Proceedings of the 33rd Annual Aquatic Toxicity Workshop: October 1 to 4, 2006, Jasper, Alberta

Compes rendus du 33ième atelier annuel sur la toxicté aquatique: du 1 au 4 Octobre 2006, Jasper, Alberta

Editors/Éditeurs

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Canadian Technical Report of Fisheries and Aquatic Sciences 2746

Rapport Technique Canadien des Sciences Halieutiques et Aquatiques 2746

Canadian Technical Report of
Fisheries and Aquatic Sciences

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Les numéros 1 à 456 de cette série ont été publiés à titre de rapports techniques de l'Office des recherches sur les pêcheries du Canada. Les numéros 457 à 714 sont parus à titre de rapports techniques de la Direction générale de la recherche et du développe-ment, Service des pêches et de la mer, ministère de l'Environnement. Les numéros 715 à 924 ont été publiés à titre de rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

Les rapports techniques sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

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Preface/Preface

The 33rd Annual Aquatic Toxicity Workshop was held at the Jasper Park Lodge, Jasper , Alberta October 1 to 4, 2006. The Workshop included three plenary presentations, 129 platform, 65 poster papers and several interactive sessions. Total attendance was 360.

This workshop was one of a continuing series of annual workshops in Canada on aquatic and environmental toxicology, covering topics from basic aquatic toxicology to applications in environmental monitoring, setting of regulations and guidelines, and the development of sediment and water quality criteria. These workshops emphasize an informal exchange of ideas and knowledge on the topics among interested persons from industry, governments and universities. They provide an annual focus on the principles, current problems and approaches in aquatic toxicology. These workshops are administered by a Board of Directors, and organized by local organizing committees. The Proceedings are published with the support of the Department of Fisheries and Oceans.

L' 33ième atelier annuel sur la toxicité a eu lieu au Jasper Park Lodge à Jasper, Alberta, du 1 au 4 October 2006. Le atelier a donné lieu a 3 communication lors de séances plénières, 129 exposés d'invités d'honneur, 65 communications par affichage et plusieurs sessions interactives. 360 personnes ont assisté au atelier.

Le atelier a premis de poursuivre les discussions tenues annuellement au Canada sur la toxicologie aquatique et l'écotoxicologie. Ces atelier annuels organisés par un comité national constitué légalement réunissent des représentants des secteurs industriels, des administrations et des universités que le domaine intéresse. Ces derniers y échangent des idées et des connaissances sur les notions fondamentales de la toxicologie aquatique, mais aussi sur son application pour la surveillance de l'environnement, l'élaboration de lignes directrices et de règlements, et la définition de critère pour les sédiments et pour la qualité de l'eau. Ils passent également en revue les principes de la spécialité, de même que les questions d'actualité et les méthodes adoptées dans le domaine. Les comptes rendus sont publies l'aide du ministre des Pêches et Océans.

Editors comments/Remarques des editeurs

This volume contains papers, abstracts or extended abstracts of all presentations at the workshop. And author index and list of participants are also included. The papers and abstract were subject to limited review by the editors but were not subjected to full formal or external review. In most cases the papers are published as presented and therefore are of various lengths and formats. Comments on any aspects of individual contributions should be directed to the authors. Any statements or views presented here are totally those of the speakers and are neither condoned nor rejected by the editors. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Ces comptes rendus sont publiés en deux volumes, en raison de leur longeur, ils renferment le texte intégral ou le résumé de toutes les communications présentées aux ateliers. Un index des auteurs et une liste des participants sont aussi inclus. Les communications et les résumés ont été revus sommairement par les éditeurs, mais ils n'ont pas fait l'objet d'une revue exhaustive en bonne et due forme ou d'une revue indépendante. La lonueur et la forme des communications varient parce que ces derniéres sont pour la plupart publiées intégralement. On est prié de communiquer directement avec les auteurs pour faire des remarques sur le travaux. Toutes les déclarations et opinions paraissant dans le présent rapport sont celles des conférenciers; elle ne sont ni approuvées, ni rejetées par les éditeurs. La mention de marques de commerce ou de produits commercialiesés ne constitue ni une approbation, ni une recommandation d' emploi.

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Assessing stream ecosystem health within agricultural watersheds in Nova Scotia. *M.G. Brisbois[1], R. Jamieson[1], R. Gordon[2], A. Madani[2] and G. Stratton[2](PL)*
[1]Biological Engineering, Dalhousie University, Halifax, NS; [2]Environmental Sciences, Nova Scotia Agricultural College, Truro, NS

Excessive nutrient loading due to agricultural activities can create water quality problems in rural waterways. One result of nutrient enrichment is an increase in algal growth, which can be characterized by elevated chlorophyll *a* levels and diurnal fluctuations in dissolved oxygen (DO) concentrations. High levels of algal growth can deplete DO concentrations and block incoming sunlight, thus depriving other aquatic organisms of energy required for photosynthesis. This can lead to a decrease in stream biodiversity. The Thomas Brook Watershed is an intensively farmed region in Nova Scotia. Water quality monitoring within the watershed has been ongoing since 2001 and elevated concentrations of nitrogen and phosphorus have been documented within the stream system. Intensive sampling of Thomas Brook and a comparable, but relatively pristine, watershed has provided data on alternative indicators of water quality in a comparative context. Continuous diurnal measurement of dissolved oxygen, temperature and flow, in conjunction with diurnal curve fitting methods, has been used to estimate primary production and respiration. The trophic status within each stream was established through the use of photosynthesis/respiration ratios. Trophic values were further reinforced using continuous chlorophyll *a* data as a measure of in-stream photosynthetic

capabilities. Benthic invertebrate sampling has provided further information on overall stream health through density and diversity distributions and indicator species. These parameters, when combined and compared to in-stream nutrient concentrations, provide an alternative method of assessing overall stream health and can be used as a tool to set regionally specific nutrient criteria in small rural waterways.

Calculating phosphorus limits based on the field-scale relationship between phosphorus in soil and in runoff. *J. Little[1], S.Nolan[1], A. Jedrych[1], B. Olson[1], J. Casson[1] and B. Paterson[1](PL)*

[1]Alberta Agriculture, Food and Rural Development, Edmonton, AB

Runoff from agricultural land is a major source of phosphorus to streams and water bodies. The Alberta Soil Phosphorus Limits team conducted research to develop field-scale relationships between soil-test phosphorus (STP) and P in runoff, and these relationships were then used to model soil phosphorus limits for all agricultural land in Alberta. Eight field-scale microwatersheds (2 to 244 ha) were instrumented to monitor runoff for three years. Soil samples from three different depths (max. 15 cm) were collected in transects by landform position every fall and spring to characterize STP levels. Spring snowmelt runoff accounted for the majority (90%) of runoff and phosphorus loss, except at the irrigated site. Mean STP ranged from 3 to 512 $mg \cdot kg^{-1}$. Flow-weighted mean concentrations of total P (TP) in runoff ranged from 0.20 to 0.86 $mg \cdot L^{-1}$ at non-manured sites and from 1.15 to 24.00 $mg \cdot L^{-1}$ at manured sites. Strong regression relationships were found between STP and flow-weighted mean concentrations of dissolved reactive phosphorus and TP. The results of the study were then used to calculate site-specific soil P limits based on selected TP water quality objectives, watershed characteristics, and runoff potential.

