal, Montreal, Quebec, Canada. Toxic effect of aluminium is pronounced for algal species when aquatic environment has a lower pH. Photosynthetic electron transport was found to be sensitive target of aluminium toxicity in different algal species. However, some algal species are very resistant to aluminium effect. In this report we used algal species *Chlamydomonas acidophila* and *Euglena gracilis*, having different level of tolerance to aluminium at pH 3.0, to investigate aluminium toxicity on cellular division and photosynthetic energy dissipation, by using Pulse-Amplitude-Modulated and Plant Efficiency Analyser fluorometers, and flow cytometer. We found that aluminium stimulated, during the first 48 hours of treatment, cellular division of both species. However, photosynthetic activity in *Euglena gracilis* was lower compared to *Chlamydomonas acidophila*. Furthermore, energy dissipation through non-photochemical quenching was evidently higher. Regardless to aluminium stimulation effect on cellular division, photosynthetic activity and algal biomass formation was affected. In this report, we discussed possible aluminium impact on algal development in polluted aquatic ecosystems.

RP125 Neurotoxicity and oxidative stress produced by Al on *C. idella*. G. Marcela, F. Lourdes, R. Celene, G. Sandra, G. Rocío, Sección de Estudios de Posgrado e Investigación, ENCB, IPN, México City, México, D.F., Mexico; G. Leobardo, A. Araceli, Facultad de Química, UAEMex, Toluca, Edo. Méx., Mexico. Heavy metals, like Al, binds to -SH groups producing damage to some enzymes like superoxide dismutase (SOD) and catalase (CAT). It has

been recognized as highly toxic to the nervous system and has been implicated in neurodegenerative diseases like Alzheimer (AD). These effects could be manifested in humans and biota associated to polluted water bodies. There are multiple Al sources for humans, such as drinking water and animal food, like fishes from polluted sites. The aim of this work was to evaluate the neurotoxic and oxidative stress effect produced by aluminium on the carp *Cyprinus carpio* L. Five aquariums of 20 L were added with 0.1 mg.L⁻¹ of Al₂(SO₄)₃ (wild life protection threshold limit). Five carps were added to each batch and were exposed during 12, 24, 48, 72 y 96 h. After the exposure time the organisms were sacrificed, the brain was extracted and the lipid peroxidation degree (LPO) (Buege & Aust, 1979), the activity of SOD (Misra & Fridovich 1972) and CAT (Radi et al, 1991), the dopamine (DA), noradrenaline (NA) adrenaline (A) (HPLC) and Al concentrations (atomic absorption spectroscopy) were evaluated. An increment in the LPO degree was observed since 48 h of exposure time. The CAT activity of the exposed organisms during the first two times (12 y 24 h) did not present significant differences with respect to control ones; nevertheless, since 24 h a significant decrease was exhibited. The SOD activity was increased since 12 h in a concentration-time dependent way. The effect was maintained until 96 h. In vivo studies had demonstrated that Al plays a role in ROS generation, and that it is capable to increase the LPO and decrease the activity of SOD in diverse tissues. Recent studies suggest that oxidative stress may play a role in a wide range of neurological diseases including AD. The DA results in exposed organisms showed a significant increment with respect to control ones since 24 h and until 96 h. The NA also showed an increment but until 72 h the concentration falls. The A did not present a significant difference until 48 h, but until 72 h showed a drastic decrement with respect to controls. The results demonstrated that Al provokes oxidative stress, increment in the concentration of DA and NA, and decrement of A, producing neurotoxicity in carps.

RP126 Water Column Toxicity within Recreational Boat Harbors in California, USA. D.J. Greenstein, D.L. Young, K. Schiff, Toxicology, Southern California Coastal Water Research Project, Costa Mesa, CA; N. Singhasemanon, California Department of Pesticide Regulation, Sacramento, CA. The use of antifouling paints containing heavy metals, especially copper, on boat hulls presents a possible source of toxicity to non-target organisms in the water column of marinas. Previous studies conducted in San Diego County marinas during 2005, found toxicity to mussel (*Mytilus galloprovincialis*) embryos that was most likely caused by copper. A larger scale project was conducted in 2006 to determine the extent of toxicity in marinas throughout California. Again, 48-hour mussel embryo development tests were conducted on marina water column samples. Two sites within Marina Del Rey in southern California were found to be toxic, with embryo %normal-alive as low as 4%. The cause of observed toxicity was determined by performing toxicity identification evaluation treatments on the water samples. TIE treatments with EDTA and sodium thiosulfate substantially reduced the toxicity, indicating that copper was a likely cause of the observed toxicity. A reduction in toxicity was also observed after solid phase extraction with a C-18 column, indicating either an organic or metal causative agent. Correlations between water column metals concentrations and toxicity will be presented.

RP127 Acclimation to Metals by Crayfish in North-central Arkansas. J.M. Conrad, R.E. Hannigan, Environmental Sciences, Arkansas State University, Jonesboro, AR. Aquatic invertebrates adapt over time to changes in water and sediment quality. Many organisms, through evolution, have adapted to high concentrations of metals such as Hg in their environment by developing strategies to regulate the uptake, excretion, and detoxification of metals. Current risk assessment methods inadequately consider shifts in tolerance caused by adaptation to ambient habitat chemistry. There is a need to understand the effect that acclimation has on a population in order to provide an accurate evaluation of the potential adverse effects or risks of metals in particular environment. Here we present preliminary results of a study centered on examining the adaptive metal regulation of crayfish in black shale draining streams. Using ecotoxicology testing approaches we compared survival of crayfish taken from black-shale draining streams (naturally high dissolved and sediment metal concentrations) to those from neighboring silt stone draining streams (lower dissolved and sediment metal concentrations). Sample populations of crayfish (n=10 per treatment) were isolated into 4 treatment and 1 control group using a static experimental design. The pH was kept slightly acidic (5-6) as found in the black shale streams and the temperature and dissolved oxygen maintained at the stream values. Tank water was prepared with using moderately hard water spiked with V, Cr, Fe,

Co, Ni, Cu, Zn, As, Se, Cd, Hg, and Pb at Criteria Chronic Levels. Mortality and molts were recorded and kept for analysis. After 2 months of testing, the remaining crayfish were euthanized and prepared for analysis. After removal of the hepatopancreas and the gills, the remaining crayfish was sectioned into 3 main parts including the internal carapace region, the abdominal muscle, and the exoskeleton. The samples were dried in an oven and digested with ultra pure nitric acid. We used the ICP-MS to determine the metal concentrations. Results suggest that crayfish that have lived in water that has naturally high concentrations of metals (e.g., black shale draining streams) exhibit a higher tolerance for these metals than crayfish that live in lower metal concentration environments. These results suggest that stream invertebrates such as crayfish adapt to metal enriched conditions and that these adaptations should be considered in risk assessment studies.

RP128 Bioavailability of metals in non-hazardous inorganic wastes beneficially used in construction applications. M. Louis, G. Triffault-Bouchet, Centre d'expertise en analyse environnementale du Québec, Québec, Canada; S. Burelle, H. Ouellette, MDDEP, Direction des politiques en milieu terrestre, Québec, Québec, Canada; F. Guay, MDDEP, Direction régionale de la Montérégie et de, Longueuil, Québec, Canada. Each year, in Québec (Canada), the mining and metallurgical industries produced millions of tonnes of wastes which have a high potential to be beneficially used in construction applications. The "Guide de valorisation des matières résiduelles inorganiques non dangereuses de source industrielle comme matériaux de construction" (MENV, 2002) describes the environmental specifications and regulation applied to this beneficial use. The waste characterization is mainly based on the metal concentrations and mobility. The metal bioavailability for organisms in the receiving environment is, however, not taken into account. The purpose of this study was to assess several chemical and biological tools to determine the metal bioavailability in inorganic wastes and proposed a new framework including metal bioavailability. 25 inorganic wastes were characterized by using total extractable content of metals, chemical analysis of their leachates (water extraction, simulation of acid rain, acetic acid extraction) and, toxicity bioassays (daphnia and earthworm survival, radish and barley germination and, barley growth). Wastes were compared on the basis of metal bioavailability and their biological effects. Sensitive endpoints (biological and chemical parameters) to these inorganic wastes have been selected. On the basis of these analyses, modifications of the framework were proposed. * Guideline for the beneficial use of non-hazardous inorganic industrial wastes in construction applications.

RP129 Bioavailability and toxicity of metals in sediments from Lake Roosevelt, Columbia River, Washington USA. J.M. Besser, W.G. Brumbaugh, C.D. Ivey, C.G. Ingersoll, U.S. Geological Survey, Columbia, MO; P.W. Moran, U.S. Geological Survey, Tacoma, WA. We studied the bioavailability and toxicity of trace elements in sediments from Lake Roosevelt (LR), a reservoir on the Columbia River that has received inputs of metals from an upstream smelter facility. The goal of this study was to evaluate relationships between chemical indicators of metal bioavailability and biological responses in laboratory sediment toxicity and bioaccumulation tests. Six sites were located within the reservoir, one site was upstream in the Columbia River, and one reference site was located in a tributary arm without significant upstream metals sources. Total recoverable concentrations of copper, zinc, cadmium, and lead in LR sediments generally decreased from upstream to downstream in the study area, except for two reservoir sites with very low metal concentrations, apparently due to deposition of eroded bank soils. Concentrations of acid-volatile sulfide and total organic carbon in LR sediments were low, and selective sediment extractions indicated that metals in most LR sediments were primarily associated with iron and manganese oxides. *Oligochaetes* (*Lumbriculus variegatus*) accumulated significantly elevated concentrations of copper, cadmium, and lead from most LR sediments, compared to the reference sediment. Survival of amphipods (*Hyalella azteca*) was significantly reduced, relative to the reference site, only by sediments from the upstream riverine site. However, growth of midge larvae (*Chironomus dilutus*) was significantly reduced by sediments from the upstream site and from three sites in the reservoir. Toxic effects were generally consistent with predictions of metal toxicity based on empirical sediment quality guidelines and, to lesser extent, with equilibrium-partitioning sediment benchmarks based on metal concentrations in sediment and pore water. These results indicate that metals in sediments from some areas of Lake Roosevelt are relatively bioavailable and may cause toxic effects on benthic fauna.

RP130 SSDs derived from biosurvey data provide more realistic models of metal influences on invertebrate populations. P.L. Shaw-Allen, National Center for Environmental Assessment, USEPA Office of Research and Development, Cincinnati, OH. Species sensitivity distributions (SSDs) derived from biosurvey data provide a more realistic picture of stressor influences than laboratory exposures because biosurvey data integrate the complex conditions under which aquatic communities have developed. R-EMAP biosurveys of Colorado's Southern Rockies Ecoregion provide ideal data to examine metal influences on field invertebrate populations because the dataset includes information on both the metals content and toxicity of site water and sediment. To best represent field exposures, the metals stressor gradient was expressed in terms of arthropod-specific toxic units (TUs) using benchmarks based on SSDs calculated from ECOTOX-MED LC₅₀ data. Biosurvey data for invertebrate taxa abundances were plotted against this gradient and analyzed using quantile regression at the 90th quantile. To eliminate sites where organisms may have acclimated to metals exposure, this analysis was repeated after removing observations from sites identified by the dataset as having toxic water and sediment. The stressor intensity at which taxa abundance declined by 50% (AB₅₀) was extracted from those regressions exhibiting a clear stressor-response relationship. These AB₅₀ values were summarized in SSDs representing data with and without observations from toxic sites. The SSD representing only non-toxic sites suggests that the stressor intensity at which 50% mortality is expected in 5% of laboratory taxa would result in a 50% reduction in abundance for most taxa in the Colorado Southern Rockies Ecoregion. The SSD including data from the toxic sites suggests this same stressor level would reduce abundance in fewer than half of the taxa. While this suggests field populations are substantially more sensitive than laboratory organisms, biosurvey and laboratory response data can not be directly compared because reduced abundances (AB₅₀s) are not equivalent to mortality (LC₅₀s). Biosurvey-derived SSDs do, however, offer the realistic models required for causal assessment because they were developed using real-world data integrating the complex conditions under which aquatic communities developed.

RP131 Effect of Temperature on Heavy Metal Toxicity in *Daphnia magna*. M.A. Khan, S.A. Ahmed, M. Vaughn, Biological Sciences, University of Illinois at Chicago, Chicago, IL. Toxicity of copper, cadmium, zinc, and lead to waterflea *Daphnia magna* Straus (Crustacea: Cladocera), at 16-180 C (habitat temperature), decreased in the following order: copper= cadmium: 30 times < zinc: 2.5 times < lead, as determined by LT50 (time to kill 50% test animals) values. A 40 C-rise in acclimation temperature (20-220 C), made copper and lead about 30% and zinc 10% more toxic, while a 100 C rise in temperature (270C) made copper 170%, lead and zinc 60%, and cadmium 25% more toxic. Acclimation at above habitat temperature increased the rate of oxygen consumption, heartbeat rate, and hemoglobin (Hb) concentration. The 100 C-rise in acclimation temperature increased the rate of oxygen consumption by about 180%, rate of heartbeat by 30%, and Hb concentration by about 20%. The increase in respiration rate, Hb concentration, and heart rate by temperature was lowered by pre-exposure to heavy metals. A 24-hr pre-exposure to sublethal concentrations of copper, cadmium (5 µg.L⁻¹), zinc, and lead (10 µg.L⁻¹) lowered the rate of oxygen consumption by 6-37% in 16-180 C- and by 42% in 270 C-acclimated daphnids. The lowering of Hb concentration and heart rate was much less than the decrease in rate of oxygen consumption. The data indicate that increase in water temperature, expected with global warming, may lower the ability of temperate populations of *D. magna* and probably of other small aquatic poikilotherms to tolerate heavy metals and other metabolic poisons.

RP132 Polar organic compounds in surface waters collected near lead-zinc mine and milling operations in Missouri. C. Rostad, T.J. Leiker, US Geological Survey, WRD, Denver, CO; C.J. Schmitt, US Geological Survey, BRD, Columbia, MO; J.G. Schumacher, US Geological Survey, WRD, Rolla, MO. Surface-water samples were collected near a lead mine and mill tailings about 70 miles southwest of St. Louis, Missouri, during the summer of 2006. The purpose of this sampling was to determine if polar organic compounds were present that could be a cause of documented negative impacts to biota downstream. Water samples contained relatively high concentrations of dissolved organic carbon for surface waters (greater than 20 mg/L), but were colorless, which precluded naturally occurring aquatic humic or fulvic acids. Previous analysis indicated that samples were devoid of pesticides and acid/base/neutral extractable semi-volatile organic compounds, such as polycyclic aromatic hydrocarbons. After isolation by three different types of solid

phase extraction, samples were analyzed by electrospray ionization/mass spectrometry. Polar organic compounds commonly used in the milling process, such as alkyl xanthates, were not found; however, xanthate degradation products were detected. Most of the polar organic compounds identified contained sulfonate groups, which are characteristic of some of the reagents used in the milling process. Sulfonate compounds may have low sorption onto soil or sediments and be mobile in the aqueous environment.