Agriculture and other impacts on water quality in the Oldman River basin. *W. Koning[1], J. Little[2], J. Villeneuve[2] and L. Fent[3](PL)*

[1]Alberta Environment, Calgary, AB; [2]Alberta Agriculture, Food and Rural Development, Edmonton, AB; [3]Alberta Sustainable Resource Development, Edmonton,AB

The Oldman River is a gravel-bed stream that flows 440 km from its headwaters in south-western Alberta, through mountains, foothills and plains into the South Saskatchewan River. Human activity in the basin includes forestry, recreation, oil and gas development, agriculture and urban development. Three major reservoirs, together with more than a dozen other structures, supply water to nine irrigation districts and other water users in the Oldman Basin. Along with the basin being intensively irrigated, it also supports the greatest density of cattle and feedlot operations in Canada. The Oldman Water Council (OWC) originated in 1998 to address concerns of basin residents regarding perceived deterioration of river water quality due to human activities. Water samples are collected from the river mainstem, tributaries, and irrigation return flows. Results show that mainstem water quality remains good, whereas tributary water quality is more of a challenge. Key variables of concern are nutrients, bacteria and pesticides. A water quality index, and separate pesticides residue index, both unique to the basin, are used to communicate the results. Results show that agriculture is one of a number activities affecting water quality. Of note, runoff from urban areas was found to contain similar levels of pesticide residues as runoff from agricultural areas. Recent data

on *Cryptosporidium* and *Giardia* presence are providing benefit for focusing watershed management activities. The water quality data collected is providing a foundation to implement community-supported urban and rural better management practices (BMP's) to improve water quality. Members of the OWC are also collaborating with federal agencies in the NAESI project (National Agri-Environmental Standards Initiative), with the goal to develop standards for waterborne pathogens in agricultural watersheds, with the Oldman basin one of 4 basins across Canada in this study.

Water quality in a small agricultural watershed: South Tobacco Creek. *N. Glozier[1], J. Elliott[1], B. Holliday[1], J. Yarotski[2] and B. Harker[2](PL)*

[1]Environment Canada, National Water Research Institute, Saskatoon, SK; [2]Agri-Food and Agriculture Canada, Water Planning and Sourcing, Regina, SK

Agricultural watersheds can contribute to cumulative nutrient loads in river and lake ecosystems, potentially leading to changes in aquatic ecosystems. South Tobacco Creek (STC) is a small catchment (76 km^2) located in the upper reaches of the Red River Basin in south-central Manitoba. Landowners in this watershed have long been concerned over increases in flooding, erosion, and sedimentation, and although flood control was an initial priority the importance of water quality was quickly recognized. In 1992, the water quality component of the STC study began as a collaborative project between Environment Canada, the Prairie Farm Rehabilitation Administration (PFRA), and the Deerwood Soil and Water Management Association. Over several years, five water quality monitoring sites within STC were established to represent stream conditions ranging from native forest and brush, agricultural edge of field, and 2^{nd} and 3^{rd} order streams. In this study we evaluated the changes in water quality using over a decade of monitoring with the specific objectives to: 1) describe and document natural and anthropogenic trends in nutrients and sediments within STC, 2) estimate potential impacts to aquatic ecosystems, 3) estimate nutrient loads to larger watersheds of concern, and 4) determine the major source of sediment loading to the STC. We discuss linkages between land use and water quality in STC and outline a series of recommendations regarding future directions for small agricultural watersheds such as South Tobacco Creek.

Fisheries Act section 36(3). *K. Fraser[1](PL)*

[1]Environment Canada, Environmental Stewardship Branch, Edmonton, AB

The Fisheries Act is a very broad act that includes fishing licenses, powers of inspectors, harvesting of marine plants, boat searches, etc. Two main Sections within the Act relate to the "protection of the environment": Section 35 (Fish Habitat protection) and Section 36(3) (Deposit of Deleterious Substances). Environment Canada is responsible for the administration of Section 36(3) of the Fisheries Act which states that "No person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substances or any other deleterious substance that results from the deposit of the deleterious substance may enter any such water." This presentation will describe what Section 36(3) means and what the section strives to achieve.

Municipal Wastewater/Eaux usée Municpales

Session Co-chairs/Présidents: John Clarke and David Beauparlant

The role of environmental quality guidelines in environmental risk management of municipal wastewater effluent discharge. *P. Jiapizian[1](PL)*

[1]Environment Canada, National Guidelines and Standards Office, Gatineau, QC

The Canadian Council of Ministers of the Environment (CCME) Development Committee for municipal wastewater effluent (MWWE) is currently establishing a Canada-wide strategy. The goal of this strategy is to prevent the release of effluent that poses unacceptable risks to human and ecosystem health. Therefore, an environmental risk-based approach will be adopted to establish discharge requirements for all substances. A major goal of the proposed environmental risk-based approach is to set Environmental Quality Objectives (EQOs) that are protective of the designated uses of receiving waters for MWWE discharge, such as aquatic life. The Canadian Environmental Quality Guidelines (CEQGs), currently produced by the CCME, are ideal tools for the development of EQOs, because a standardized but flexible framework may be used to develop national or site-specific guidelines for any Canadian context. Where necessary, Environmental Discharge Objectives will be derived to enable effluent discharges to meet the EQOs of the receiving waters. This presentation will describe the role of CEQGs in supporting the protection goals established in municipal wastewater management.

City of Edmonton ammonia risk assessment study. *D. Morgan[1], D. Gyurek[2], G. Craig[3] and J. Taylor[1](PL)*

[1]TetrES Consultants Inc., Winnipeg, MB ; [2]City of Edmonton, Edmonton, AB; [3]GR Craig & Associates, Schomberg, ON

The objective of this study was to assess whether ammonia found in effluent released from Gold Bar Waste Water Treatment Plant posed a risk to aquatic life in the North Saskatchewan River (NSR). An aquatic risk assessment model was developed describing effluent chemistry, effluent-plume mixing within the NSR, and effects of various ammonia discharge concentrations and durations on aquatic biota. Utilizing this model, ammonia reduction strategies were assessed, including biological nutrient removal, diffuser implementation within the NSR and strict compliance with the City of Edmonton effluent licence requirements. Results of the risk assessment indicated that under a variety of NSR flows, baseline conditions (no effluent treatment) did not comply with a variety of criteria (Alberta Environmental Protection, US EPA, and CCME). All ammonia reduction strategies complied with the CCME ammonia criterion except under low-flow conditions. A sensitivity analysis indicated that CCME criteria are likely over-protective for the NSR. Baseline NSR conditions could be in compliance with site-specific ammonia criteria developed through toxicity testing of local species in accordance with CCME guidelines.

North Saskatchewan River site-specific toxicity study. *J. Taylor[1], G. Craig[2], D. Gyurek[3] and D. Morgan[1](PL)*

[1]TetrES Consultants Inc.,Winnipeg, MB ; [2]GR Craig & Associates, Schomberg, ON; [3]City of Edmonton, Edmonton, AB

The objective of this study was to determine un-ionized ammonia $LC_{20/50}$ and EC_{20} of early life stages of locally resident fish species from the North Saskatchewan River (NSR) in order to determine whether current CCME ammonia criteria was truly protective or over-protective to NSR aquatic biota. Twelve acute and chronic site-specific, ammonia-toxicity tests, conducted from May 26 to July 12, 2004, were successfully completed on white sucker (*Catostomus commersoni*), fathead minnow (*Pimephalus promelus*) and scud (*Hyalella azteca*) to evaluate effects of un-ionized ammonia (NH_3) on growth and survival. Site-specificity was established utilizing NSR water as control and dilution water for all tests. Chronic extrapolated LC_{20} values ranged from 0.25 to 0.33 $mg \cdot L^{-1}$ -NH_3 for white sucker and 0.26 to 0.44 $mg \cdot L^{-1}$ -NH_3 for fathead minnow. Acute extrapolated LC_{20} values ranged from 0.55 to 0.60 $mg \cdot L^{-1}$ - NH_3 for white sucker and 0.33 to 0.63 $mg \cdot L^{-1}$ - NH_3 for fathead minnow. *H. azteca* results indicated an LC_{20} value of 0.13 $mg \cdot L^{-1}$ - NH_3, an $LC5_0$ value of 0.31 $mg \cdot L^{-1}$ - NH_3 and an EC_{20} value of 0.15 $mg \cdot L^{-1}$ - NH_3. An "unknown" toxicant that caused elevated control-exposure mortality was discovered in NSR dilution water. Charcoal filtration and ultraviolet (UV) disinfection apparatus alleviated this control-mortality somewhat; however, expected toxicity responses for all species were not apparent until NH3 levels greater than 0.10 $mg \cdot L^{-1}$ - NH_3 were observed. Results indicate the CCME criteria are over-protective for NSR aquatic biota.

Assessing the health of Halifax Harbour's intertidal ecosystem: preliminary steps toward monitoring remediation efforts. *C. Coray[1](PL)*

[1]Department of Biology, Dalhousie University, Halifax, NS

After 250+ years of pumping raw sewage directly into Halifax Harbour, Nova Scotia, an advanced primary treatment system is to debut in early 2007. Work in the summer of 2005 involved collecting baseline data on species richness and relative abundance of mid-low intertidal macrofauna and macroalgae at sites located both inside and outside Halifax Harbour. Spatial analyses indicated no significant difference in average species richness, but significant differences in relative abundance of certain species between sites inside and outside the harbour. Diversity monitoring in these areas continued with the addition of new sites chosen to encompass a wider range of pollution exposures in the summer of 2006. Research in this area is expanding to encompass studies of toxicological effects of sewage on marine organisms at the level of population and individual. A series of laboratory assays were undertaken to investigate immune function in endemic wild mussel populations (*Mytilus edulis* and *M. trossulus*), and endocrine disruption will be examined by evaluating the incidence of imposex in Atlantic dogwhelks (*Nucella lapillus*) and intersex in common periwinkles (*Littorina littorea*) collected at these sites. Pairing population and individual fitness of these species with characterization of community structure along established effluent gradients will aid in creating a monitoring program to evaluate the success of remediation in Halifax Harbour at the level of ecosystem, population and organism, down to the cellular and molecular realms.

Immune response, bacterial clearance and histopathology of caged blue mussels exposed to raw and treated sewage effluents. *F. Akaishi[1], S. St-jean[2], F. Bishay[3], S. Rabitto[1], J.D. Clarke[4] and C. Ribeiro[1](PL)*

[1]Federal University of Parana, Curitiba City, Brazil, [2]Jacques Whitford Environment Ltd., Moncton, NB; [3]Greater Vancouver Regional District, Burnaby, BC; [4]Environment Canada, Environmental Stewardship Branch, Gatineau, QC

Wastewater effluents are a known source of pollution in the marine environment. This study aimed to assess the potential toxicity of sewage effluents on the immune system and tissues of caged *Mytilus edulis* in the estuarine environment receiving wastewater, and to test mussels' disease resistance after exposure. East River and Pictou Harbour, NS, Canada receive secondary treated sewage from a wastewater treatment plant (WWTP) and raw sewage from the town of Pictou, respectively. Caged mussels were deployed 50 m up (ER1) and downstream (ER2) of treated sewage outfall and 100m (ER3) downstream. In Pictou Harbour, mussels were deployed directly into two raw sewage outfalls (PS1, PS2) and 300 m (PS3) upstream from outfalls. Reference sites (REF1 and REF2) were located outside of Pictou Harbour away from anthropogenic inputs. *In situ* exposure began in early May and ended in July 2005. Phagocytic activity (PA), H_2O_2 and nitric oxide (NO) production and haemocyte count (HC) were measured in haemolymph of 10 mussels per site. Catalase and histopathology of gills and digestive gland were analyzed in 15 mussels. After *in situ* exposure, 10 mussels were infected with *Listonella anguillarium* for 24 h to test for disease resistance. Results showed that mussels from PS1, PS2 and PS3 presented higher PA, H_2O_2 and NO production and lower HC than mussels from REF/REF2. Gills of mussels at estuarine sites receiving raw and treated sewage presented lamellar fusion, dilated sinus, haemocyte infusion in tissue and lipofuscin granules, while digestive gland showed tubular necrosis, vacuolized cytoplasm and epithelium disorganization. Bacterial clearance did not show difference among sites, nor did catalase activity. In conclusion, the immune system of mussels was affected at some sites, after 90 days exposure in the receiving environment adjacent to the outfalls. The distinction observed may be due to difference in treatment and/or environmental conditions among the sites.

Use of goldfish (*Carassius auratus*) as a bioindicator of pollutant exposure in treated municipal wastewater. *J.L. Kerr[1], Z. Guo[1], D. Smith[1], G.G. Goss[1] and M. Belosevic[1](PO)*

[1] Department of Biological Sciences, University of Alberta, Edmonton, AB

Treated municipal wastewater can contain many chemicals that impact living organisms. Aquatic organisms, such as goldfish, are constantly exposed to chemicals in their environment and, as such, are good model organisms for detecting potential synergistic effects of these xenobiotics on animal physiology. We exposed goldfish for 90 days in a real- time, flow-through system to i) final sewage effluent (FE), ii) membrane-filtered FE or iii) membrane-filtered FE in conjunction with activated carbon filtration at Gold Bar Waste Treatment Plant in Edmonton, Alberta. At different times post-exposure fish were sacrificed and analysed for xenobiotic exposure by 7-ethoxyresorufin de-ethylase (EROD) activity, as well as for estrogenic compound exposure by plasma vitellogenin induction. Immunocompetence of the goldfish was examined by infection of fish with the protazoan parasite *Trypanosoma danilewskyi*. Membrane filtration did not effectively

remove xenobiotics from the wastewater, whereas activated carbon filtration substantially reduced concentrations of all pesticides and pharmaceuticals detected. Fish exposed to xenobiotic-contaminated wastewater had higher EROD activity than fish exposed to activated carbon-filtered wastewater. Parasitemia of xenobitoic-exposed fish was variable, depending upon unknown factors, possibly seasonality or the underlying health of the fish upon infection.