RP133 An In Situ Assessment of the Impact of Metal Contaminated Sediments on Temperate and Polar Marine Assemblages. N. Hill, E.L. Johnston, School of Biological, Earth & Environmental Sciences, University of New South Wales, Kensington, Sydney, New South Wales, Australia; S.L. Simpson, Centre for Environmental Contaminants Research, CSIRO Land and Water, Lucas Heights, New South Wales, Australia; J.S. Stark, Environmental Protection & Change, Australian Antarctic Division, Kingston, Tasmania, Australia. Metal contaminated sediments are a common form of anthropogenic disturbance that impacts on sediment communities. Through the resuspension of contaminated sediments by biological and physical processes, organisms such as bryozoans, tube worms and sponges that live on boulders and other hard substrates above the sediment, may also be affected. This presentation contrasts the impacts of contaminated marine sediments on hard and soft substrate assemblages in a temperate and polar region. Manipulative in situ experiments were undertaken in Sydney Harbour, Australia and Casey Station, Antarctica. Artificial hard-substrates (small boulders) were placed on top of sediments spiked with varying concentrations of copper, lead and zinc and deployment in each environment. Temperate experimental units were retrieved after 6 months and Antarctic units after 10 months. The abundance of most Antarctic organisms recruiting to the soft substrate was negatively affected by increasing metal concentrations. However, this trend was not seen in the Antarctic hard substrate community possibly due to low recruitment rates. In contrast, the abundance of most groups of temperate hard substrate invertebrates were positively affected by metal contamination, whereas the soft sediment fauna were negatively affected. This suggests that the impacts of metal contaminated sediments are not straightforward and there are interactions between the two communities. Results on the fate of spiked sediments in the field are also presented.

RP134 An Integrated Approach to the Management of Contaminated Harbour Sediment: Peninsula Harbour Ecological Risk Assessment. M. Henning, ENVIRON International Corporation, Portland, ME; K. Leigh, P. Fuchsman, T. Barber, ENVIRON International Corporation, Cleveland, OH; R. Santiago, Environment Canada, Downsview, Ontario, Canada. An ecological risk assessment was conducted to estimate risks to benthic invertebrates, fish and wildlife posed by mercury and polychlorinated biphenyls (PCBs) in sediment and biota from Peninsula Harbour, Lake Superior. The goal of the analysis was to understand the extent to which sediment management is warranted to protect such ecological receptors. Area use factors and spatially weighted exposure concentrations were employed to illustrate the effect of varying assumptions regarding the extent to which biota forage within the more contaminated Jellicoe Cove area of the harbour. The analysis found that, based on multiple lines of evidence, benthic invertebrates are not at significant risk due to mercury and PCBs. Current mercury levels may reduce reproductive success in bottom-feeding fish species, but other fish species do not appear to be adversely affected by current conditions. Waterfowl are unlikely to be adversely affected by current concentrations of mercury and PCBs in prey from the harbour. Current concentrations of mercury in fish are not expected to adversely affect piscivorous mammals, but may reduce reproductive success in individual piscivorous raptors. Current concentrations of PCBs in fish are not expected to adversely affect piscivorous birds, but may reduce reproductive success in piscivorous mammals. Although adverse effects are predicted for certain receptors, risk estimates are not so high as to suggest mortality, but some reproductive and developmental effects cannot be ruled out. Effects on bottom-feeding fish have the potential to propagate to the population level, while effects on piscivores are more likely to be restricted to individual organisms and thus are unlikely to have population-level consequences.

RP135 An Integrated Approach to the Management of Contaminated Harbour Sediment: Peninsula Harbour Human Health Risk Assessment. C. Stubbs, I. Benekos, ENVIRON International Corporation, Emeryville, CA; M. Henning, ENVIRON International Corporation, Portland, ME; T. Barber, ENVIRON International Corporation, Cleveland, OH; R. Santiago, Environment Canada, Downsview, Ontario, Canada. Risks to human health

from mercury and polychlorinated biphenyls (PCBs) in fish consumed from Peninsula Harbour, Lake Superior, were evaluated in order to better understand the extent to which sediment management is warranted to protect human health. The assessment assumed unrestricted fishing in Peninsula Harbour by hypothetical sport anglers and subsistence anglers, even though a fish consumption advisory is currently in place and no local survey results are available to confirm the use of the Harbour by anglers. For all scenarios, estimated risks posed by PCBs in fish were consistently higher than those posed by mercury. For example, while adult sport anglers that target lake trout were not predicted to experience adverse health effects from methylmercury in fish, adverse effects from PCBs in fish were predicted if such anglers derive more than 5% of their fish diet from Peninsula Harbour. Young children of sport anglers were predicted to be adversely affected by methylmercury in lake trout if 50% or more of their fish diet is derived from Peninsula Harbour. These family members were predicted to be adversely affected by PCBs in fish even if as little as 5% of the fish they consume is derived from Peninsula Harbour. Adult subsistence anglers that consume longnose sucker, lake trout, and lake whitefish were predicted to be at risk from methylmercury in fish tissue only if all of the fish they consume comes from Peninsula Harbour. Subsistence anglers were predicted to be adversely affected by PCBs in fish even if as little as 5% of the fish they consume is derived from the harbour. Children of subsistence anglers were predicted to be adversely affected by methylmercury in fish if they derive 25% or more of the fish they consume from Peninsula Harbour. These family members were predicted to be adversely affected by PCBs in fish even if as little as 5% of the fish they consume is derived from the harbour. Given the potential risks to human health, risk management measures are recommended. These measures could include 1) conducting a local fish consumption survey to determine whether anglers are actually consuming fish from Peninsula Harbour and 2) taking steps to ensure the effectiveness of the existing fish consumption advisory.

RP136 An Integrated Approach to the Management of Contaminated Harbour Sediment: Peninsula Harbour Remediation Goals, Management Areas, and Residual Risk. M. Bock, E. Martin, M. Henning, A. Piper, ENVIRON International Corporation, Portland, ME; T. Barber, ENVIRON International Corporation, Cleveland, OH; R. Santiago, Environment Canada, Downsview, Ontario, Canada. The extent to which sediment management in Peninsula Harbour is warranted to protect human health and the environment was explored based on sediment management goals calculated based on the findings of human and ecological risk assessments, existing guidelines, background concentrations in fish, and source control of hot spots. To calculate risk-based sediment management goals, those ecological and human receptors found to drive risks were used to back-calculate fish tissue concentrations that would not be expected to cause adverse effects in those receptors. A food web bioaccumulation model was used to estimate sediment concentrations that would be required to achieve target fish tissue concentration goals based on the risk assessment, tissue guidelines, and background levels. In order to characterize the area and volume of sediment potentially warranting management based on these goals, the spatial distribution of mercury and polychlorinated biphenyls (PCBs) was first considered under current conditions. Simulations of various remedial scenarios were then employed to determine the area and volume of sediment warranting remediation in order to yield spatially-weighted average sediment concentrations that do not exceed the sediment management goals. Based on the available data on the distribution of mercury and PCBs in Peninsula Harbour, specific management areas were defined that would achieve sediment management goals. Volumes associated with those areas were estimated based on the depth of sediment in the harbour. The food web bioaccumulation model was used to predict post-remediation fish tissue concentrations; based on the predicted post-remediation fish tissue concentrations, residual risks and the percent reduction in risk were calculated. This analysis demonstrated that meeting sediment management goals would require extensive remedial actions in the harbour. Hot spot management for purposes of source control warrants consideration, as it can provide significant risk reduction based on a more modest remedial action.

RP137 Assessment of Contaminated Sediment in the Lower Trent River (Trenton, Ontario) using the Canada-Ontario Agreement Framework. D. Milani, L.C. Grapentine, Environment Canada, Burlington, Ontario, Canada; R. Fletcher, Ministry of the Environment, Etobicoke, Ontario, Canada. Elevated levels of sediment dioxins and furans (PCDD/Fs) in the lower Trent River (Trenton, Ontario), part of the Bay of Quinte Area of

Concern, led to the evaluation of whether these sediments were polluted using the Canada-Ontario Agreement framework. Site assessments were performed using integrated information from sediment chemistry, benthic invertebrate communities, sediment toxicity and the potential for contaminant biomagnification. The potential for biomagnification was assessed by measuring tissue contaminant concentrations in laboratory-exposed mayflies, caged mussels and young-of-year fish. Concentrations of PCDD/Fs and coplanar (dioxin-like) PCBs in the sediment, expressed in total toxic equivalency (TEQ) units, were as much as two times Sediment Quality Guidelines, with PCDD/Fs contributing almost the entire total TEQ. There was mild chronic toxicity to the oligochaete worm *Tubifex tubifex* at several sites due to a lower percentage of hatched cocoons and lower production of young compared to reference. The cause of toxicity was not clear but did not appear to be related to PCDD/Fs or PCBs. There was no strong evidence of degraded benthic communities as most communities were equivalent to reference or possibly different from reference conditions; differences were generally associated with increased diversity and increased abundances of certain taxa. PCDD/Fs in laboratory-exposed mayflies were above the Tissue Residue Guideline (TRG) for the protection of wildlife consumers of aquatic biota at about half the sites; coplanar PCBs in the mayflies were above the TRG at all sites. Caged mussels and resident young-of-year fish PCDD/Fs and coplanar PCB tissue levels were above guidelines in certain locations of the lower river. Based on the decision-making framework, management actions were not indicated at any site. However, the need to fully assess the risk of biomagnification due to PCDD/Fs and coplanar PCBs was indicated. Consequently, a detailed ecological risk assessment was recommended.

RP138 Northern Wood Preservers Sediment Remediation Project (Thunder Bay Harbour). R. Santiago, Environment Canada, Toronto, Ontario, Canada; P. Inch, Ontario Ministry of the Environment, Thunder Bay, Ontario, Canada. Contaminated sediments are recognized as significant contributors to impaired water quality in the Great Lakes. Thunder Bay Harbour sediment contamination of polycyclic aromatic hydrocarbons (PAHs), chlorophenols, dioxins and furans around Northern Wood Preservers contributed to the International Joint Commission's (IJC) identification of the Harbour as an Area of Concern. In order to delist the area, government agencies, industry and the public partnered to develop a Remedial Action Plan (RAP) that identifies water use goals and initiatives for the remediation of the harbour. The remediation of contaminated sediment at Northern Wood Preservers is a key element of this plan. Abitibi-Consolidated Inc., Northern Wood Preservers Inc., and Canadian National Railway Co., together with Environment Canada and the Ontario Ministry of the Environment developed and implemented a remediation plan for the site (referred to as the Northern Wood Preservers Alternative Remediation Concept (NOWPARC)), to isolate the contaminant source, clean-up the contaminated sediment, and enhance fish habitat. A biological assessment study was conducted by the Ontario Ministry of the Environment to establish site specific clean up criteria. On the basis of measured biological effects, three cleanup zones were identified corresponding to areas of acute toxicity, chronic toxicity and no measurable toxicity. Remedial work commenced in August 1997 and was completed in the summer of 2003. Monitoring of the harbour sediment is on-going.

RP140 Application of a New Assessment Framework to Evaluate Sediment Quality in California Bays and Estuaries. S.M. Bay, A. Barnett, K.J. Ritter, S.L. Moore, Southern California Coastal Water Research Project, Costa Mesa, CA. Sediment Quality Triad data from multiple stratified random surveys were integrated to conduct a spatial assessment of sediment quality in California bays and estuaries. The objective of this analysis was to evaluate the impact of a new framework for sediment quality assessment in California. Novel aspects of this framework include a consistent set of indicators, multiple thresholds for interpreting each line of evidence, and an integration framework that emphasizes benthic community condition. Sediment chemistry, toxicity (amphipod survival), and benthic infaunal community composition data from 381 stations representing multiple EMAP and southern California Bight regional surveys conducted between 1999 and 2005 were combined to conduct the most comprehensive evaluation of California sediment quality to date. The individual triad components were integrated using new assessment framework developed for the California sediment quality objectives program that classified each station into one of five condition categories: unimpacted, likely impacted, possibly impacted, likely impacted, and clearly impacted. Overall, 83% of California embayments were classified into one of the three impacted categories, with the majority (63%) classified as possibly impacted,

the most uncertain classification. These results were dominated by San Francisco Bay, which comprised 79% of the area surveyed and had 96% of its area classified in one of the impacted categories. Other California embayments had a much lower proportion of potentially impacted sediments, ranging from 38% in southern California to 21% in the north. Several factors potentially responsible for the regional differences in the sediment quality assessment results were investigated, including variations in classification thresholds, study date, sample density, and data completeness. The influence of these factors on the results will be discussed.

RP141 Importance of Selenium in Seafood Risk: Benefit Evaluations.

N.V. Ralston, Energy & Environmental Research Center, University of North Dakota, Grand Forks, ND; J. Kaneko, PacMar Inc, Honolulu, HI. Maternal consumption of common varieties of ocean fish has not been associated with adverse fetal neurodevelopmental outcomes. Instead, recent studies performed in the U.K. find increasing maternal fish consumption provided substantial benefits to child neurodevelopment, while avoidance of fish during pregnancy had profound adverse consequences. The protective effects of selenium (Se) against Hg toxicity have been recognized for over 50 years, and have been demonstrated in all animal models evaluated. Since interactions between Se and Hg and their molar ratios in seafood are essential factors in evaluating risks associated with dietary Hg exposure, considering Hg content alone is an inadequate means of assessing risk. In this study, the absolute and molar concentrations of Hg and Se were determined in edible portions from 420 individual fish representing 15 species of pelagic fish collected from the central North Pacific Ocean near Hawaii. A molar excess of Se in relation to Hg was observed in most fish species. The rank order of Se:Hg molar ratios was striped marlin (17.6) > yellowfin tuna (14.1) > mahimahi (13.1) > skipjack tuna (12.8) > spearfish (11.4) > wahoo (10.8) > sickle pomfret (6.7) > albacore tuna (5.3) > bigeye tuna (5.2) > blue marlin (4.1) > escolar (2.4) > opah (2.3) > thresher shark (1.5) > swordfish (1.2) > mako shark (0.5). Mako shark may be hazardous for maternal consumption since its Se:Hg ratio approaches that of pilot whale meat (~0.25), a food known to be associated with adverse effects on child neurodevelopment. All well characterized instances of Hg toxicity have involved exposures that resulted in Hg in molar excess of Se. Although ocean fish are generally Se-rich, the amount of protective Se present in fresh water fish can vary dramatically depending on soil Se concentrations and pH. As a result, Hg levels that are safe in fresh water fish from areas with normal or rich Se may constitute major Hg toxicity risks in areas where Se availability is poor. Furthermore, lack of bioavailable Se can limit Hg-retirement and result in accentuated Hg bioaccumulation such as those observed in 'Hg-hotspot' regions of the Northeastern U.S. Comprehensive criteria that incorporate absolute molar concentrations and Hg:Se ratios present in fish will provide an improved basis for assessing environmental risk and food safety issues concerning Hg.

RP142 Development of Site-Specific Bioaccumulation Factors for Selenium.

D.B. Simmons, Watershed Ecosystems Graduate Program, Trent University, Peterborough, Ontario, Canada; A. McDonald, D. Wallschlaeger, Environmental Resource Sciences, Trent University, Peterborough, Ontario, Canada. Phytoplankton can be used as an indicator organism to provide valuable information about the movement of selenium species in freshwater systems. In our method the species *Chlorella vulgaris* was used as a biomonitoring organism to gather site-specific information about the concentration, kinetics and fate of selenium in the natural environment. *Chlorella vulgaris* is presented as an excellent species to determine the kinetics of selenium uptake in freshwater ecosystems as it is a small, rugged species of algae which can undergo rapid growth in ideal conditions. Additionally, *Chlorella* has demonstrated bioaccumulation factors of over 10 for selenium in aquatic test systems. In order to test Selenium uptake kinetics models and site-specific bioaccumulation factors, a novel methodology has been developed. Passive Algae Diffusion Samplers (PADS) consisting of pure cultures of *C. vulgaris* grown in semi-solid medium contained within a semi-permeable membrane were constructed. Stages in method development will be demonstrated and the results from the most efficient and effective design will be presented including the conditions of growth, chlorophyll a and total selenium. In order to determine selenium uptake, algae from PADS were microwave-digested and analyzed for total selenium using inductively-coupled-plasma mass-spectrometry (ICP-MS).

RP143 Selenium bioaccumulation by juvenile desert pupfish (*Cyprinodon macularius*) during a chronic dietary and aqueous selenium exposure. C.D. Ivey, J.M. Besser, J.L. Kunz, W.G. Brumbaugh, C.G. Ingersoll,

U.S. Geological Survey, Columbia, MO; L. Wan, University of Missouri, Columbia, MO. The desert pupfish (*Cyprinodon macularius*), a federally-listed endangered species, inhabits aquatic habitats of the Imperial Valley and Salton Sea in southern California USA that have elevated concentrations of selenium (Se) in water and aquatic food webs. We are conducting a chronic life-cycle toxicity test with desert pupfish exposed concurrently to waterborne and dietary selenium to evaluate the potential for toxic effects of selenium on pupfish populations. In the first phase of these studies, juvenile pupfish were exposed simultaneously to five exposure levels of aqueous and dietary Se for 12 weeks in a slightly saline (5 g/L) test water. Pupfish were exposed to a mixture of inorganic selenium species (85% selenate and 15% selenite) in water and were fed Se-dosed diets consisting of live oligochaetes (*Lumbriculus variegatus*), previously dosed for four weeks with yeast enriched with the S-amino acid, selenomethionine. After 8 weeks of selenium exposure, pupfish in the highest exposure level (48 ug Se/L in water and 56 ug/g Se dry wt. in diet) accumulated whole-body Se concentrations as high as 22 ug/g (dry weight). Whole-body Se concentrations in pupfish from the four highest exposure levels averaged 37% of Se concentrations in oligochaete diets and consisted predominantly of selenomethionine (69% of total Se). After 12 weeks of selenium exposure (about 16 weeks post-hatch), pupfish had reached reproductive maturity and showed no effects on survival or growth at any exposure level tested. These preliminary results suggest that juvenile desert pupfish are relatively insensitive to chronic Se toxicity. Ongoing studies will continue this exposure regime to evaluate effects of selenium on adult reproduction and on survival, growth, and morphological deformities of offspring.

RP144 Selenium in Fish Tissue: Prediction Equations for Conversion between Whole body, Muscle, and Eggs.

B.C. Osmundson, Division of Environmental Quality, U.S. Fish & Wildlife Service, Grand Junction, CO; J.P. Skorupa, Division of Environmental Quality, U.S. Fish & Wildlife Service, Arlington, VA; T.W. May, Columbia Environmental Research Center, U.S. Geological Survey, Columbia, MO. A U.S. Department of the Interior irrigation drainwater study of the Uncompahgre Project area and the Grand Valley in western Colorado revealed high selenium concentrations in water, sediment, and biota samples. Within the study area, portions of the Gunnison and Colorado River, plus associated tributaries, appear on the CWA 303(d) list of impaired waterbodies for the State of Colorado because of elevated selenium concentrations. The lower Gunnison River and the Colorado River (including the 100-year floodplain) are also designated critical habitat for two endangered fish species: the Colorado pikeminnow and the razorback sucker. The U.S. EPA has recently proposed using a whole body fish tissue selenium criterion to protect aquatic life. Other researchers have used fish whole body, muscle, and ovary (plus egg) tissue selenium residues to assess hazard from selenium toxicity. The endangered status of the Colorado River fish precludes collection of whole body and ovary samples to assess selenium hazard. We have been able to use the non-lethal sampling procedure of collecting muscle plugs to determine selenium residues. There was a need for an accurate and validated conversion factor which predicts selenium concentrations in whole body fish plus ovarian concentrations from measured muscle plug residues. We developed a model to predict fish whole body and ovarian selenium concentrations from a measured muscle plug residue using a high accumulator species (green sunfish) and a low accumulator species (white suckers). This model was tested on other species occurring within critical habitat in the upper Colorado River Basin. The model will be used to assess selenium risk to the endangered Colorado River fish. Seasonal patterns of selenium incorporation into whole body, muscle, and ovary tissues were investigated, as well as sexual differences in selenium loads.

RP145 Selenium accumulation and effects in aquatic organisms downstream of a uranium mining and milling area in northern Saskatchewan, Canada.

J.R. Muscatello, A. Belknap, D.M. Janz, Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; D.M. Janz, Department of Veterinary Biomedical Sciences, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Elevated concentrations of selenium have been reported in water, sediments and fish tissues downstream of uranium mining and milling operations in northern Saskatchewan, Canada. Dietary, as opposed to aqueous, exposure is the most important route of selenium exposure in aquatic organisms. A major implication of elevated environmental selenium levels is its propensity to bioaccumulate through aquatic food webs, resulting in potential adverse effects (e.g., impaired reproduction) on top predatory fish. The objective of the present study was

to determine total selenium concentrations in all major compartments of the aquatic ecosystem downstream of a uranium milling operation, and to correlate these with the appearance of selenium-induced deformities in a native fish specie, northern pike (*Esox lucius*). Water, sediment, plankton, periphyton, invertebrates and small bodied fish samples were collected from a reference lake and two exposure lakes, all within the same watershed. Selenium concentrations were consistently higher for all trophic groups from both exposure sites in comparison to the reference site. Our results suggest that selenium was accumulated through the food chain even though the water concentrations were low (approximately 0.8-2.6 µg/L). The bioaccumulation of selenium in prey items at the exposure sites was sufficient to result in elevated selenium-induced larval deformities in northern pike, a top predatory fish species.

RP146 Deformity evaluation in northern pike and white sucker exposed to uranium mining and milling effluent. J.R. Muscatello, D.M. Janz, Toxicology Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada; D.M. Janz, Department of Veterinary Biomedical Sciences, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Effluents from uranium mining and milling operations generally contain elevated concentrations of various metals (e.g., U, Ni, As, Se, Mo) and ions (e.g., sulfate, ammonium). Our previous work showed elevated deformities in northern pike exposed to uranium milling effluent at a site in operation for more than 20 years. The objective of the present study was to evaluate potential selenium-induced terata (craniofacial, skeletal, and fin deformities) and edema in northern pike (*Esox lucius*) and white sucker (*Catostomus commersoni*), exposed to effluents from a uranium mine in operation for less than 10 years. Spawning fish were collected from a reference site and an exposure site located downstream of effluent discharge. A two-way ANOVA design was employed with embryos originating from reference and exposure sites incubated in both reference and exposure water. Mean egg selenium concentrations were significantly higher in pike (8.02 µg/g (dry weight)) and white sucker (4.89 µg/g (dry weight)) from the exposure site compared to reference site (2.35 µg/g and 1.94 µg/g, respectively). Among all evaluated deformities, only edema in white sucker fry was significantly elevated compared to the reference site. Our results are consistent with published selenium tissue thresholds for early life stage abnormalities in other fish species, with selenium accumulation in pike and white sucker collected at this site below the 10 µg/g egg threshold associated with elevated deformities.

RP147 Variability in Selenium Bioaccumulation as a Function of Site Type and between Fish Species. D.K. DeForest, Parametrix, Bellevue, WA; W.J. Adams, Rio Tinto, Magna, UT; K.V. Brix, EcoTox, Jacksonville, FL. Selenium in aquatic environments can be present in many different inorganic and organic forms, each of which is differentially bioavailable and bioaccumulative. In nature, selenium concentrations in fish predominantly result from dietary exposure to organoselenium. The relative amount of organoselenium in an aquatic system in turn depends on site-specific factors that favor its formation (such as high biological productivity, reducing conditions). Thus, although water bodies may have similar aqueous selenium concentrations, selenium concentrations in fish can be highly variable. To help overcome this site-to-site variability, the draft ambient water quality criterion for selenium developed by the USEPA is expressed as a whole body fish tissue residue. The draft criterion is based on the sensitivity of bluegill (*Lepomis macrochirus*) simultaneously exposed to cold stress and consists of a summer/fall monitoring "trigger" of 5.85 µg/g dry wt. and a criterion of 7.91 µg/g dry wt. In order to evaluate the potential implications of these two values, co-located aqueous and fish tissue selenium concentrations (including bluegill) were compiled from several sites throughout North America. Bioaccumulation trends as a function of site type (e.g., lentic vs. lotic) and the propensity for different site types to exceed the monitoring trigger and criteria values were assessed. Variability in selenium bioaccumulation between species within a site was also evaluated as this has important implications for implementing a tissue-based criterion.

RP148 Development of a Site-specific Standard for Selenium in Open Waters of Great Salt Lake, Utah. W.O. Moellmer, T. Miller, Division of Water Quality, Utah Department of Environmental Quality, Salt Lake City, UT; H. Ohlendorf, CH2M HILL, Sacramento, CA; J. DenBleyker, CH2M HILL, Salt Lake City, UT. The Great Salt Lake (GSL) is a unique terminal lake located adjacent to a rapidly growing metropolitan area in Utah. The open waters of the GSL are protected for their current beneficial uses through the application of a narrative criteria clause in the state water quality standards.

The Utah Department of Environmental Quality (DEQ) initiated a process in 2004 to develop a site-specific numeric water quality standard for selenium for the open waters of the GSL to balance protection of the GSL's unique ecology and beneficial uses with burgeoning development. The process the DEQ initiated included the formation of a Great Salt Lake Water Quality Steering Committee and a Science Panel to identify the studies required, manage the studies and finally recommend a site-specific standard. The Steering Committee provides a forum for stakeholders to assist in guiding the process of developing numeric standards for the lake. This group consists of federal and state regulatory agencies, other public entities, conservation organizations, recreation groups, and industrial users of the lake. The Science Panel, composed of nine members representing federal and state regulatory agencies, industry and academia, advises the DEQ and Steering Committee and provides overall technical direction and review for the program. A partnership of researchers—including local and national experts from education and industry—are collaborating with the DEQ, the Steering Committee, and the Science Panel to complete the studies required to provide essential information for derivation of the site-specific standard for selenium in the open waters of GSL. Studies are currently under way to assess concentrations and effects of selenium in five species of birds; measure concentrations of selenium in water, seston, brine shrimp, and brine flies; measure selenium loads entering the GSL; and measure flux of selenium from water to other media. Information from these studies will be used to "populate" the elements of a comprehensive conceptual model for the GSL to describe sources, loads, transfer factors, and concentrations of selenium in important resources of the lake (e.g., birds and their food webs) that will be used to establish the site-specific standard for selenium.

RP149 Review of Dietary Toxicity Endpoints for Aquatic Birds Exposed to Selenium. A.V. Pawlisz, Arcadis-BBL, Sarasota, FL; T. Bartol, Saint Johns River Water Management District, Palatka, FL; J. Schell, Arcadis-BBL, Houston, TX. Literature on the toxicity of selenium to birds is extensive. This is due to the multitude of selenium chemical states, each with a specific toxicological potential. However, the chemical form that is most relevant in aquatic food chain exposures consists of selenomethionine. This organic metalloid not only readily bioaccumulates in aquatic biota, but also is highly toxic to birds. In this poster presentation, we review and list the toxicological results of key dietary studies on selenomethionine and aquatic birds. The studies were identified via a literature search using query parameters, which considered bird species (i.e., aquatic vs terrestrial birds), constituent delivery method (i.e., dietary vs egg injection), chemical form (i.e., inorganic vs the organic form of selenium), age (i.e., adult or juvenile), water content of feed (i.e., wet or dry), dose (i.e., no-effect vs effect levels), toxicological endpoint (i.e., growth, reproduction, mortality), and exposure duration (only long-term exposure studies were considered). A total of 72 separate toxicity results (from the lower range of the reported concentrations) were identified for various bird species exposed to selenomethionine in diet. These were sorted in the order of increasing dose level and were listed in a table. A dietary threshold associated with no effects on survival, reproduction, and growth was identified at about 4 ppm dry weight for mallard ducks. Adverse effects on growth (45% reduction compared to controls; significant at P<0.05) and egg fertility (21% reduction compared to controls; significant at P<0.05) of the same species were seen at 7 ppm dry weight in diet. At 8 ppm dry weight in diet, mallard juveniles experience mortality (19% increase compared to controls; significant at P<0.05). Therefore, literature data show that the avian toxicological threshold for the dietary exposure to selenomethionine is somewhere between 4 and 8 ppm dry weight.

RP150 Impact of Selenium on Birds in Phosphate Mining Region of Southeast Idaho. E.O. Garton, R.V. Miller, J.T. Ratti, Fish and Wildlife, University of Idaho, Moscow, ID. Field surveys of breeding red-winged blackbirds and American robins on 53 sites in the phosphate-mining region of Southeast Idaho were conducted in 2001-2002 to estimate breeding bird density, nest density and reproductive success of these bird populations. A single egg was removed from each of 657 nests monitored and analyzed for selenium content to assay the impact of selenium contamination on reproductive success of these populations. Analysis of the impact of selenium level on nesting success and fledging success of individual blackbird and robin nests indicated that reproductive success increased with increasing levels of selenium up to a peak at 7 ppm selenium in eggs for robins and 20 ppm selenium in eggs for blackbirds before declining at higher levels of selenium in eggs. Is this the first clear demonstration using field measurements

of the transition of selenium from an essential micronutrient at low levels to a toxic contaminant at higher levels? It demonstrates dramatically different sensitivities to toxic selenium levels in these 2 bird species. To assess population-level responses we used stratified random sampling of 3 key riparian strata classified by the National Wetland Inventory to estimate the size of the red-winged blackbird and American robin populations at the end of the 2001 breeding season. Mean bird density and reproductive success estimates for each of these strata were incorporated into simulation models to predict population sizes through time. A realistic stochastic simulation model incorporating immigration and variation in demographic rates projects that the current red-winged blackbird metapopulation fluctuates annually with a mean of 399,500 and standard deviation of 60,000. The total American robin population in the buffer zone along streams and lakes is projected to average 2400 female birds with a standard deviation of 300 birds. This population-level assessment of the impact of selenium on red-winged blackbirds and American robins demonstrates a generally positive impact of selenium contamination from phosphate mining in 2001-2002 on these 2 species occupying this selenium deficient region but a potential for negative effects in localized areas where selenium contamination of surface waters reaches high levels.

RP151 Derivation of a Hydric Soil Cleanup Number for Cadmium. J.A. Bleiler, K. Cerreto, C. Archer, ENSR, Westford, MA; B. Burgess, ENSR, Florence, AL. An investigation of a cadmium-contaminated palustrine wetland in the southeastern USA was recently conducted to evaluate cadmium bioavailability, determine whether a potential risk to ecological receptors occurs, and develop risk-based preliminary remedial goals (PRGs). Cadmium is present in a 15 acre area of hydric soils at concentrations ranging from background levels to approximately 160 mg/kg. To evaluate the potential for ecological risks, a biological and chemical testing program was conducted. This program included 14-day toxicity testing with a hydrophytic plant (*Echinochloa crusgalli*), 10-day toxicity testing with an early life stage amphibian (northern leopard frog (*Rana pipiens*), Selective Sequential Extraction (SSE) procedures to evaluate the potentially bioavailable fraction of cadmium, 28-day bioaccumulation testing with earthworms (*Eisenia foetida*), and field collection of adult amphibians for tissue residue analysis. Potential risks associated with cadmium exposure were evaluated using a weight-of-evidence approach, which considered strengths and weaknesses of various endpoints. The SSE analysis suggested that cadmium was potentially mobile, and results of the biological and toxicological testing programs suggested that ecological receptors do not generally appear to be at risk of lethal, or acute, harm due to exposure to cadmium. However, at several sampling locations representing the upper bound range of cadmium concentrations evaluated, sub-lethal effects on plants and amphibians were observed at concentrations ranging from 120 to 160 mg/kg cadmium for amphibians and 90 to 160 mg/kg for plants. In addition, cadmium was found to accumulate in earthworm tissue, and to a much lesser extent in the field-collected amphibians. Although there is some uncertainty associated with interpreting the significance of the tissue residue analyses, the tissue data suggested that a range of 50 to 125 mg/kg cadmium in soil is considered protective of amphibians and a range of 100 to 110 mg/kg cadmium in soil is considered protective of invertebrates such as earthworms. These ranges, when considered in conjunction with the sub-lethal toxicity effects ranges measured in the amphibian and plant toxicity studies, indicated that a hydric soil cadmium concentration of approximately 100 mg/kg is protective of the majority of ecological receptors at the site, and therefore this value was selected as the PRG.