Use of fish cells in culture and the ciliated protozoan *Tetrahymena* to study the impact of environmental pharmaceuticals on aquatic environments. *S. Schnell[1], M. D. Pinheiro[2], A. Kawano[2], M. Power[2], B. Butler[2], R. Slawson[3], L. E.J. Lee[3], D. Lynn[4], C. Porte[1] and N.C. Bols[2](PO)*

[1]Institute of Chemical and Environmental Research, CSIC, Spain; [2] Department of Biology, University of Waterloo, Waterloo, ON; [3] Department of Biology, Wilfrid Laurier University, Waterloo, ON; [4] Department of Integrative Biology, University of Guelph, Guelph, ON

The pharmaceuticals that are inadvertently released into the environment have been studied for their actions at the cellular level on mammalian cells, but in the aquatic environment, they have potentially new targets and their cellular actions on these are poorly understood. Two possible targets are fish and ciliates. Fish cell lines are available for cellular studies and the free-living ciliate, *Tetrahymena thermophila*, is a single cell organism that is easy to maintain in the laboratory. One interesting environmental pharmaceutical is ibuprofen, which is a nonsteroidal, anti-inflammatory drug (NSAID) that acts by inhibiting cyclooxygenases and blocking prostaglandin synthesis. In this study ibuprofen has been shown to have a range of effects on liver (RTL-W1 and RTH-149) and monocyte/macrophage (RTS11) cell lines from rainbow trout and *Tetrahymena* depending on the concentration and manner of exposure. Sublethal effects were observed after exposure to concentrations between 5 and 50 $\mu g \cdot ml^{-1}$. Among the sublethal effects was an impairment of proliferation in both RTH-149 and *Tetrahymena* and of phagocytosis and killing of green fluorescent protein-expressing E. coli by *Tetrahymena*. At high ibuprofen concentrations cytotoxicity was observed using two fluorescent dyes, alamar Blue to measure energy metabolism, and CFDA AM, to measure membrane integrity. This was true for both the fish cell lines and *Tetrahymena* but the concentrations necessary to elicit cytotoxicity depended on the carrier solvent and how the test solution was added to the fish cell cultures. Generally 500 $\mu g\ ml^{-1}$ and higher was cytotoxic to all cells. This suggests that ibuprofen can be expected to alter some fundamental activities of cells in all eukaryotic organisms. However, the concentrations that elicit these effects are unlikely to be reached in multicellular organisms, such as fish, but *Tetrahymena* might be exposed to them in certain environments, such as during episodic events in sewage treatment plants.

Pesticides/Pesticides

Session Co-chairs/Présidents: Alice Hontela and Amie Quinn

Toxicity of pesticides in short-term pulse exposures to rainbow trout and *Daphnia magna*. *T. Steeves[1], P.M. Jackman[1] and K.G. Doe[1](PL)*
[1]Environment Canada, Environmental Conservation Branch, Moncton, NB

In the past 12 years in PEI there have been approximately 30 documented fish kills. Pesticides have been implicated as a cause in many of these fish kills because: the kills occur following a heavy rainfall; there is evidence of recent pesticide application; the dead fish have food in stomachs and no disease or parasites. To examine the role of pesticides in these fish kills, we conducted short term "realistic" pulse exposures of 1, 4, and 10h duration to mimic runoff situations. The data were compared with standard test durations (96-h continuous exposure for trout, 48-h continuous exposure for *Daphnia magna*). The pesticides were tested alone, and in combination with 10,000 $mg \cdot L^{-1}$ suspended PEI farm soil. The pesticides tested were Azinphos-methyl, Chlorothalonil, Endosulfan, Mancozeb and Carbofuran. Ammonia, a major nutrient found in run-off from potato fields, was also tested. Results indicate that pesticides tested in "realistic" exposures of 1, 4, 10h duration were significantly less toxic than in standard test durations. For invertebrates, immobilization of test species ("ecological death") is an important consideration. Addition of farm soil did not produce the expected decrease in toxicity, and possible reasons will be discussed. This new data should be used in risk assessments of the pesticides. Future planned research includes testing of more pesticides and measuring the short-term "realistic" pulse toxicity of mixtures of 2 or more pesticides, alone and in combination with other stressors such as nutrients, elevated temperatures and suspended soil particles.

Physiological stress indicators in whitefish (*Prosopium williamsoni*) and sucker (*Catostomus* sp.), cold- and cool-water species, from a river impacted by agriculture (Oldman River, Alberta). *A. L. Quinn[1], J. Rasmussen[1] and A. Hontela[1](PL)*
[1]Department of Biological Sciences, University of Lethbridge, Lethbridge, AB

Fish are exposed to multiple stressors in their environment. The interactive effects of pesticide exposure, increased water temperature and changes in water flow rates (flooding events) on physiological fitness were investigated in this two-year comparative field study with cold-water (whitefish *Prosopium williamsoni*) and cool-water (sucker *Catostomus* Sp.) fish species from the Oldman River, Alta. Analyses of primary (plasma cortisol), secondary (plasma glucose, liver glycogen), tertiary (condition) stress responses, and acetylcholinesterase inhibition suggested that whitefish are at higher risk at sites where pesticide exposure and species-specific temperature thresholds are surpassed. Relationships between sites and species were investigated to better understand the mechanisms that underlie species-dependent differences in vulnerability to stressors. (Funded by Alberta Ingenuity)

Alternative approaches for assessment of contaminants in wetlands. *E. Wallace[1], N. Glozier[1], M. Waiser[1], D.B. Donald[2] and J. Froese[1](PL)*

[1]Environment Canada, National Water Research Institute, Saskatoon, SK; [2]Environment Canada, Ecosystem Health Assessment, Saskatoon, SK

Ecotoxicological studies are conducted to determine effects of contaminants on aquatic biota and water quality. Many different approaches are used for these types of studies; both laboratory and field. Field studies allow for investigation of complex communities and their environments; however replication in the natural environment is difficult. Enclosures or mesocosms are used to improve the statistical strength of field studies. Mesocosms are used as a tool in bridging the gap between field and lab studies as they allow for both environmental realism and replication. To date there is no single type of design used for all aquatic field studies but rather a variety dependent on the study objectives and endpoints being tested. In the summers of 2003, 2004 and 2005 several different wetland assessment approaches were tested with herbicide applications in Saskatchewan. Prairie wetlands located in agricultural areas are susceptible to herbicide overspray and provide an ideal area, frequently exposed to contaminants, to evaluate the utility of several approaches. In this study we discuss the advantages and disadvantages of the approaches used with comparisons to each other as well as to other designs described in relevant literature. The results of these studies provide insight in determining the best mesocosm design for particular environments.