RP152 Modeling the effect of environmental variables on the reproduction of *Paronychiurus kimi* for estimating baseline toxicity. J. Son, K. Cho, Environmental Science and Ecological Engineering, Korea University, Seoul, South Korea; K. Shin, Statistics, Hankuk University of Foreign Studies, Yongin, South Korea. What is the most important thing to conduct ecological soil risk assessments (ERAs) is to understand the adverse effect caused by heterogeneous natures of soil themselves. Moreover, when conducting in ERA with polluted soil it is difficult to search the reference soils where the historical origin and soil properties are same with the contaminated soil. There is, therefore, an urgent need to study how the reproduction of test animals varies depending on the soil physicochemical properties. In this study, a circumscribed central composite (CCC) design with five levels and three factors (pH, organic matter and clay) was used to estimate the optimal reproduction of *Paronychiurus kimi* at a certain combination of soil physicochemical properties. According to the previous study, these soil characteristics significantly affected the 28-d reproduction of *P. kimi*, an

indigenous collembolan species in Korea. In this study, 28-d reproduction of *P. kimi* could be modeled as functions of these soil physicochemical properties as well as the level of significant effect on the reproduction of *P. kimi* caused by these soil physicochemical properties were different from one another. The result of present study will be used as a reference value for the optimal reproduction of *P. kimi* at a certain soil physicochemical properties. Further research on the validation of the present model, of course, remains to be resolved. *Funded by Korea Institute of Environmental Science and Technology (No. 2007-09001-0043-0)

RP153 Canadian Soil Quality Guidelines for Polynuclear Aromatic Hydrocarbons. D. Spry, K. Potter, Environment Canada, Gatineau, Ontario, Canada; S. Coad, C. Rowat, Health Canada, Ottawa, Ontario, Canada; D. Bright, UMA Engineering, Victoria, British Columbia, Canada. Development of Canadian Soil Quality Guidelines entails a review of recent scientific information on the chemical and physical properties of potentially carcinogenic and other commonly analyzed unsubstituted PAHs; sources and emissions in Canada; expected environmental fate; toxicological significance of these PAHs to soil microbial processes, plants, animals and humans. This information is used to derive soil quality guidelines for PAHs to protect human health and ecological receptors for: agricultural, residential/parkland, commercial and industrial land uses according to published protocols (CCME, 2006). The lowest of the preliminary values for both human health and environmental health protection, are recommended as the Canadian Soil Quality Guidelines for each of the four land use types. Preliminary human health soil quality guidelines derived for the carcinogenic PAHs include compound-specific limits based on cancer-type endpoints. The guidelines also included assumptions regarding the relative cancer potencies of the individual PAHs. The preliminary environmental soil quality guidelines for PAHs included consideration of assumed threshold-acting (non-carcinogenic) effects on soil ecological functioning, and specifically on soil invertebrate and plant responses. For soil invertebrates, the major mode of toxic action might be non-polar narcosis, although other modes of toxicological action (photoinduced toxicity, for example) might be important in some cases, and may be inherent in some of the underlying toxicological data used to develop the preliminary direct soil contact guidelines. As a result, it was not possible to nominate a single SQG for each of human health and environmental health for the PAHs examined, since several compounds were examined, and the approach for dealing with PAH mixtures needed to be adapted for different exposure/receptor groups. Guideline values for some exposure pathways are based on the concentrations of the individual PAHs (e.g., mg fluoranthene /kg soil) while for other pathways they are based on potency relative to benzo[a]pyrene (i.e., mg B[a]P TPE /kg soil) and are intended to be considered together with any other PAHs present at the site. Consequently, it is recommended that the guidelines for all applicable pathways at a site be considered individually in determining whether there are exceedances.

RP154 Investigations into the aerobic biodegradation of 1H,1H,2H,2H-perfluorooctane sulfonate. E.B. Marchington, S.A. Mabury, Chemistry, University of Toronto, Toronto, Ontario, Canada. Fluorotelomer sulfonates are manufactured by the telomerization process and primarily used in fluorinated surfactant mixtures, such as aqueous fire-fighting foam (AFFF). Fluorotelomer sulfonates have the generic structure $F(CF_2)_nCH_2CH_2SO_3^-$, where n is an even number; for example, $F(CF_2)_6CH_2CH_2SO_3^-$ is 1H,1H,2H,2H-perfluorooctane sulfonate (THPFOS). THPFOS has been detected in human blood and serum samples, AFFF-contaminated ground water, and wastewater treatment plant (WWTP) influent and effluent. Fluorotelomer alcohols (FTOHs) have been shown to undergo aerobic biodegradation under WWTP conditions to form perfluorinated carboxylic acids (PFCAs), and it has been proposed that fluorotelomer sulfonates could follow a similar degradation pathway after oxidation of the C-S bond. An experimental set-up involving two systems, one closed and another with air flowing through XAD traps, spiked with mixed liquor bacteria and THPFOS, was developed to test biodegradation. Through the analysis of non-volatile degradation products in liquid samples from both systems via LC/MS/MS, and analysis of volatile degradation products from the purge system via XAD extraction and GC/MS, a mechanism of THPFOS biodegradation has been proposed. It is expected that after C-S bond cleavage by bacteria, the 6:2 FTOH will form and then degrade to perfluorohexanoic acid (PFH_xA); these metabolites have been identified in the systems and quantification is in progress. Future work includes analysis of the biodegradation of other fluorotelomer sulfonates and fluorosurfactants of interest.

RP155 The Fate of Fluorotelomer Carboxylic Acids (FTCAs) in Abiotic Environments. A. Myers, S. Mabury, Chemistry, University of Toronto, Toronto, Ontario, Canada. Fluorotelomer carboxylic acids (FTCAs) are degradation products of fluorotelomer alcohols (FTOHs), which are released into the environment through the production and use of industrial fluorinated polymers and surfactants. FTOHs are widely dispersed and eventually undergo atmospheric oxidation to produce FTCAs. FTCAs have subsequently become widely dispersed in the aquatic environment as a result of their lower volatility and higher water solubility. FTCAs eventually biodegrade to perfluorocarboxylic acids (PFCAs), such as perfluorooctanoic acid (PFOA). Although PFCAs have been the focus of environmental concern, attention is turning to precursor degradation compounds such as FTCAs and the corresponding fluorotelomer unsaturated carboxylic acids (FTUCAs). FTCAs and FTUCAs have been detected in various environmental samples including bottlenose dolphins and precipitation, and have been shown to be more toxic in aquatic invertebrates than PFCAs themselves. Past studies have encountered difficulties while working with FTCAs because they undergo dehydrofluorination to FTUCAs and partition to container walls. This study attempts to understand the basic abiotic behaviour of FTCAs and FTUCAs through mesocosm studies incorporating environmental variables and LC/MS/MS analysis. Results of these experiments will be useful in directing future toxicological studies and field campaigns interested in these contaminants.

RP156 An Accurate pKa Determination of Monomeric PFOA and its Environmental Implications. D.C. Burns, H. Li, Worsfold Water Quality Centre, Trent University, Peterborough, Ontario, Canada; D.A. Ellis, Chemistry, Trent University, Peterborough, Ontario, Canada; E. Webster, L.K. Reid, D. Mackay, Canadian Environmental Modelling Centre, Trent University, Peterborough, Ontario, Canada. Perfluorooctanoic acid (PFOA) belongs to a class of perfluorinated carboxylic acids (PFCAs) that are used in the production of non-stick cookware, waterproof textiles, electronics, and other industrial products. It is also a persistent organic pollutant that has been detected in the blood sera of mammals (including humans), birds, and fishes. The persistence, bioaccumulation potential, and possible toxicity of PFOA has prompted increased efforts from the scientific community to better understand its long-range transport and environmental dissemination. Until now, these efforts have been directed towards the study of PFO (deprotonated PFOA) because the percentage of acid in an environmental system is thought to be negligible. However, this assumption has been based on pKa values for which PFOA is in equilibrium between an aggregated and monomeric state; a situation that is not likely to be encountered at environmental concentrations. Herein are presented two methods, a titrimetric-based method and a quantitative ¹⁹F NMR-based method, which together probe the influence of aggregation on PFOA pKa. From these studies it was found that aggregation significantly lowers the pKa of PFOA, and that the measured value is in fact the equilibrium-weighted average of both the monomeric and aggregated species. The pKa of monomeric PFOA was found to be 3.4. In general, the environmental fate of PFCAs, including PFOA, has been associated with anion transport (i.e. deprotonated PFO-) via ocean-water flux, atmospheric decomposition of fluorotelomer alcohol (FTOH) analogues, as well as atmospheric marine aerosol transport. These models have been put forward based on the assumption that the pKa of PFOA is ~ 2.5. However, we have found that the pKa of monomeric PFOA is 3.4, so that at normal environmental pHs there will exist a significant proportion of PFOA in solution (ca. 10% in rainwater, pH 4.5). Given the Kaw of PFOA, large bodies of water such as lakes and oceans may now be considered as a viable source of PFOA to the atmosphere.

RP157 Development of an ecotoxicological risk assessment (ERA) approach for the sediments of the St. Lawrence river. L. Martel, M. Desrosiers, S. Masson, CEAEQ, Sainte-Foy, Quebec, Canada; M. Babut, M. Desrosiers, Cemagref, Lyon, Rhône-Alpes, France; C. Bélanger, Environment Canada, Montréal, Quebec, Canada; P. Michon, MDDEP, Québec, Quebec, Canada; S. Masson, PAQ-SEPAQ, Québec, Quebec, Canada. The sustainable navigation strategy, drawn up under the aegis of the St. Lawrence Action Plan III, explicitly identifies the need to develop sediment quality assessment tools. More specifically, the implementation of such a strategy for the St. Lawrence River entails the development of a risk assessment framework for sediments taking into account the various management options. An ERA approach using a chemical characterization in the initial stage and biological bioassays in the subsequent stages is currently under development. The first management option addressed in this perspective is the discharge of dredging

sediments in unconfined water. In this case, in addition to establish the level of contamination and toxicity of dredged sediments, it is essential to determine what will become of the deposit and to take into account the hydrodynamic characteristics of the discharge site. Interstitial water and colloids are rapidly dispersed in the water column, whereas particles may form deposits, then be subject to erosion or be covered by the natural sedimentation at the site. As a result, the assessment parameters cover three types of potential impacts: the short-term survival of pelagic organisms, the potential for the recolonization of the deposit by benthic organisms, and the reproductive success of sensitive fish species. This presentation will describe the various stages of the ERA and the measurement tools considered, as well as the future steps in the development of this approach. This work is being carried out within the context of a cooperation program involving Environment Canada, the Ministère du Développement Durable, de l'Environnement et des Parcs du Québec, and Cemagref groupement de Lyon.

RP158 The Assimilation of Nutrients From Municipal Waste Water Effluent Within a Heavily Impacted Watershed. H.A. Loomer, M.R. Servos, Biology, The University of Waterloo, Waterloo, Ontario, Canada. Stable isotopes are used as a tool in the construction of food webs. It has been observed that anthropogenic nitrogen inputs shift the nitrogen signature of aquatic organisms which can potentially affect the usefulness of this tool. The mechanism underlying this shift is not well understood and it is unclear how anthropogenic sources and natural cycling will affect nitrogen signatures in the biota. The Grand River Watershed in Southern Ontario houses 27 waste water treatment plants and is dominated by agricultural activities in the upper reaches. During three seasons (spring, summer and fall), invertebrate and fish species were collected to define food webs along river reaches influenced by MWW and agricultural run-off. Sites impacted by MWW showed shifts in $\delta^{15}\text{N}$ signatures at the base of the food chain which were conserved through the food chain. This shift appeared to differ between treatment plants indicating that treatment processes may change the $\delta^{15}\text{N}$ of the various nitrogen forms within the effluent which are available for assimilation by biota in the receiving environment. This study investigates the complex relationship between treatment processes, food web dynamics, and isotope dynamics.

RP159 Multi-Trophic-Level Assessment of a Southeastern United States Stream. S. Hall, Ecotoxicology, ADVENT-ENVIRON, Brentwood, TN; S. Hall, Ecotoxicology, ENVIRON, Brentwood, TN. A multi-trophic-level assessment was conducted to characterize the structure of key components of a small, effluent-dominated stream and reference stream in the southeastern United States. The periphyton, benthic macroinvertebrate, and fish communities were assessed. Periphyton community metrics (diatom and soft algae) and chlorophyll-a assessments were utilized, as were macroinvertebrate and fish community metrics specific to the region. Appropriate control sites were selected to account for stream sedimentation and habitat alteration. Chlorophyll-a data indicated the stream was of low-productivity, and were too imprecise to be a useful metric. The Siltation Index and taxa composition metrics were useful indicators of periphyton conditions, as were species-specific assessments that indicated the sites were dominated by silt-tolerant Nitzschia and Navicula. The seven benthic macroinvertebrate metrics applied were useful indicators of benthic community health, with the abundance of silt-tolerant organisms reflected by high percent oligochaete and chironomid values. Other macro invertebrate metrics indicated subtle differences between control and study sites. Fish tolerance ratings and taxa richness metrics were also shown to be useful community metrics. Study results indicated the importance of considering habitat conditions in data interpretation, and pointed to useful metrics to assess the effects of silt. The importance of reference sites incorporating local watershed effects and controlling for habitat variables was demonstrated by comparison of benthic macro invertebrate metrics for the study-specific reference stream to "ecoregion reference values" for minimally impacted streams.

RP160 Sources of mercury, selenium, and other trace metals in wastewater streams at a coal-fired plant in eastern Ohio. R. Reash, American Electric Power, Columbus, OH. To meet upcoming effluent limitation requirements for mercury and selenium, a trace metal source study was conducted at a coal-fired power plant located in Coshocton County (eastern) Ohio, during 2006 and 2007. The plant burns bituminous medium to high sulfur Northern Appalachian Basin coal, with two of the four generating units equipped with lime-based flue gas desulfurization (FGD) systems. Most of the bottom and fly ash created by coal combustion is transported to a series of settling ponds. The supernatant in the final settling pond discharges to the

Muskingum River. We collected a series of coal, bottom ash, fly ash, FGD tank liquor, and various wastestream samples and analyzed these for trace metals, salts, and routine constituents. Washed coal (burned at two generating units) contained consistently lower concentrations of trace metals compared to unwashed coal. Maximum concentrations of As, Hg, and Se in coal samples were 21.6, 6, and 0.379 mg/kg, respectively. Metal concentrations in bottom ash samples were considerably lower than for fly ash samples. Trace metal leaching from fly ash particles was the dominant contribution of mass loading, in the wastestream samples, for Hg and most other trace metals. Levels of mercury and selenium from FGD wastestreams were often high, but the mass loading contribution was only about 1/7 that of fly ash contribution. While acute toxicity testing of the final effluent indicated no evidence of toxicity, the source evaluation study will provide insights into what actions can be taken to reduce loads of Hg and Se.

RP161 Is the Mechanism of Retene (Alkyl-PAH) Toxicity Similar to that of Dioxin? J. Scott, P.V. Hodson, Biology & School of Environmental Studies, Queen's University, Kingston, Ontario, Canada; J.P. Incardona, Ecotoxicology and Environmental Fish Health Program, Environmental Conservation Division, Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration, Seattle, WA. Complex mixtures of polycyclic aromatic hydrocarbons (PAHs), including crude oils, are often rich in 3-4 ring alkyl-substituted PAHs. In the early life stages of fish, chronic exposures of alkyl-substituted PAHs, such as retene (7-isopropyl-1-methylphenanthrene), are known to produce toxicity similar to that of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), characterized by the signs of blue sac disease. The hallmark signs include pericardial and yolk sac edema, cardiovascular dysfunction, and craniofacial deformities. The mechanism of toxicity of alkyl-substituted PAH toxicity is not well understood; however, it is thought to be mediated by the aryl hydrocarbon receptor (AhR) pathway and cytochrome P450 1A (CYP1A) induction. Using zebrafish embryos, the mechanism of retene toxicity was investigated via blockade of the AhR and CYP1A using antisense morpholino oligonucleotides. Retene toxicity was observed as early as 36 hpf, as indicated by the presence of pericardial edema and cardiovascular dysfunction. At 72 hpf, the ventricles were reduced in size, while the atrium appeared distended, suggesting the heart as the primary target. Circulation was reduced in the peripheral vasculature, likely as a result of decreased stroke volume and/or delayed development. Intracranial hemorrhaging and craniofacial defects were also observed. Blockade of AhR2 prevented toxicity, while CYP1A knockdown did not alter toxicity, suggesting that retene toxicity is dependent upon the AhR2 pathway and independent of CYP1A. These results are consistent with TCDD toxicity; however, the effects differed dramatically from those previously reported on phenanthrene (unsubstituted), which produced signs characteristic of AV conduction block independent of AhR2.

RP162 A predictive evaluation of whole effluent toxicity caused by power plant flue gas desulfurization (FGD) wastestreams. R. Reash, American Electric Power, Columbus, OH; T. Horsley, S. Hall, R. Lockwood, Advent-Environ, Corp., Brentwood, TN. Many coal-fired power plants across the United States are being fitted with flue gas desulfurization (FGD) sulfur dioxide removal units to comply with emission reduction requirements under the Clean Air Act. FGD units are very efficient at removing volatile trace metals (e.g., As, Hg, and Se) and chlorine (which is converted to chlorides in aqueous media). At many FGD units, a moderately saline, trace-metal enriched wastestream must be managed (or treated) to comply with effluent limitations based on state water quality standards. We conducted a predictive whole effluent toxicity evaluation in 2006 using: 1) existing coal ash pond water from eight midwestern power plant sites; 2) predicted concentrations of dissolved salts and trace metals; 3) 'spiked' ash pond water to simulate projected pollutant levels; and 4) mock (synthetic) simulated 'FGD wastestream influenced' ash pond water. Acute toxicity testing was conducted using fathead minnow and Ceriodaphnia dubia. All existing ash pond effluents did not exhibit acute toxicity. For spiked and/or mock sample tests, C. dubia was considerably more sensitive than fathead minnow. Acute toxicity was attributed, in most cases, to elevated ion levels. Estimated acutely toxic thresholds for C. dubia (defined as LC50 values being less than 70% effluent) were 1,500 mg/L (chlorides) and 3,500 mg/L (total dissolved solids). Our study indicated the potential for whole effluent toxicity, due to ion enrichment, at power plant sites fitted with FGD systems.

RP163 The compounds in crude oil that are chronically toxic to fish are mainly alkyl tri-cyclic PAH. P.V. Hodson, C.W. Khan, G. Saravanabhavan,

S. Brown, School of Environmental Studies, Queen's University, Kingston, Ontario, Canada; B. Hollebone, Z. Wang, T. King, Environmental Technology Centre, Environment Canada, Ottawa, Ontario, Canada; J. Short, K. Lee, Centre for Offshore Oil and Gas Environmental Research, Fisheries and Oceans, Dartmouth, Nova Scotia, Canada; L. Clarke, Standards and Guidelines, Environment Canada, Hull, Quebec, Canada. We used "effects-driven" fractionation of Alaska North Slope and Scotian Light crude oil to show that CYP1A induction in juvenile rainbow trout and chronic developmental toxicity to Japanese medaka (blue sac disease or BSD) are associated mainly with 3-ringed alkyl PAH. Of four fractions prepared by low-temperature vacuum distillation (F1-F4), F3 (31% of total carbon in whole oil) contained the highest concentration of PAHs, was the strongest CYP1A inducer, and was chronically toxic, causing the same signs of toxicity as whole oil. Fraction F4 (high molecular weight PAHs) caused moderate CYP1A induction, but was non-toxic. In contrast, F1 and F2, contained mono-aromatics and alkylnaphthalenes, did not induce CYP1A in trout, but caused acute narcosis to medaka. These volatile fractions would not persist to cause chronic toxicity. Sub-fractions of F3 were created by cold acetone extraction: F3-1 (extract; rich in PAHs; 35% of total carbon) and F3-2 (wax precipitate; trace amounts of PAHs; 65% of total carbon). The F3-1 extract was a strong CYP1A inducer and highly toxic, while the F3-2 precipitate was not. Normal-phase HPLC separation of F3-1 produced five sub-sub-fractions: F3-1-1 (saturates and monoaromatics), F3-1-2 (alkyl naphthalenes and dibenzothiophenes), F3-1-3 (alkyl fluorenes, phenanthrenes, and naphthobenzothiophenes), F3-1-4 (chrysenes, pyrenes), and F3-1-5 (residual material recovered by column backwash). CYP1A induction in trout was caused by F3-1-3 to F3-1-5, but not by F3-1-1 and F3-1-2. The most toxic fraction was F3-1-3, indicating that alkylphenanthrenes, fluorenes, and naphthobenzothiophenes, unique to this fraction, were the constituents causing the chronic toxicity of whole oil.

RP164 Oil sands naphthenic acid toxicity: Does size matter? R. Frank, R. Kavanagh, K.R. Solomon, University of Guelph, Guelph, Ontario, Canada; K. Burnison, Environment Canada, Burlington, Ontario, Canada; J.V. Headley, Environment Canada, Saskatoon, Saskatchewan, Canada; G. Arsenault, Wellington Laboratories, Guelph, Ontario, Canada. The Athabasca oil sands of Alberta, Canada, contain an estimated 174 billion barrels of bitumen. During oil sands refining processes, an extraction tailings mixture is produced that is reported as toxic to aquatic organisms and is therefore collected in settling ponds on site. Investigation into the toxicity of oil sands tailings pond water has identified the sodium salts of naphthenic acids (NAs) as the major toxic components, and a multi-year study was initiated to identify the principal toxic components within NA mixtures. Little is understood regarding individual NA toxicity, however, investigation of oil sands tailings ponds has revealed a correlation of increased toxicity with an increased concentration of lower molecular weight NAs. Successful fractionation of a NA mixture based on differing boiling points was attained using a Kugel Rohr distillation apparatus. Toxicity testing on the generated fractions using the Microtox bioassay support correlations observed in oil sands tailings ponds, in which a slight decrease in toxicity is associated with fractions containing a smaller concentration of lower molecular weight NAs. The aim of current research is to gain an understanding as to why the lower molecular weight NAs seem to be the most toxic constituents, considering the mode of action is most likely narcosis, which is driven by lipophilicity. To investigate the potential for NA structural effects, toxicity tests with individual surrogate NAs were conducted using the Microtox bioassay in addition to Daphnia magna acute lethality tests. Preliminary results indicate that NA toxicity may be more dependent upon structure, rather than just being a function of molecular size. A clearer understanding of how NAs elicit their toxicity is essential for the improvement of oil sands tailings pond remediation techniques.

RP165 The Effects of Diesel Fuel on Artemia salina. T. Tatum, Biological Sciences, Saint Xavier University, Chicago, IL. One of the most promising alternatives in environmental toxicology uses lower organisms with limited sentence including bacteria, fungi, algae, plants, and invertebrate animals. Cyst-based tests have been developed from a relatively new bioassay technology, which makes use of resting (dormant) stages of selected aquatic invertebrate species as biological starting material. The main advantage of cyst-based bioassays over conventional tests is Artemia salina can be hatched within a short period of time (24 hr) and used for routine ecotoxicity testing. Artemia are found in marine environments, have been widely used for testing the inhibitory effects of carcinogens on the hatching of the eggs.

The first experiment was designed to examine the affect of the toxicant on the fecundity, hatching success, of the *Artemia*. Petri dishes containing 250 eggs each had individual concentrations of 0.5%, 1%, 5%, 10%, and 20% and a control dish with a 0% concentration. Petri dishes were maintained at a constant temperature of 26C for 24 hours. Photos were taken at 12 hr intervals for 48 hr. total number of hatched individuals were calculated and least significant difference (LSD) statistical analysis was conducted to determined if there is a difference between the concentrations. Changing the concentration of diesel fuel did not appear to have a statistically significant impact on the fecundity of the *Artemia*. Changing the concentration of diesel fuel did have a statistically significant impact on the fecundity of the *Artemia* with mortality ranging from 20% in the control group to 100% in the 40% group. Even 0.5% resulted in a significant percent mortality (47%). Based upon these data, it appears that diesel fuel contamination is more deleterious on survival of adult *Artemia* than their hatching. This may be a result of the cyst serving as a protection from the toxicant. Further studies of the different life stages and effects on reproductive success must be conducted.

RP166 Differing water quality characteristics between three regions of Appalachia, USA, as indicators of coal mining impact on well water. S. McSpirit, S. Saylor, Department of Anthropology, Sociology, & Social Work, Eastern Kentucky University, Richmond, KY; A.J. Wigginton, Department of Biology, University of Kentucky, Lexington, KY; J.M. Caddell, Department of Earth Sciences, Eastern Kentucky University, Richmond, KY; D. Sims, Gateway Area Development District, Morehead, KY. The effects of coal extraction, especially mountain top coal removal (MTR), and the disposal of the wastes generated by mining, especially deep mine injection, on ground and surface water have been of increasing concern to residents of Appalachia, USA. Previous study has indicated that concerns about water quality are higher than many other topics, including occupational injury and terrorism. Concern has recently grown about the possible human health and ecological effects of deep mine injection practices and "black water" events. In an effort to assess the relative impact of MTR and coal waste disposal, water samples were taken from wells in Martin and Pike Counties in Kentucky and Mingo County, West Virginia. Martin and Mingo Cos. face concerns about coal waste injected into deep coal mines and accidental releases from coal slurry impoundments. A suite of metals was analyzed using inductively couple plasma optical emission spectroscopy and several anions, including sulfate and chloride, were analyzed using ion chromatography in each water sample. Some of these metals were chosen for their human health effects (e.g. As, Cd, Cr, Pb) while others (e.g. Fe, Mn) and sulfate were chosen because they can act as indicators of contamination from acid mine drainage. Results indicate that there are several differences between the water qualities measured in each county. Iron levels in both Martin and Mingo Cos. exceeded U.S. EPA standards more than 70% of the time. Sampling locations in both Martin and Pike Cos. had Pb levels greater than U.S. EPA standards 25%, or more, of the time. All three counties had greater than 60% of locations with Mn levels above U.S. EPA standards. One Pike Co. site had extremely poor water with As levels at 1.34 mg/L and Pb levels at 0.35mg/L. ANOVA reveals that mean values for chloride are different between counties ($p < 0.05$) while values for sulfate are not different ($p > 0.05$).

RP167 The use of single indicator test kits and inter-metal correlations to assess water quality in coal producing areas of Appalachia, USA. A.J. Wigginton, Department of Biology, University of Kentucky, Lexington, KY; S. McSpirit, S. Saylor, Department of Anthropology, Sociology, & Social Work, Eastern Kentucky University, Richmond, KY; J.M. Caddell, Department of Earth Sciences, University of Kentucky, Lexington, KY; D. Sims, Gateway Area Development District, Morehead, KY. Local communities in Appalachia have become more concerned about water quality in recent years. Mountain top coal removal (MTR), coal slurry impoundments, and deep mine coal slurry injections are all suspected by local residents of altering hydrology and impairing water quality. To provide a tool by which a local community might assess its own water quality, including individuals using private wells, at reasonable cost, the effectiveness of a sampling plan using single indicator test kits was evaluated. Water samples were taken from private wells in Martin and Pike Counties in Kentucky and Mingo County, West Virginia. Water samples were taken and analyzed using single indicator test kits for As, Cu, Fe, and Mn. These metals were chosen because in previous research, it was found that concentrations of some metals correlate with each other. This indicated that analysis for certain metals may give clues about the presence of other metals. Simultaneously gathered samples were analyzed

using inductively couple plasma optical emission spectroscopy (ICP-OES) to confirm test kit results. Additionally, a suite of 30 metals was analyzed to test for additional inter-metal correlations. Correlations between test kit results and ICP-OES analysis were generally significant for As, Fe, and Mn, but not for Cu, perhaps because of uncertainly caused by relatively low levels of Cu in the well water. Significant correlations between test kits and ICP-OES metal values ranged from $r = 0.445$ to 0.984 ($p < 0.05$). The concentrations of all metals except Zn were correlated with two or more other metals. Ag, Ba, K, Li, Sb, Si, Sr, and V had seven or more positive correlations each. Boron had nine negative correlations. These correlations ranged from $r = 0.333$ to 0.945 , or $r = -0.346$ to -0.975 ($p < 0.05$). There were correlations between As, Cu, Fe, and Pb and several other metals, illustrating the usefulness of the test kits to indicate the presence of additional metals beyond those directly measured.

RP168 Aqueous Solubility and Toxicity of Biodiesels and Blends. B. Hollebone, T.C. Lumley, B. Fieldhouse, M. Landriault, Emergencies Science and Technology Division, Environment Canada, Ottawa, Ontario, Canada; K. Doe, P. Jackman, Toxicology Laboratory, Environment Canada, Moncton, New Brunswick, Canada. With increasing use of plant and animal oils as petroleum fuel supplements and alternatives, there is growing potential for accidental release of these biodiesels to the environment. While the behaviours and effects of petroleum diesels have been extensively studied, the fate and behaviour of biofuels in water or their potential effects on aquatic ecosystems are largely unknown. The most important mechanism for exposure of aquatic organisms to spilled biodiesels and petroleum diesels is by transfer from the non-aqueous phase liquid (NAPL) into the aqueous phase, as both soluble and dispersed components. The equilibrium levels of fuel components in the water, the water-accommodated fractions (WAF) have been measured for biodiesels from a wide variety of feedstocks, including soy oil, canola oil, waste fry oil and fish wastes. These are compared to determinations for petroleum diesels as well as for 5% (B5) and 20% (B20) blends of biodiesel in petroleum diesel. Acute toxicities for *D. magna* (water fleas), *O. mykiss* (rainbow trout), and bioluminescent bacteria are reported. The correlations between acute toxicity, WAF concentrations and fuel property data are examined. Biodiesels are found to have significant solubility and dispersability into the water column and significant potential for negative ecological impacts. All organisms tested have been significantly affected by all biodiesels and all biodiesel blends with petroleum diesel.