Effects of sulfonylurea herbicides (singly and in mixtures) on prairie wetland communities . *N. Glozier[1], M. Waiser[1], E. Wallace[1], D.B. Donald[1], A. Cessna[1] and J. Froese[1](PL)*

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Effects of low-level episodic exposure to herbicide mixtures are relatively unknown; due in part to the difficulty associated in assessing effects with field surveys. Multi-trophic level approaches are used to examine the effects of herbicides on entire wetland communities which can not be examined in single-species laboratory bioassays. In this study, three distinct approaches to multi-trophic level herbicide exposures have been utilized over three years: 1) whole wetland treatment, 2) wetland enclosures and 3) wetland mesocosms. These approaches range in physical scale from largest to smallest but also range in level of experimental control from lowest to highest. Over the course of this study we have found that sulfonylurea herbicides (SUH), particularly in mixtures, can, and do, have effects on biomass and production of free-living and attached microbial communities, algal production, zooplankton and invertebrate community structure in prairie aquatic ecosystems. These results lead to a greater understanding of the potential for community level shifts due to herbicide exposure. Importantly, in a parallel study, we have also found that SUH's are persistent in prairie water bodies - a month after treatment sulfonylurea herbicides were still detected at >60% of initial herbicide concentrations. Considering that effects were observed largely for herbicide mixtures, the accumulation of SUH's in prairie wetlands in conjunction with additional herbicide inputs could have the potential for deleterious effects on wetland communities. These findings are key to developing approaches for setting environmentally relevant standards for herbicide mixtures.

Nutrient levels, historical primary production and temporal trends of organochlorine pesticides and PCB from Lake Laberge, Yukon Territory: sediment core analysis. *M. Ryan[1], G. Stern[2], M. Diamond[3], D. Armstrong[1], H. Kling[4] and P. Roach[5](PL)*

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The recent temporal trends of contaminants and historical primary production in Lake Laberge were measured using radioisotope dating, organochlorine (OC) analyses and phytoplankton enumeration methods from collected sediment cores. The fluxes of OC pesticides and PCB in sediments through the 1990s remained relatively stable with slight increases for all groups except chlordane in more recent years. All 6 groups, DDT, HCH, PCB, chlorinated benzenes (CBz), chlordane (CHL), toxaphene (CHB) had average fluxes (1992-1999) less than historical peaks except for HCH in 1999. Elevated levels of BHCH in the core slice dated to 1999 (surface) coincides with a year of abnormally high precipitation for the lower Yukon region. During this decade, phytoplankton assemblages climbed to an all time 51 year high (primarily in 1995) as measured by diatoms, chrysophytes and cyanophytes enumerated from sediment slices. The population increases, also noted in 1982, generally correlate with warm, dry periods (droughts) that exceed 2 years in length. No correlations of sediment OC levels were found with these changes in phytoplankton populations. It is suspected that growth dilution of contaminants in the 1990s that occurred in most Lake Laberge fish coincides with the dramatic growth of phytoplankton during the same period providing evidence for growth dilution of contaminants from the base of the food web. We postulated that the regional climate change in the mid-1990s (warm, low precipitation) may be responsible for creating a concurrent change in both recent OC sediment flux and phytoplankton growth in Lake Laberge through related mechanisms (heat, light, terrestrial runoff, varying sedimentation, atmospheric deposition).

Derivation of ideal performance standards for ten pesticides in Canadian surface waters. *P. Jiapizian[1], P.Y. Caux[1], E. Sabo[1], M.J. Demers[1], D.R.J. Moore[2], S. Teed[3], R. Breton[3], R. Roshon[4] and G.L. Stephenson[4](PL)*

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In the past year, Ideal Performance Standards (IPS) were developed for ten priority pesticides. These IPS help fulfill the goal of the Canadian Agricultural Policy Framework to reduce impacts of agricultural practices to surface waters through the use of non-regulatory standards. IPS are standards that are protective of biota in receiving environments affected by agricultural operations. The approach for IPS development involves decision criteria that are used to select from six derivation methods. Data availability determines the derivation method for each of the ten priority pesticides. These IPS are national standards rather than site-specific standards, therefore watershed-defined and site-specific species sensitivity distribution (SSD) methods were not used. The generic SSD method was applied to chlorpyrifos, malathion, methomyl, trichlorfon, atrazine, and diquat. The Canadian Council of Ministers of the Environment

(1991) interim guideline process was implemented to develop IPS for tefluthrin, and pendimethalin. Due to a paucity of data, the IPS for fluroxypyr and quintozene were developed by adopting approved benchmarks. The process of method selection and derivation will be described in this presentation of 10 IPS for priority pesticides.

Derivation of ideal performance standards for pesticides with bimodal distributions. E. Sabo[1], P. Jiapizian[1], M.J. Demers[1] and P.Y. Caux[1](PL)
[1]Environment Canada, National Guidelines and Standards Office, Gatineau, QC

Under the Canadian Agricultural Policy Framework, Ideal Performance Standards (IPS) are currently being developed to protect freshwater life in surface waters affected by agricultural operations. The preferred approach for developing these IPS is to model a species sensitivity distribution (SSD) for the pesticide, from which the protective concentration may be estimated. Although this method is useful in predicting thresholds for toxic effects for many different substances, pesticides with targeted, rather than broad effects, produce a bimodal distribution (distinct clusters of sensitive and tolerant species) that is not well suited to the SSD method. Potential solutions include a mixed-distribution approach, and the inclusion of only the most sensitive species group in SSD modelling. This presentation builds on the previous presentation of the 10 IPS derived in 2005-2006, and describes the current approaches to developing IPS for pesticides with this type of distribution, including case studies.

Chlorpyrifos impairs the swimming ability of coho salmon and it makes no difference how long the swim test is: a new swim test called the quick-Ucrit.. *M. Casselman[1], S. Takeda[1], K. Tierney[1], A.P. Farrell[2], and C. Kennedy[1](PL)*
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Swimming performance and brain acetylcholinesterase (AChE) activity were evaluated in coho salmon (28.1±0.2 cm) given 4-d exposures to 0, 5, 10, 20 or 40 $\mu g \cdot L^{-1}$ of chlorpyrifos. Swimming performance was assessed using the ramp-Ucrit protocol as well as a novel protocol, the quick-Ucrit. Both protocols consisted of step-wise speed increases of 0.2 body lengths per second (bl/s) from a base of 0.3 bl/s, however with ramp-Ucrit, steps began at 5-min then switched to 20-min at ~75% of the estimated Ucrit whereas with quick-Ucrit all steps were of 2-min duration. There were no differences between ramp- and quick-Ucrit values in each chlorpyrifos exposure group. Overall, swimming performance only became significantly impaired at exposure concentrations ≥ 20 $\mu g \cdot L^{-1}$ (i.e. Ucrit was 80.4% of the control value of 3.58±0.08 bl/s). In contrast, brain AChE activity decreased in a concentration-dependent manner with significant AChE reductions beginning at a concentration of 10 $\mu g \cdot L^{-1}$ (i.e. AChE activity was 56.8% of the control value of 282.7±18.3 $nmol \cdot min^{-1} \cdot mg^{-1}$ protein). These results indicate two things: the time required for testing impaired Ucrit can be considerably reduced (from > 3-h to < 1-h), and that coho appear able to maintain their swimming performance despite significant impairment of the cholinergic nervous system.