RP169 Genotoxicities of Chinese Particulate Matter: Contributions of Particulate Bound Nitro and Oxy Substituted Polycyclic Aromatic Hydrocarbons. J. Layshock, S. Simonich, Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR; J. Murray, T. Primbs, B. Simoneit, S. Simonich, Chemistry, Oregon State University, Corvallis, OR; B. Tilt, Anthropology, Oregon State University, Corvallis, OR; B. Simoneit, College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR. Many adverse health effects of air pollution have been attributed to combustion byproducts such as particulate matter (PM) and polycyclic aromatic hydrocarbons (PAHs). Oxy and nitro PAH (OPAH, NPAH) derivatives are considered even more harmful than the parent PAHs, but research is limited. Arising from rapid industrialization, China is now the largest coal consumer and one of the top petroleum users in the world contributing to elevated amounts of PM and PAHs in the global atmosphere. Total suspended particulate matter and PM10 collected in Guangdong and Sichuan provinces in 2002-2003 were evaluated to determine the PAH composition and genotoxicity. The mutagenic potential of extracted PM was analyzed using the Ames Salmonella mutagenicity assay using TA98 and TA98NR strains. DNA damaging potential was measured using the Comet test on human lung cells grown in cell culture. An extensive collection of parent PAHs and substituted OPAHs and NPAHs were measured using GC-MS. Ames tests, with and without metabolic activation, suggest that a large portion of the mutagenicity can be attributed to direct-acting mutagens such as OPAHs and NPAHs rather than the parent PAHs. Significant portions (greater than 50%) of the total mutagenicity can be apportioned to nitro-containing compounds when comparing TA98 and TA98NR (nitroreductase deficient) bacterial strains in the Ames test. Correlations of the total genotoxic response to the concentrations of direct-acting mutagens (OPAH and NPAH) show better correlations than comparison to the concentrations of indirect-acting mutagens (PAH). Results indicate enhanced mutagenicity of Chinese PM in winter compared to summer months. Key Words: PM, Nitro-PAH, Oxy-PAH, Mutagenicity, Air Pollution, China

RP170 Population-level effects of pesticides and pesticide mixtures on *Daphnia Pulex* and a comparison to chronic aquatic life criteria values. J.D. Stark, Entomology, Washington State University, Puyallup, WA. Mixtures of pesticides at environmentally relevant concentrations were evaluated for effects on populations of the cladoceran, *Daphnia pulex* (Leydig). The protectiveness of chronic aquatic life criteria (ALC) was also evaluated from a population perspective. The insecticides diazinon, malathion, chlorpyrifos, and carbaryl and the herbicide 2,4-D were evaluated separately and as a mixture at the maximum (field) concentrations found in Puget Sound area rivers and streams and at higher concentrations (2.5, 5 and 10 times the field concentrations). Survival of the original adults used in the population growth study, number of offspring per surviving female, population size, and population growth rate after 10 d were the endpoints evaluated. Exposure to field (1X) concentrations of each pesticide alone or the mixture had no significant effect on the survival of the initial adults, offspring per surviving female, population size or population growth rate. Exposure to the mixture at > 2.5X resulted in negative population growth rate indicating *D. pulex* populations headed towards extinction. Diazinon and chlorpyrifos contributed most to the toxicity of the mixture. Concentrations equivalent to the chronic ALC for each pesticide did not result in a decline in population growth rate indicating that the ALC were protective of *D. pulex* populations even for the mixture. These results showed that a mixture of 5 pesticides at the maximum concentrations detected in surface waters in the Puget Sound region did not negatively affect *D. pulex* populations. Pesticides have been detected at concentrations well above their respective ALC in many areas of the United States. This is cause for concern with regard to aquatic life, particularly where diazinon and chlorpyrifos are found together.

RP171 Pyrethroid Toxicity at Environmentally Relevant Concentrations: Lethal and Sublethal Effects in the amphipod *Hyalella azteca*. S.M. Brander, Environmental Toxicology, UC Davis, Davis, CA; I. Werner, Anatomy, Physiology, VetMed, UC Davis, Davis, CA; I. Werner, L.A. Deavonic, Aquatic Toxicology Laboratory, UC Davis, Davis, CA. The pyrethroid pesticides cyfluthrin and permethrin were detected in Sacramento-San Joaquin Delta water in the summer of 2006. In order to gauge the toxicity of pyrethroids at these concentrations, elucidate any additive, synergistic, or antagonistic effects between the two pyrethroids, and to determine whether pyrethroid exposure upregulated heat shock proteins (HSP60 & 70), a ten-day laboratory exposure was run with juvenile amphipods (*Hyalella azteca*). Cyfluthrin and permethrin were tested both singly and in combination at detected levels, and also at one-half and twice the detected levels. Concurrent treatments were also run with the addition of piperonyl butoxide (PBO), a commonly used pesticide synergist. Mortality in all treatments was significantly higher than controls, with LC50s for permethrin and cyfluthrin with and without PBO at 0.013 ug/L and 0.039 ug/L; 0.004 ug/L and 0.005 ug/L, respectively. Overall survival in the combination treatments was lower than that in single treatments, although there was evidence for slight antagonism. Initial results also indicate that HSP70 was elevated in some pyrethroid treatments. This study further illustrates the need for better regulation of pyrethroid pesticides, as our results indicated high toxicity at the ng/L (pptr) level.

RP172 Toxicity evaluation of treated sewage sludge samples of São Paulo State, Brazil using *Vibrio fischeri* luminescence assay. W.Á. Soares, P.F. Rodrigues, G.A. Umbuzeiro, CETESB - Companhia de Tecnologia de Saneamento Ambiental, São Paulo, São Paulo, Brazil; M.M. da Matta, Department of Pathology, Universidade de São Paulo - Faculdade de Medicina, São Paulo, São Paulo, Brazil. The municipal wastewater treatment plants (WWTP) in Brazil usually receive domestic and industrial sewage in different proportions. As a consequence, the sludge generated during the treatment can contain toxic compounds in different concentrations. In order to consider its safe use in agricultural soil as nutrient source, it is important to evaluate its toxicity. Bioassays have been successfully used to complement chemical analysis of complex mixtures. The objective of this study was to verify the applicability of the *Vibrio fischeri* acute toxicity assay as a screening tool to evaluate the toxic effects of samples collected in five different São Paulo State WWTP in three consecutive sampling campaigns in 2005, 2006 and 2007. Treated sludge leachate samples were prepared by shaking with distilled water (1:4) for 24 h, pH adjusted when necessary and tested in different concentrations (81.9% highest) and the exposure time was 15 min. The most toxic samples, with EC20 (%) of 1.3, 5.6, 5.4 for AT2 WWTP and 5.7, 36.0, 2.2 for PCJ1 WWTP, corresponded to the treatment plants that receives

chemical and textile industrial effluents. The three other WWTP presented variable toxicity results with differences along the years. The WWTP sludge samples (PCJ2) that treats domestic sewage and mainly wood and food industrial effluents presented EC20 of non-toxic, 26.8, 74.9, for the three samples analyzed from each year, corresponding to the lowest toxicity levels. For the AT1 and SG WWTPs the values of EC20 were 1.7, 28.0, 67.7 and 0.5, 24.1, non-toxic respectively showing a decrease of toxicity along the years. The *Vibrio fischeri* acute toxicity test seems to be a sensitive tool to monitor the toxicity of sludge samples from São Paulo State WWTPs. Three more sampling campaigns are scheduled for 2007. Chemical analysis are in progress as well as other toxicity and genotoxicity assays with plants, microcrustaceans and rodents in order to provide a complete characterization of those WWTPs.

RP173 Sources of Pesticide Mixtures in the Environment: Active Ingredients in Formulated Products and Tank Mixes. C. Grue, W. Madden, J. Frew, J. Grassley, University of Washington, Seattle, WA. Fish and wildlife are rarely exposed to individual contaminants, but rather mixtures of chemicals. For example, Gilliom and Martin (2004) collected water samples from 182 streams in the United States and found more than 75% of the streams had mixtures of two or more chemicals and more than 10% had mixtures containing greater than 10 pesticides. Sources of pesticide mixtures in the environment include "environmental mixing" of formulated products (FPs) containing a single active ingredient (e.g., through run-off) and/or the application of formulated products and tank mixes (TMs) containing multiple AIs. The contribution of FPs and TMs containing multiple AIs to pesticide mixtures in the environment is not known. We compiled a list of the herbicides and insecticides registered for use in Washington State. Information was collected from the Pesticide Information Center Online (PICOL), a database managed by Washington State University. More than 30% of the formulated products within the database contain 2 or more AIs. An initial review of label recommendations for FPs containing single AIs included many instances where registrants recommended combining their product with one or more additional FPs, also containing one or more AIs. Some suggested combining products with AIs with the same mode of action. One of the herbicides reviewed recommended over 30 different tank mix combinations depending on crop type. In the United States, pesticides are regulated based on the non-target toxicity of individual AIs, not mixtures within FPs or TMs. Our initial review raises concerns about possible non-target toxicity associated with interactions among the active ingredients in FPs and TMs and highlights the need for considering mixtures within FPs and TMs in the current regulatory framework. A more thorough analysis of the herbicides and insecticides selected from the database will be presented.

RP174 Effects of Pesticides in Urban Streams in Western Washington on Coho Salmon Eggs and Sac Fry. K. King, R. Fisk, J. Grassley, C. Grue, University of Washington, Seattle, WA. The research presented represents the third year of a five-year effort to determine the effects of a chemical cocktail, present in urban streams in Western Washington, on different life stages of Coho salmon (*Oncorhynchus kisutch*). The cocktail consisted of 8 herbicides, 2 insecticides, a fungicide, and a common breakdown product; nominal concentrations were the maximums reported after storm-water events in fall. With the exception of the fungicide and breakdown product, formulated products (single AI) were used, and if possible were selected from those available at retail outlets. In 2004 and 2005-06, research focused on adult Coho; recent monitoring efforts had suggested that pre-spawn mortality of Coho salmon had increased in natural waters, particularly urban streams in Western Washington. We found no effects on time to death, brain cholinesterase activity, sperm motility, or hatching success and growth of fry (from exposed adults) for 35 d. In 2006-07, our objective was to determine if there were effects on fertilization and eggs/sac fry as a result of a pulsed exposure to the chemical cocktail, simulating storm flows. The first part of the study examined effects on fertilization of the eggs and subsequent survival of the sac fry. Endpoints included fertilization success, hatching success, and viability through swim-up (emergence). The second part examined the effects on hatching success of exposed eggs, sac fry survival, fry survival, and subsequent growth of fry for 35-d. Preliminary results suggest that there were no effects on the endpoints examined. Overall, results suggest that other factors (general water quality, habitat, or other contaminants) may be responsible for the reproductive effects observed in the field.

RP175 Effects of physically and chemically dispersed oil on the symbiotic soft coral *Xenia elongata* and the anemone *Anthopleura elegantissima*. C.L. Mitchellmore, M.J. Teasdale, E. Beard, D.M. Yost, J.E.

Baker, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, Solomons, MD; W.I. Hatch, St Mary's College of Maryland, St Mary's City, MD. The tropical soft coral *Xenia elongata* and the temperate sea anemone *Anthopleura elegantissima* were exposed for 8 hours to either physically-dispersed (dissolved PAHs) or chemically-dispersed (dissolved/colloidal/particulate PAHs and dispersant) oil fractions using weathered Arabian light crude and the dispersant Corexit 9500. In the coral study concentrations of oil used were driven by dispersant-only toxicity limits (8 hour LC50 <50 ppm). Oil exposures also consisted of filtered (via 0.7 micron glass fiber filters) versus non-filtered preparations to investigate in more detail the route of exposure (dissolved, colloidal versus particulate fractions). We determined acute toxicity and assessed a variety of sublethal endpoints, including recovery and delayed responses after 28-38 days removal into clean seawater. Various biomarkers were used to assess sublethal impacts of the dispersant to the cnidarians. Pulsing rate, pulsing intensity and rigidity were sensitive endpoints for the soft coral. Tentacle retraction and mucus production were visual biomarkers for the anemones. Additional biomarkers, including chlorophyll levels, algal cell numbers, gene expression levels of sym32, dissolved oxygen content, protein content and growth rate were also assessed in this study. Corals after 8 hours exhibited decreased pulsing rates and intensity in the dispersant and oil-dispersant exposures. Delayed mortality was observed in the oil-dispersant unfiltered exposure and at the end of the 38-days experiment growth rate was significantly reduced in the dispersant, filtered and non-filtered oil-dispersant exposures. In the anemones, reductions in tentacle expansion, increased mucus production and decreased dissolved oxygen content were observed in the dispersant and oil-dispersant doses. Bioaccumulation of PAHs by the anemones was from both the dissolved and colloidal fractions. Gene expression levels of sym32 were decreased following oil exposure after 8 hours. Recovery of visual biomarkers was observed after 2 days removal into clean seawater in the anemones.

RP176 Characterizing the toxicity of produced water, a complex mixture. J. Fisher, J.R. Bidwell, Zoology, Oklahoma State University, Stillwater, OK. Produced water, which often has elevated levels of dissolved salts and soluble hydrocarbons, is a byproduct of petroleum production. Increased demand for domestic petroleum resources is increasing the need to better understand and manage produced water discharges. This study investigated acute toxicity of produced water and its constituents to *Daphnia pulex* using both conventional toxicity identification evaluation procedures and laboratory experimentation with mock effluents. Additional bioassays, for comparison with *D. pulex*, utilized *Daphnia magna*, *Ceriodaphnia dubia*, and fathead minnows for which predictive models exist. Acute bioassays with *D. pulex* have generated 48-h LC50's ranging from 4% to less than 1% concentration, but predictive models are not available for this species. Initial modeling and acute bioassays using *D. magna*, *C. dubia*, and fathead minnows indicate major ions as the primary source of toxicity, though actual toxicity is significantly greater than predicted toxicity, suggesting toxicity derived from constituents other than the ions modeled. Mock effluents were comprised of binary and tertiary combinations of the essential metals, nonessential metals, ammonia, and petroleum hydrocarbons found in the original mixture. The results of these experiments will be used to generate a predictive mixture toxicity model for *D. pulex* that can be applied to other produced water management efforts.

RP177 Brain AChE Inhibition in Juvenile Rainbow Trout Exposed to Pesticide Mixtures Within Urban Streams in Western Washington: Reasons for Non-Additive Effects. K. King, C. Grue, K. Ayers, J. Frew, S. Rui, J. Slipper, A. Thompson, A. Yahnke, J. Grassley, University of Washington, Seattle, WA; H. Michael, Texas Tech University, Lubbock, TX. Recent efforts have documented pesticide concentrations within surface waters of urban streams in western Washington. Although levels reported are low (most <1.0 ppb), the presence of these chemicals has generated concerns, particularly their potential effects on salmonids. Previously, we exposed juvenile (ca. 10 g) rainbow trout (*Oncorhynchus mykiss*) to a chemical cocktail representative of urban streams in western Washington. Nominal concentrations (ppb active ingredient) of 9 herbicides, 3 insecticides (ChE-inhibitors, carbaryl, diazinon, and malathion), an insecticide breakdown product, and a fungicide were the maximum reported during peak storm flow events (hereafter 1X). With the exception of the fungicide and the breakdown product, formulated products (FP, single AI) were used and if possible were selected from those available at retail outlets. Brain AChE activity was not inhibited in fish exposed to the 1X cocktail, but was in the 3.3X (23%) and 10X (84%) cocktails. Enzyme activity was not affected by the 10X concentrations of the individual cholinesterase

inhibitors as AIs or FPs, but was inhibited 59 and 78 percent in fish exposed to the mixtures, respectively. Recently, we exposed juvenile rainbow trout of the same size to the same individual cholinesterase inhibitors (10X) as AIs or FPs as well as binary and tertiary mixtures in an effort to identify the combination responsible for the potentiation of AChE inhibition and the underlying physiological mechanisms. Results for the AIs and FPs were similar and indicated that the combination of diazinon + malathion (AChE inhibition = 85-88%) was responsible. Results of complementary studies of the relationships between effects on plasma BuChE and carboxylesterases and the interaction between the two AChE inhibitors will be presented. The implications of these results to urban streams, the regulation of pesticide mixtures, and assessments of the hazards pesticides pose to non-targets will be discussed.