Using *in situ* exposures of *Hyalella azteca* to evaluate pesticide impacts on freshwater streams. *A. J. Bartlett[1], J. Struger[2], D.B. Donald[3] and V.P. Palace[1](PO)*

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Hyalella azteca is a freshwater amphipod that has been widely used in aquatic toxicology due to its sensitivity to a variety of contaminants, ease of culture in the laboratory, and ubiquitous presence in North American freshwaters. In this study, we investigated the feasibility of using *in situ* exposures of *H. azteca* to evaluate the impacts of pesticides on freshwater streams in agricultural areas of Ontario and Manitoba. In 2005, juvenile and adult amphipods were caged for one-week exposures at five sites in Southern Ontario and four sites in Southern Manitoba. Exposures were conducted in late April-early May (pre-pesticide application), June, July, and August (peak pesticide usage), and late September-early October (post-pesticide usage). Decreased survival of juvenile and adult amphipods was observed at one or more of the Ontario sites for June, July, and August exposures when compared to the pre- and post-pesticide application exposures. Caging at the Manitoba sites was compromised due to heavy rainfall events during peak pesticide usage. Analysis of acetylcholinesterase activity in adult amphipods is in progress and will be compared to survival of *H. azteca* and to pesticide levels in the water to evaluate its use as an indicator of pesticide exposure.

National agri-environmental standards initiatives (NAESI) pesticide team method demonstration and verification project. *P.Y. Caux[1], R. Kent[1], C.C. Murphy[2], L. Poissant[3], J. Struger[4], T. Tuominen[1], P. Jiapizian[1], M. Amrani[2] and A. Rousseau[5](PO)*

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National Agri-environmental Standards are voluntary and are measures of the level of desired environmental quality sought in an agricultural landscape for air, biodiversity, pesticides and water. They can be qualitative or quantitative. For pesticides, the concentration in the receiving water body is measured through water quality monitoring. Predictions of how these concentrations can be reduced are made with a watershed model that incorporates a Best Management Practices (BMPs) function. The resulting desired concentration is an estimate of the level of environmental quality that is technically achievable through application of BMPs. This concentration can be adopted, unchanged, as an Achievable Performance Standard (APS); or, it may be adjusted according to the socio-economics of BMP implementation to reflect the level of environmental quality that is likely to be achieved given the current technology and socio-economics. Using input variables relating to hydrology and agricultural practices, the watershed model first predicts the loading of pesticide from the field edge to the stream network, and then the resulting in-stream concentration of pesticide. Studied BMPs may include: (i) reduced rate of pesticide application, (ii) buffer strips, and (iii) both BMPs combined. The BMP reduction function acts as an input parameter to the model that modifies the load calculated at the field edge. The first year of the project was conducted on the Chaudière River in Quebec to demonstrate the feasibility of the

approach. Then, four pilot representative watersheds were chosen to describe integrated systems (e.g., corn - hog; potato - french fries) with the premise that the knowledge gained could be transposed to other similar systems elsewhere in Canada. This approach has its limitations but is deemed an excellent base for further determinations of this type. This poster presents the work being conducted in these watersheds, namely the Wilmot/Dunk, Yamaska, South Nation and Okanagan.

Pulp and Paper/Pâte et Papier

Session Co-chairs/Présidents: Brendan Galloway and Ken Jefferies

A national investigation of cause project in pulp and paper environmental effects monitoring: effects on fish reproduction. *M. Hewitt[1], T. Kovacs[2], D. MacLatchy[3], P. Martel[2], M.E. McMaster[1], M. Paice[2], J.L. Parrott[1] and G. Van Der Kraak[4](PL)*

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For over 25 years pulp and paper mill effluents have been reported to affect fish reproduction. During this time, some improvements have been observed as a result of in-plant (e.g., spill control, discontinued use of products containing alkyl phenol ethoxylates) and effluent treatment (e.g., increased retention time) changes. However, despite this, effluent-related effects continue to be reported. The first three cycles of Environmental Effects Monitoring (EEM) show two consistent national response patterns in fish; responses related to nutrient enrichment, and metabolic disruption, typified by larger liver size and smaller gonad size. While improvements in effluent quality have been observed, the precise source(s) and cause(s) of the reproductive effects as well as the consequences of changes in mill operating conditions on fish reproduction are not fully understood. Consequently, effective and economical mitigating solutions have yet to be identified. This is primarily due to the chemical complexity of effluents as well as the complexity of reproductive processes in fish. As such, the probability of future success will depend on a concerted and collaborative effort. To this end, a team comprised of key researchers from Environment Canada, Paprican, the University of New Brunswick and the University of Guelph has been assembled. In 2005, a five-activity plan with the objective to evaluate in-mill and end-of-pipe treatment options for removing substances affecting fish reproductive capacity from pulp and paper mill effluents was devised on a multi-year (and multi-EEM cycle) timeframe. Research got underway in the spring of 2006 and an overview of the research activities and progress will be presented.

Diagnosing the most common causes of toxicity in pulp and paper mill effluents. *T. Kovacs[1], S. Gibbons[1], B. O'Connor[1], P. Martel[1], V. Naish[1], M. Paice[1] and R. Voss[1](PL)*

[1]Pulp and Paper Research Institute of Canada, Pointe Claire, QC

Despite the general compliance of pulp and paper mill effluents with Canada's toxicity regulation, in any given year, up to 25% of mills can experience a failure in tests with trout or *Daphnia magna*. In such cases, there is a need for a simple and effective diagnostic strategy for identifying the cause of effluent toxicity, which is the key to remediation, a quick return to compliance and the prevention of future toxicity episodes. Since 1997, Paprican has investigated over 80 cases of effluent toxicity and, in the process, devised such a diagnostic strategy. The hypothesis-driven approach, supported by the toxicological properties of causative agents and knowledge of mill operating conditions, has been successful in correctly diagnosing about 70% of effluent toxicity episodes. This presentation will describe the most common causes of effluent toxicity and outline the criteria used to identify them.

Moving the pulp and paper environmental effects monitoring program beyond sampling and analysing. *G. Kaminski[1], K. Hedley[1] and A. Willsie[1](PL)*

[1]Environment Canada, Science and Technology Branch, Gatineau, QC

In Canada, pulp and paper mills are required to participate in an Environmental Effects Monitoring (EEM) Program under the 1992 Pulp and Paper Effluent Regulations (PPER). The program helps to assess the adequacy of the regulation in protecting fish, fish habitat, and the use of fisheries resources by measuring the effects of effluent in the receiving environment. The EEM program is carried out in three-year cycles and consists of a biological monitoring study and sublethal toxicity testing of effluent and supporting environmental measurements. In early 2005 a multi-stakeholder project was launched to evaluate the effectiveness and efficiency of the requirements of the pulp and paper EEM Program, and to make recommendations on how the program could be improved. It was suggested that monitoring and related activities should be focused where they are most needed, based on effects identified by the program. The process produced a set of eight major recommendations, which include one process recommendation to set up a collaborative, open and transparent multi-stakeholder group to track progress of implementing the suggested changes, three recommendations to industry and Environment Canada (EC) to take action to address effects identified in EEM, and four recommendations to EC on EEM program changes - including short term regulatory amendments, program guidance and longer term regulatory changes. All these recommendations have been positively received by EC and it is expected that implementing them will allow for further improving of the effectiveness and efficiency of the EEM program, moving it past the continual routine monitoring towards taking actions where necessary and reducing monitoring elsewhere.