RP178 Biomonitoring as a Tool to Assess the Environmental Performance of Integrated Farm Practices. M.B. Gopalan, J.L. Farris, J.L. Bouldin, Environmental Sciences, Arkansas State University, State University, AR. Conservation programs have been developed to provide economic and technical assistance to farmers in adopting and successfully implementing select best management practices (BMPs). However, it has been proposed that performance of implemented BMPs be assessed prior to federal program payments. The objective of this study was to use biomonitoring as a tool to measure the environmental performance or environmental gain associated with integrated farm management practices. As a preliminary assessment, we conducted water quality analyses and laboratory biomonitoring assays following one base-flow and seven major storm events. Water and sediment were sampled from eight agricultural drainage ditches and the receiving system from a 1550-ha cotton operation in Poinsett County, Arkansas, with 45 out of 63 samples collected during the cropping season. Ditches of varying sizes were characterized by class size, water retention capacity, and vegetative characteristics. Farm practices associated with each ditch sampled were also utilized in the analysis. Non-parametric statistical analysis was utilized for water quality parameters. Phosphorus measured as orthophosphate was significantly higher during the second year sampling (p - Value: 0.0037); whereas, nitrites, alkalinity, and hardness of the aqueous samples were significantly different between the cropping and non-cropping seasons. The higher frequency of impairment measured in *Ceriodaphnia dubia* than experienced with *Pimephales promelas* could be linked with pesticide-related effects. Reduced *C. dubia* survival was measured with 13 samples and reduced reproduction with 14. Survival impairments in *C. dubia* were predominantly acute in nature. Chironomus dilutus survival was reduced to 30 - 70% of control survival in sediment samples from impacted sites. This research suggested that dedicated sampling during storm water events following pesticide application and biomonitoring using *C. dubia* should yield useful information more specific to the practices. Targeted investigations include monitoring larger-scale farms under a select range of agricultural management practices.

RP179 Determining Cause of Toxicity in Wastewater from a Scrubber Used to Remove Sulfur Dioxide from a Coal-Fired Electricity Generating Facility. K.L. Tobiason, Nautilus Environmental, Tacoma, WA; J.R. Elphick, Nautilus Environmental, Victoria, British Columbia, Canada; H.C. Bailey, Nautilus Environmental, San Diego, CA. Wastewater from a scrubber used to remove sulfur dioxide from aerial emissions at a coal-fired electricity generating facility exhibited a significant degree of toxicity in chronic toxicity tests using *Ceriodaphnia dubia* and fathead minnows (*Pimephales promelas*). In order to discharge wastewater from this scrubber, it was necessary to identify the primary causes of toxicity so that appropriate treatment strategies could be implemented. The effluent was complex, with high concentrations of total dissolved solids, particularly sulfate, and included elevated concentrations of a number of metals. A Toxicity Identification Evaluation (TIE) was conducted and definitively identified boron, present in the sample as borate, as the primary cause of toxicity, with a smaller contribution to toxicity from zinc. A bench-scale testing program was conducted to evaluate treatment options for removal of boron and zinc from the discharge, and demonstrated that pH adjustment was effective at removing the metals responsible for toxicity. A treatment system was installed at the site and has resulted in wastewater discharge from the facility meeting conditions associated with the NPDES permit. This presentation describes the TIE procedures used to definitively determine the cause of toxicity in this complex effluent and the subsequent actions taken to evaluate and implement treatment options.

RP180 Can one contaminant reduce the toxicity of another? A mixture of endocrine disruptors in white sturgeon (*Acipenser transmontanus*). A. Palumbo, R. Tjeerdema, Environmental Toxicology, University of California, Davis, CA. White sturgeon are native to the Sacramento River and subject to agricultural, municipal and industrial waste water effluent. Contaminants in these waters may include endocrine disruptors, which interfere with normal hormone signaling and may interfere with wildlife reproduction. Different classes of these contaminants have seemingly opposing modes of action, such as estrogenic and anti-estrogenic. It is our hypothesis that dioxin-like compounds can diminish the effect of estrogen mimicking contaminants. This was tested by i.p. injection of these compounds into white sturgeon. Then, the resulting estrogenic response, synthesis of a yolk protein, vitellogenin, was measured via an enzyme-linked immunosorbent assay. Reduction of estrogen-induced vitellogenin was observed in fish that were also exposed to beta-naphthoflavone, a model for dioxin. Further experiments will address if the effect is following the proposed pathways and if it may be seen with environmentally relevant chemicals and concentrations. Results of this study will be relevant for those with monitoring programs who measure vitellogenin, as it is important to understand how dioxin-like contaminants can influence this study endpoint.

RP181 Tilapia ovarian cultures for evaluating endocrine mechanisms and mixture effects of pharmaceuticals. C.J. Borgert, T.S. Gross, Department of Physiological Sciences, University of Florida College of Veterinary Medicine, Gainesville, FL; C.J. Borgert, Applied Pharmacology and Toxicology, Inc., Gainesville, FL; G. Casella, Department of Statistics, University of Florida, Gainesville, FL; P.D. Guiney, SC Johnson & Son, Inc., Racine, WI. Tilapia may be an attractive source of ovarian tissue for evaluating in-vitro effects of endocrine-active substances and mixtures because they readily reproduce year round in captivity. Initial efforts with tilapia ovarian/oocyte cultures validated steroidogenesis as a function of tissue mass and incubation parameters, demonstrated responsiveness to gonadotropins and aromatase inhibitors, and verified that significant levels of steroidogenesis remain following storage of tissues in liquid nitrogen for extended times. The present study evaluated effects on steroidogenic activity in tilapia ovarian cultures treated with the estrogens ethinyl estradiol and norethindrone, the anti-estrogen tamoxifen, the aromatase inhibitor anastrozole, and the antidepressant paroxetine HCL. Based on effects in humans, all were predicted to depress steroidogenesis except paroxetine, which lacks such effects in humans but has gonadotropic effects in some shellfish. Ovarian tissues were collected from adult female tilapia, pooled to make three large composites and placed into culture with 100mg tissue per 2ml media for 24h of incubation. Treatments were 0, 0.1, 1, 10, 100, 1000, and 10,000 ng each pharmaceutical/culture for each ovarian composite, four replicates each to characterize dose-responses. Potential interactions were evaluated using binary and ternary combinations of ethinyl estradiol, tamoxifen and anastrozole at doses of 0, 1, 10, 100, and 1000 ng/culture, and comparing results to predictions from standard models of non-interaction. Culture media were analyzed for estradiol, testosterone, 11-ketotestosterone and progesterone. Ethinyl estradiol, tamoxifen and anastrozole each inhibited ovarian estradiol production as predicted, while norethindrone stimulated estradiol production, a response opposite the effects reported in humans. Paroxetine HCL stimulated estradiol production as predicted by the invertebrate response models as opposed to human data. These rapid, prognostic in vitro results are encouraging and suggest tilapia ovarian cultures may be useful for evaluating latent effects of endocrine-active pharmaceuticals likely found in wastewater to which wild fish populations may be exposed.

RP182 Kinetic Evaluation of Exposure to Ecologically Relevant Concentrations of 2,3,7,8-TCDF and 2,3,4,7,8-TCDF to Mink. M.J. Zwiernik, J.N. Moore, J.P. Giesy, National Food Safety and Tox. Ctr. and Ctr. for Integrative Tox., Dept. Zoology/Vet. Med, Michigan State University, E Lansing, MI; S.J. Bursian, A.C. Napolitano, Dept. Animal Sci, Ctr for Integrative Tox., MSU, E Lansing, MI; S.D. Fitzgerald, Dept. Anatomic Pathology and Diagnostic Ctr. for Pop. and Animal Health, MSU, E Lansing, MI; J.P. Giesy, Dept. Biomed. Sci. and Tox. Ctr. Univ. of Saskatchewan, Saskatoon, Saskatchewan, Canada; L.L. Aylward, Summit Tox. LLP, Falls Church, VA; K.J. Beckett, Woodlot Alt., Inc., Topsham, ME; D.P. Kay, J.L. Newsted, ENTRIX, Inc, Okemos, MI. Mink (*Mustela vison*) are often utilized as a sentinel species for ecological risk assessment at sites where contaminants of concern (COCs) are dioxins and dioxin-like compounds. Site-specific field studies employing a weighted-multiple-

line-of-evidence-approach were conducted to quantify exposure and risk to resident mink of the Tittabawassee River basin in central Michigan, USA. One area of the field study in which substantial uncertainties remain is the toxico-kinetics of the mink COC exposure profile which is which is dominated by 2,3,7,8-tetrachlorodibenzofuran (TCDF) and 2,3,4,7,8-pentachlorodibenzofuran (4-PeCDF). A laboratory study was conducted to assess: 1) the spiked feed dosages necessary to achieve liver concentrations bracketing those observed in wild mink; 2) time to achieve steady state concentrations in female mink at the time of mating; and 3) the impact of co-administration of TCDF and 4-PeCDF on the pharmacokinetics and distribution of each. Three doses each of TCDF and 4-PeCDF bracketing estimated wild dietary exposure levels and one mixture dose were administered in feed to mink for 180 d. Concentrations of TCDF and 4-PeCDF in adipose and hepatic tissues were measured at 0, 90, and 180 d, and mink scat was analyzed at several time points. Concentrations of the two congeners measured in scat indicated nearly complete absorption of test compounds from diet. Whole body half-lives for TCDF elimination were <15 hr and decreased with increasing dose, while those for 4-PeCDF were approximately 7 to 9 d with no clear dose-dependency in the tested dose range. Co-administration of 4-PeCDF and TCDF resulted in accelerated clearance of TCDF compared to administration of TCDF alone at the same dose, but clearance of 4-PeCDF was not affected by co-administration with TCDF. Distribution of 4-PeCDF was dose-dependent, with relative hepatic sequestration increasing with dose as compared to adipose, conversely dose did not effect the distribution of TCDF between liver and adipose tissues.

RP183 Modeling Bicarbonate Ion Excess-driven Sublethal Toxicity in Mysids (*Americamysis bahia*). J.D. Horne, S.C. Bunch, Environmental Toxicology, PBS&J, Houston, TX; S.S. Brown, Rohm and Haas, Spring House, PA. An industrial wastewater has exhibited persistent sublethal toxicity to the mysid (*Americamysis bahia*) in chronic WET tests. Ion-pattern analysis of the effluent suggests that sublethal toxicity may be a result of an unusually-high bicarbonate concentration (> 2600 mg/L, on occasion, or more than twice the excess bicarbonate IC25 concentration reported by Pillard, et.al., 1998). Chemical speciation data (Visual MINTEQ) and toxicity test results are used in a Principal Component Analysis framework, to develop predictive models for chronic toxicity based on the ionic composition of the test media.

RP184 Oil particles, dissolved PAHs, and embryo toxicity. M.G. Carls, L. Holland, M. Larsen, Auke Bay Laboratory, NOAA/NMFS, Juneau, AK; T. Collier, N. Scholz, J. Incardona, Ecotoxicology & Environmental Fish Health Program, Environmental Conservation Division, Northwest Fisheries Science Center, Seattle, WA. To distinguish the toxicity of whole oil droplets from compounds dissolved in water, responses of zebrafish embryos exposed to particulate-laden, water-accommodated fractions (WAF) of North Slope crude oil were compared to those in embryos embedded in agarose. Most polycyclic aromatic hydrocarbons (PAHs) in WAF were contained in oil droplets; about 16% were dissolved. The agarose precluded embryo contact with particulate oil but allowed diffusive passage of dissolved PAHs. Although total PAH (TPAH) concentrations in WAF were 17 times greater than in agarose, paired embryo responses in the two media were highly similar, generally within a factor of 1.5 (the 95% confidence bound was 1.0 to 2.1), typically with a larger response in embryos exposed to WAF. The incidence of edema, hemorrhaging, and cardiac abnormalities in embryos was dose dependent in both WAF and agarose and the biological effects in these treatments were identical in character. The response difference between treatments (17%) is explained by diffusion; averaged over 48 h, the estimated mean TPAH concentration in agarose was about 16% less than the dissolved TPAH concentration in WAF. We conclude that PAHs dissolved from oil are toxic to fish embryos and that physical contact with oil droplets is of little or no consequence to embryonic fish.

RP185 Uncertainty analysis of dioxin-like PCB related TEQ in fish. S.P. Bhavsar, D. Jackson, University of Toronto, Toronto, Ontario, Canada; S.P. Bhavsar, A. Hayton, Ontario Ministry of the Environment, Toronto, Ontario, Canada. The Toxic Equivalent (TEQ) concept is widely used to assess toxicity potential of a dioxin-like chemical mixture. The TEQ converts concentrations of various dioxin-like compounds into a single 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) toxic equivalent concentration using Toxic Equivalency Factors (TEFs). It has been shown that in the absence of costly measurements of dioxin-like PCBs (dl-PCBs) in fish, relatively inexpensive measurements of total PCB can be utilized to estimate dl-PCB related TEQ (i.e., DLP-TEQ) (Bhavsar et al. 2007a). We assess impacts of uncertainties

in dl-PCB measurements, dl-PCB estimates, and TEFs on DLP-TEQ using the Monte Carlo technique. The analysis suggests that measurement errors for dl-PCBs translate into up to 1.3-fold uncertainty in DLP-TEQ while uncertainties in estimates of dl-PCBs generally produce up to a 3-fold uncertainty in DLP-TEQ. In contrast, the uncertainty due to TEFs normally ranges 10-13-fold and spans over 30-40-fold under extreme cases. For WHO-2005 TEFs, PCB-126 is the dominating contributor to uncertainty in DLP-TEQ. When we considered uncertainties in the TEFs and estimated dl-PCB concentrations simultaneously, there was little increase in uncertainty in DLP-TEQ that was already produced by the TEFs only. These results indicate that the dl-PCB composition in fish (Bhavsar et al. 2007b) and/or relationship between total PCB and DLP-TEQ (Bhavsar et al. 2007a) can be utilized to estimate DLP-TEQ with reasonable confidence.