Investigation of cause for eutrophication effects in the pulp and paper environmental effects monitoring (EEM) programme. *A. Willsie[1], R. B.Lowell[1], B. Kilgour[2], M.E. Bowerman[1], N. Glozier[3], J. Culp[4], P. Chambers[5], K. Hedley[1], G. Kaminski[1](PL).*

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Under the Fisheries Act, the 1992 Pulp and Paper Effluent Regulation (PPER) requires mills to undertake an EEM study to monitor fish, fish habitat and the usability of fisheries resources. Once the effluent effect on monitored biota has been confirmed, and the extent and magnitude of the effect assessed, the PPER requires that a mill conduct an investigation of the cause (IOC) of the effect. Today, after three biological monitoring and assessment cycles, on a national scale, two key effects have been identified and confirmed: reduced gonad size in fish and eutrophication effects. In their December 2005 report of recommendations on how to improve the Pulp and Paper EEM, the Smart Regulation Project Multi-stakeholder Working Group recognized the importance of investigating these two major effects and moving towards a solution-oriented agenda. Following this Group's recommendation, Environment Canada is working on criteria to better define pronounced eutrophication. Using data from the Pulp and Paper EEM benthic studies, a classification system of eutrophication levels has been drafted. Guidelines outlining recommendations for actions subsequent to IOC studies will be developed in the near future.

Monitoring the toxicity of dioxin and furan contaminated sediment in the Spanish Harbour area of concern. *T.K.George[1], T. Kolic[1], K. MacPherson[1], L. Fayez[1], V. Khurana[1] and E. Reiner[1](PO)*

[1]Ontario Ministry of the Environment, Environmental Monitoring and Reporting, Etobicoke, ON

The Spanish Harbour Area of Concern (AOC) is located in the North Channel of Lake Huron and includes the lower 52 km of the Spanish River and the Whalesback Channel. The area was initially listed as an AOC by the International Joint Commission in 1985 as a result of impacts from the upstream pulp and paper mill, mining activities, sewage treatment plant discharges and historical logging operations. In 1999, the AOC was recognized as an area in recovery after actions, such as operational upgrades of industrial and municipal facilities, were complete. However, sediment in the area remains contaminated with concentrations of metals that exceed the Ontario Sediment Quality Guidelines. In addition, a 2005 monitoring survey of the area revealed elevated levels of dioxins and furans in the sediment, especially in the depositional areas of the Whalesback Channel, where the average TEQ concentrations ranged from 50 to 360 pg g^{-1}. Analysis of the sediment dioxin and furan congener distribution indicated that the historical bleaching process at the upstream pulp and paper mill was the primary source of contamination. Preliminary results of the analysis of muscle tissue from adult common white suckers showed a direct correlation with the level of dioxin and furan sediment contamination at the same sites. Further investigations will determine the impacts of these elevated sediment contaminants on higher tropic levels.

Oil Sands Research/Recherche des Sables Bitumineux

Session Co-chairs/Présidents: Terry van Meer, Jan Ciborowski and Carla Wytrykush

Carbon dynamics, food web structure & reclamation strategies in Athabasca oil sands wetlands (CFRAW). *J. J. H. Ciborowski[1], D.G. Dixon[2], L. Foote[3], K. Liber[4] and J. E. Smits[4](PL)*

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Wetlands will make up 20-40% of the final reclamation landscape of areas surface mined for oil sands in northeastern Alberta. Over the past five years, seven mining partners and a consortium of university researchers have formed a collaborative group that has provided understanding of effects of mine tailings and process waters on wetland communities. Young constructed wetlands, especially those amended with reclamation materials quickly become productive. Having learned some biological characteristics of young and older local wetlands, we can now predict the time required for development of more natural conditions in constructed systems. We can also assess the pathways and relative environmental risk associated with the dynamics of mine process-associated constituents that are part of constructed wetlands. However, these tools have yet to be validated. We also do not know how productivity of new wetlands is maintained. Natural wetlands slowly accumulate materials (organic carbon) from algal production, aquatic plants, and influx of outside materials. Supplementing wetlands with stockpiled peat or topsoil is thought to accelerate succession and community development. Hydrocarbons present in tailings (bitumen) and process water (naphthenic acids) are initially toxic, but may ultimately serve as a surrogate source of carbon once they degrade and/or are metabolized by bacteria. The CFRAW project is documenting how tailings in constructed wetlands modify maturation leading to natural conditions in a reclaimed landscape. Our research will explain how different types of biomass are incorporated into the food web as wetlands age; how this influences community development, food web structure and complexity, and the productivity and health of fish and wildlife; and whether wetlands built with peat amendments can be expected to maintain their productivity and have the potential to ultimately become true peat lands. We will produce validated tools (calibrated indicators, risk assessments) that measure reclamation success. Ultimately we will be able to recommend the materials and strategies most effective and economical in producing a functioning reclamation landscape. The research is being combined to build a conceptual model of carbon pathways and budgets to assess how the allocation of carbon among compartments changes as newly formed wetlands mature in the boreal system.

Water capping as a reclamation option for oil sands soft tailings: learnings and gaps. *M. D. Mackinnon[1] and T. Van Meer[1](PL)*

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A major challenge associated with development of northern Alberta's vast oil sands deposits is the reclamation of "soft" tailings. These materials require containment since they are too weak to be stacked or allow access of large reclamation equipment. Soft tailings include mature fine tails (MFT), composite tails (CT) and thickened tails (TT). They contain various aqueous mixtures of fines and sands resulting from segregation of extraction tailings or from engineered tailings processes (chemically-induced non-segregation mixtures). Being too weak to be placed above grade, they must be contained within geotechnically secure areas. If capping of these materials with soil to allow terrestrial reclamation is not feasible, then the use of a water cap, in which an aquatic ecosystem will develop and be sustained, has been shown through lab and field projects to be a viable alternative. Over the past 20 years, studies on the physical, chemical and biological factors affecting these water-capped soft tailings deposits have been undertaken. Such end pit lakes are part of current mine closure plans and will be constructed in the voids left from mining and will be important components of the lease closure watersheds. The initial quality of the "capping" water can range from natural surface waters to varying portions of oil sands process affected waters (OSPW). The properties of the OSPW and its impact of the water cap will depend on its source, age and transport pathways. Within the capped lake systems, exchange or release from the soft tails will occur, but negative effects will be mitigated through time, dilution and bioremediation. Some of the current understanding of the sensitivities surrounding the successful implementation of the wet landscape option for reclamation will be discussed.