RP186 TEQ conversion factors for various TEF schemes. S.P. Bhavsar, University of Toronto, Toronto, Ontario, Canada; S.P. Bhavsar, E.J. Reiner, A. Hayton, Ontario Ministry of the Environment, Toronto, Ontario, Canada. The overall toxicity of complex mixture of dioxins, furans and dl-PCBs is generally expressed as a 2,3,7,8-TCDD Toxic Equivalent (TEQ) concentration. A toxic equivalency factor (TEF) of 1 is given to 2,3,7,8-TCDD, and the TEFs for the other 28 congeners, which generally range from 0.00001 to 1, are assigned based on their toxicity compared to the toxicity of 2,3,7,8-TCDD. A TEQ is calculated by summing the multiplication of congener concentrations with congener specific TEFs. Over the last two decades, a number of TEF schemes such as Eadon (USA, 1982), Ontario (Canada, 1984), Germany (1985), California (1986), U.S.EPA (1987), Nordic (1988), NATO (1989), and WHO (1994, 1998 and 2005) have been developed. These TEF schemes differ by number of congeners considered and TEF values assigned to each congener. Therefore, for a set of measured dioxins and dioxin-like compounds, the reported TEQ value can be affected by the selection of TEF scheme. The TEQ approach is so widely accepted that virtually all dioxin results are now expressed in this form and underlying congener concentrations are not explicitly mentioned. Therefore, in order to compare TEQs on a temporal scale, conversion factors to convert TEQ from an old TEF scheme to a newer TEF scheme are needed. We explore possibilities of producing such conversion factors using what likely is the largest known dioxins, furans and dl-PCB fish database in world. The database includes concurrent measurements of PCDD/F and dl-PCB in more than 1400 fish samples with wide distribution of species, size, sex, and contamination levels from various sources. We present conversion factors for PCDD/F-TEQ and dl-PCB-TEQ separately as well as collectively in terms of TOT-TEQ.

RP187 Evaluating the role of storm water retention basins in the fate of roadway derived Zinc. S.M. Lev, Physics, Astronomy and Geosciences, Towson University, Towson, MD; V. Schmidt, R.E. Casey, Chemistry, Towson University, Towson, MD; J.W. Snodgrass, Biological Sciences, Towson University, Towson, MD; R. Flora, Environmental Science Program, Towson University, Towson, MD; E.R. Landa, Water Resources Division-National Research Program, US. Geological Survey, Reston, VA. Highway runoff has the potential to negatively impact surface water receiving systems due to elevated levels of deicing salts, organic compounds, nutrients, and metals. Zinc enriched tire wear particles continuously collect on roadway surfaces and act as a constant source of Zn to the environment. As a result, storm water retention basins become a focusing environment for Zn and other roadway derived compounds. Roadway derived Zn deposited in storm water retention basins may result in significant exposures of biota to elevated levels of Zn. Additionally, accumulation of Zn by biota inhabiting ponds may result in trophic transfer of Zn out of ponds as semiaquatic wildlife feed on pond organisms that accumulate significant quantities of Zn. At the watershed level, we will assess whether the scale of Zn storage in pond sediments is significant in comparison with the magnitude of Zn transported out of the watershed through surface water flow and ultimately assess whether retention ponds significantly decrease Zn fluxes in the Red Run watershed located in Owings Mills, MD. Zinc storage within a sub-catchment of the Red Run Watershed was estimated from the direct measurement of core samples from sediment in 11 separate storm water retention basins. The total annual Zn load transported out of the same catchment area was determined by continuously monitoring stage and periodic sampling of the main tributary in the watershed over a one year period. The particulate and total dissolved Zn load, were calculated based on a series of models derived from field and laboratory measurements for discharge and suspended sediment load. The total background corrected

Zn storage in the retention basins is estimated at 46 kg accumulated over approximately 6 years of storm water management. The annual background corrected Zn transport out of the catchment area is estimated at 6.9 kg yr⁻¹. Based on these values, the storm water retention basins in this catchment are retaining approximately 52% of the total anthropogenic Zn flux and are in fact acting as a significant sink for roadway derived Zn

RP188 Use of Management Practices to Mitigate Chemical Transport with Runoff from Fairway Turf. P.J. Rice, USDA-Agricultural Research Service, Saint Paul, MN; B.P. Horgan, Horticulture, University of Minnesota, Saint Paul, MN. Water quality surveys have detected chemical pollutants in surface waters of urban and rural areas. As a result, attempts are being made to identify the sources of these compounds and reduce their inputs. The use of fertilizers and pesticides in highly managed turf systems has raised questions concerning the contribution of runoff from managed turf. To address these questions we designed experiments to measure the quantity of fertilizers and pesticides transported with runoff from turf plots managed as a golf course fairway, and to evaluate the ability of chemical application strategies and cultural practices to reduce the transport of applied chemicals with runoff. Selective application of multiple conservative tracers enabled identification of areas that contribute the most to chemical transport, while implementation of cultural practices increased rainfall infiltration, reduced runoff volumes and chemical transport with runoff. This research provides information that will allow for informed decisions on management practices that offer quality turf and are environmentally responsible.

RP189 Contribution of Dry Deposited Mercury to Urban Run-Off. A. Maizel, Brooks Rand Labs, Seattle, WA. Mercury (Hg) dry deposition to natural environments and surfaces such as moss has been well studied, however, less is understood regarding the extent and fate of atmospheric Hg that deposits onto urban surfaces. Quantifying these values is especially important in urban areas due to the elevated levels of Hg deposition, compared with sites removed from anthropogenic Hg sources, and the presence of storm drains that convey surface water directly into natural environments. Pavement has been shown to be a more effective sink of dry deposited Hg than bare soil with deposition rates of up to 1.05ng Hg/m²/hr recorded. Reactive Gaseous Mercury (RGM), a highly soluble form of mercury that is the dominant Hg substrate for methylating microbes, exhibits elevated atmospheric concentrations in urban areas and has a relatively high deposition velocity compared to other Hg forms. At an industrial site in the city of Seattle, WA static water surface and ion exchange membrane samplers were deployed to determine total and RGM dry deposition respectively. The use of ion exchange membranes has been shown to be a precise and reproducible method of determining RGM dry deposition. At the same site urban surfaces, consisting of sections of pavement and cement, were exposed to the atmosphere for week-long periods and then washed to determine run-off labile Hg. All surfaces were protected from rainfall and direct sunlight. Extraction fluid #1 from EPA Method 1311 (TCLP) was used to simulate urban run-off. Prior to the study, blanks were taken to ensure that the urban surfaces were not significantly contaminating. Measured values for RGM deposition were in keeping with existing data for urban areas while the values for total Hg deposition were reduced compared with studies conducted in the eastern half of the US. Both asphalt and cement surfaces significantly accumulated Hg that was removed with the simulated run-off, with asphalt releasing slightly elevated amounts of dry-deposited Hg in rinses. Increased RGM deposition was found to correspond to increased deposition of run-off labile Hg and it is suspected that RGM accounts for a significant amount of the what accumulated on the urban surfaces. From this we determined the contribution of Hg from dry deposition in urban Seattle to the bodies of water that abut it.

RP190 Using Stormwater to Monitor Urban Contaminant Sources. R. Raina, M. Etter, K. Buehler, K. Starks, L. Sun, Chemistry & Biochemistry, University of Regina, Regina, Saskatchewan, Canada; D. Wang, Centre for Sustainable Infrastructure Research (CSIR), National Research Council (NRC), Regina, Saskatchewan, Canada. The approach to the analytical methods (GC/MS, LC/MS/MS, GC/MS/MS) and sample clean-up requirements for analysis of selected pesticides for stormwater and surface water samples will be presented. The focus of these studies includes several common herbicides (trifluralin, trifluralin, ethalfluralin), insecticides (such as chlorpyrifos), acid herbicides commonly used in residential areas (2,4-D, dicamba, mecoprop), and other selected pesticides (DCPA, PCNB). Identification of some degradation products of OPPs and acid herbicides in water samples will also be presented. These studies include an urban watershed

(Wascana Lake and Creek) and more recent preliminary data on stormwater retention ponds within the City of Regina.

RP191 Road Salt: Are Urban Streams in a Pickle? R.E. Casey, Chemistry, Towson University, Towson, MD; S.M. Lev, Physics Astronomy and Geosciences, Towson University, Towson, MD; J.W. Snodgrass, Biological Sciences, Towson University, Towson, MD. The application of deicing salts to roadways in the northern United States, Canada and northern Europe is a common occurrence in winter months. These applications have the potential to contribute large quantities of road salt to receiving waters. Road salts have little affinity for soil particulate matter and can be directly transported into surface waters or leached into groundwater. A study recently conducted in Central Maryland indicated that increasing stream salinity in the northeastern United States poses a threat to potable water sources and habitat for freshwater wildlife (Kaushal et al. 2005). This gradual increase in surface water salinity coincides with an increase in impervious surface and an associated increase in storm water management systems over the last 20 years. More than 70 storm water retention basins within the Red Run watershed in Owings Mills, Maryland have been surveyed over the last year with surface water conductivities ranging from 70 uS to more than 200,000 uS. The highest conductivities observed in these surface waters to date were measured in April, 2007 approximately 3 months after the last road salt application in the watershed. The groundwater beneath one highway pond remains elevated (> 10,000 uS) for most of the year suggesting that a slow-moving groundwater domain of salt exists under some ponds, creating a long-term source of salt to adjacent surface waters. The groundwater between two adjacent residential ponds and a tributary of Red Run has remained elevated (> 1300 uS) for a period of more than 3 months following the first road salt application of 2007. Ion chromatographic analysis of these surface waters demonstrated that elevated conductivities correspond to elevated chloride levels. The elevated conductivities associated with groundwater recharge from storm water retention basins in the Red Run watershed suggests that these basins may serve as a mechanism for the long-term salinization of surface waters by enhancing the proportion of road salt that enters a slow-moving groundwater domain. This may account for year-round elevated chloride levels that have been observed in surface waters in this region.

RP192 Development of consensus characterization factors for primary and secondary particulate matter. Y. Nishioka, G. Stevens, HSPH, Harvard University, Boston, MA; S. Humbert, A. Horvath, CEE, UC Berkeley, Berkeley, CA; S. Shaked, O. Jolliet, SPH, University of Michigan, Ann Arbor, MI; P. Preiss, IER, Uni Stuttgart, Stuttgart, Germany; J. Marshall, CEE, University of Minnesota, Minneapolis, MN. Primary and secondary particulate matter (PM) often dominate the human health damage category in life cycle assessment (LCA). The PM subgroup of the UNEP/SETAC Life Cycle Initiative Task Force 4 has the mission of providing state-of-the-art consensus characterization factors that can be used to estimate the fate, population exposure and health effects of primary and secondary particulate matter. As a first step, an extensive review of literature and existing models has been conducted. Differences in assumptions, input data, models and results have been carefully evaluated in order to derive "consensus" values for the characterization factors. Our approach is consistent with the USEtox values developed for organics and other inorganics. The consensus characterization factors are publicly available as both generic factors and situation-specific factors (urban, rural, and average population density conditions). Uncertainty and variability of factors is also discussed. These results are intended for, and can be incorporated into, life cycle impact assessment for human health. **KEYWORDS:** Particulate matter; fate factor; intake fraction; effect factor; characterization factor; human health; life cycle assessment

RP193 Modeling the Long-Term Fate of Polychlorinated Biphenyls in San Francisco Bay, CA. J.J. Oram, J.A. Davis, J.E. Leatherbarrow, SFEI, Oakland, CA; D. Schoellhamer, M. Lionberger, USGS, Sacramento, CA. Polychlorinated biphenyls (PCBs) are currently a high regulatory priority in San Francisco Bay. In work funded by the Regional Monitoring Program for Water Quality in San Francisco Estuary, a multi-box mass budget model was developed to improve understanding of the long-term fate of PCBs in San Francisco Bay. The model builds upon two existing models; a tidally-averaged hydrodynamic model previously used to interpret daily to decadal variability in salinity concentrations and a sediment transport model used to estimate long-term bathymetric change. Despite uncertainties in historical PCB load estimates and influential parameters, the model was found to reasonably match observed PCB concentrations in water and surface sediment. Extensive

uncertainty and sensitivity analyses were conducted to identify key processes controlling PCB fate and to guide future monitoring efforts. Results indicate that Bay recovery is controlled by the vertical distribution of PCBs in bedded sediments, a parameter that is currently not well characterized.

RP194 Particulate Carbonaceous Materials: On the Trail of Polycyclic Aromatic Hydrocarbons in a Small Urban Watershed. Y. Yang, C.J. Werth, Department of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign, Urbana, IL; B. Ligouis, M. Razzaque, Tübingen University, Tübingen, Germany. Concentrations of polycyclic aromatic hydrocarbons (PAHs) have been increasing in recent decades in many urban lakes and streams, particularly in areas with rapid urbanization. PAHs are primarily associated with carbonaceous material (CM) particles and enter receiving water bodies with storm runoff, as well as by atmospheric deposition. CMs differ in type and amount, and are hypothesized to affect the fate of PAHs in urban watersheds. The objectives of this study are 1) to determine the types and amounts of CMs in urban soil and dust particles with storm runoff, in suspended particles during transport, and in lake sediments after settling, accumulation and burial, 2) to identify the sources of CM particles that may concentrate, transport, and redistribute PAHs in urban watersheds, and 3) to elucidate the relationships between CM properties and PAH loadings. Samples were collected from the Lake Como watershed in Fort Worth, Texas. They include residential and commercial soils, residential street dust, sealed and unsealed parking lot dust, stream sediments, and lake sediments as a function of depth. All samples are subject to CM characterization by two complementary methods: 1) density separation followed by sequential chemical treatment, and 2) quantitative petrographic analysis. PAH concentrations in bulk samples and in density separated fractions are analyzed. Sorption isotherms for ¹⁴C-labeled phenanthrene were obtained to estimate the PAHs uptake capacities of CMs. Results indicate that the majority of CMs are associated with the density separated heavy fractions which control the sorption of phenanthrene. Coal tar pitch dominates the sealed parking lot dust, while asphalt-like substances dominate the unsealed parking lot dust and street dust. The dominant anthropogenic CMs in lake sediments are soot and asphalt-like substances, while relatively little to no coal tar pitch was observed by organic petrographic analysis. Total PAHs in sealed parking lot dust are 30 times greater than in unsealed parking lot dust, and 80-110 times greater than in sediments. It is not yet clear if PAHs from sealed parking lots contribute to PAH concentrations measured in lake sediments. Relationships between CM properties and PAH concentrations will be presented, as well as implications for watershed management.

RP197.5 Pilot Scale Study of Aircraft Deicer Treatment in a Gravel Wetland. A. Watts, R. Roseen, T. Ballesterio, Environmental Research Group, University of New Hampshire, Durham, NH. The University of New Hampshire Stormwater Center conducted a pilot scale study to evaluate the effectiveness of a small horizontal flow gravel wetland for the treatment of aircraft deicer. The EPA estimates that approximately 21 million gallons of aircraft deicing fluid are released to surface waters each year in the US. Biodegradation of deicing fluid exerts a high biological oxygen demand, and can impair water quality. The UNH Stormwater Center is a product verification facility which evaluates the effectiveness of a variety of stormwater treatment devices, including a 5,000 square foot horizontal flow gravel wetland. Propylene glycol-based aircraft deicer was added to influent stormwater at the gravel wetland from February to May, 2007. The deicer was loaded at a constant rate with influent concentrations up to 850 mg/l. Stormwater influent flow rate varied from 230gpm to less than 1gpm and the system retention time varied from a few hours during a storm to several days during dry periods. The gravel wetland consists of a vegetated forebay, and two subsurface treatment cells. Biological oxygen demand (BOD), chemical oxygen demand (COD), propylene glycol concentrations, pH, temperature, oxygen levels and conductivity were measured in the influent, effluent, forebay, and several in-system wells. BOD concentrations were reduced by 40% in the forebay and an additional 60% in the subsurface cells, for a total reduction of 75% in the gravel wetland treatment system. Oxygen concentrations decreased in the wetland cells, while the presence of volatile fatty acids increased. Both aerobic and anaerobic microbial processes appeared to be active, and removal occurred in both the open forebay and the underground gravel substrate. The correlation between BOD, COD and propylene glycol concentrations were generally poor, indicating that BOD and COD are not suitable surrogates for propylene glycol in this system.

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