Monitoring the biodegradation of naphthenic acids by gas chromatography-mass spectrometry (GC-MS). *A. C. Scott[1], M. D. Mackinnon[2] and P. M. Fedorak[1](PL)*

[1]Department of Biological Sciences, University Of Alberta, Edmonton, AB; [2]Syncrude Canada Ltd., Edmonton, AB

Naphthenic acids (NA) are described by the formula $C_nH_{2n+Z}O_2$, where *n* indicates the carbon number and *Z* is zero or a negative, even integer that specifies the hydrogen deficiency resulting from ring formation. NA are natural constituents in bitumen from the oil sands of northern Alberta. Much has been learned about this toxic, complex mixture of acids from GC-low resolution MS analyses of their *tert.*-butyldimethylsilyl derivatives. For example, (1) commercial preparations of NA contain higher proportions of low molecular mass acids than NA found in oil sands process-affected waters, and (2) as the proportion of higher molecular mass acids (≥C22) increases, the toxicity of the mixture decreases. In addition, laboratory incubations using microorganisms indigenous to tailings pond waters demonstrated that commercial NA are more readily biodegradable than acids from oil sands tailing waters. This evaluation was based on the shape of humps from total ion current chromatograms. Recent GC-high resolution MS analyses of acids from tailings waters indicate that some of these compounds do not fit the general formula for NA ($C_nH_{2n+Z}O_2$). From exact mass data, derivatized acids containing three oxygen atoms were detected. These results suggest that some microbial activities may simply add oxygen to NA, producing acids with higher molecular masses that are no longer NA.

Detection of naphthenic acids in waters using a gas chromatography-low resolution mass spectrometry (GC-LRMS) method. *M. Merlin[1], P. M. Fedorak[1] and S. Guigard[1](PL)*
[1] Department of Biological Sciences, University of Alberta, Edmonton, AB

Naphthenic acids (NAs) are a toxic mixture of aliphatic and cycloaliphatic carboxylic acids found in oil sands tailings water. Fourier transformed infrared spectroscopy is the industry standard method for the detection of NAs in waters. Because this method detects all dichloromethane-extractable carboxylic acids, we sought a method that was more specific for NAs. The gas chromatography-low resolution mass spectrometry GC-LRMS analyses of *t*-butyldimethylsilyl esters of NAs was evaluated for its specificity to detect NAs. GC-LRMS data from 35 samples of NAs were examined and three characteristic ions were common in all of the samples. Reconstructed ion chromatograms (RICs) for m/z 265, 267, and 279 yielded humps with a retention time between 15 to 23 min that were indicative of the presence of NAs. Analyses of NAs-spiked water showed a detection limit of 10 μg $NAs{\cdot}L^{-1}$. Twenty-two water samples from three provinces in Canada were collected, extracted and analyzed by GC-LRMS. These included waters that were in contact with petroleum (5), surface waters (11), and well waters (7). In general, the RICs of samples that had contacted petroleum showed the characteristic hump suggesting the presence of NAs. The RICs of samples that had not contacted petroleum showed no characteristic hump, thus no NAs. Surprisingly, two domestic well waters contained extractable compounds that were indistinguishable from NAs. Selected samples were analyzed by GC-high resolution MS to confirm the results from GC-LRMS. These methods provide the basis for specifically detecting NAs in waters, with the possibility to detect NAs in animals and plants.

Detection of naphthenic acids in fish. *R. Young[1], E. Orr[1], G.G. Goss[1] and P.M. Fedorak[1](PL)*
[1] Department of Biological Sciences, University of Alberta, Edmonton, AB

Naphthenic acids (NAs) are water-soluble components of bitumen, and they are present in process-affected waters from oil sands operations. These acids are among the most toxic and most abundant components of oil sands tailings waters, and they have been implicated in fish tainting. To date, there has been no analytical method to detect NAs in fish. We have developed extraction, cleanup, and gas chromatography-mass spectrometry (GC-MS) methods to detect NAs in rainbow trout at concentrations as low as 1 μg g^{-1} of fish. Reconstructed ion chromatograms were used to selectively distinguish NAs from other lipids and fatty acids extracted from the fish. In laboratory studies, rainbow trout were fed NAs-containing food. Analyses of the whole fish (after removal of the head and tail) showed the presence of NAs. When the NAs-fed fish were eviscerated, the majority of the NAs were found in the viscera. In 96-h static renewal exposure experiments, one group of fish was exposed to 3 mg commercial (Merichem) $NAs{\cdot}L^{-1}$, and another group was exposed to Syncrude's Pond 9 water that contained 15 mg $NAs{\cdot}L^{-1}$. Analyses of whole fish (heads and tails removed) from both groups showed the presence of NAs. This analytical method should allow monitoring of NAs uptake by fish in the wild or in oil sands reclamation ponds.

Identification of compounds in crude oil that are toxic to fish. *C. W. Khan[1], G. Saravanabhavan[1], R. S. Brown[2] and P. V. Hodson[1](PL)*
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Using an "effects-driven" fractionation approach with different crude oils, we found that CYP1A induction in rainbow trout (*Oncorhynchus mykiss*) varied widely after exposure to four unique crude oil fractions: F1, F2, F3, and F4. F3 contained the highest concentration of PAHs and accounted for most of the CYP1A induction caused by whole oil. F4 (containing high molecular weight PAHs) also caused moderate CYP1A induction, while F1 and F2, which contained primarily mono-aromatics and two ring PAHs, caused none. F3 was also the most toxic to the early life stages of trout and Japanese medaka (*Oryzias latipes*). We generated two new sub-fractions of F3 using a cold acetone extraction technique, respectively referred to as F3-1 (extract rich in PAHs - 65% of total carbon) and F3-2 (wax precipitate with trace amounts of PAHs - 35% of total carbon). F3-1 was a strong CYP1A inducer, while F3-2 was not; similarly, F3-1 was chronically toxic to medaka, while F3-2 was not. Further fractionation of F3-1 using normal-phase HPLC has isolated particular groups of PAHs referred to as: F3-1-1 (waxes and monoaromatics), F3-1-2 (napthalenes and dibenzothiophenes), F3-1-3 (phenanthrenes, fluorenes, and pyrenes), F3-1-4 (chrysenes), and F3-1-5 (resins). CYP1A induction was correlated with specific PAH composition, and chronic assays were conducted with the inducing fractions F3-1-2 (moderate), F3-1-3 (strong), and F3-1-4 (moderate). Results indicate that these three fractions are chronically toxic to medaka.

An overview of the application of stable isotopes in the oil sands region of Alberta, Canada. *A. Farwell[1], P. Videla[1], B. Butler[1], C. Daly[2], C. Wytrykush[2] and D. G. Dixon[1](PL)*
[1]Department of Biology, University of Waterloo, Waterloo, ON ; [2]Department of Biological Sciences, University of Windsor, Windsor, ON

Naphthenic acids (NAs) and polycyclic aromatic hydrocarbons (PAHs) are naturally occurring organic compounds associated with bitumen from the Athabasca oil sands region in Alberta (Canada). These groups of complex mixtures are of environmental concern since both groups cause chronic toxicity to aquatic organisms. Due to the complex nature of these mixtures and the potential for transformation, analysis of these compounds in exposed organisms is challenging. In this overview, the potential use of stable carbon and nitrogen isotopes as a tool to trace the exposure of aquatic organisms to oil sands constituents will be summarized. At oil sands reclamation sites, trends of ^{13}C depletion in benthic invertebrates, and changes in dissolved organic carbon (DOC) and dissolved inorganic carbon (DIC) concentrations and $d^{13}C$ values were correlated to increased levels of oil sands processed-material (OSPM). Pronounced ^{15}N enrichment in benthic invertebrates was attributed to elevated ammonia levels. Studies along the Athabasca River and its tributaries showed site specific trends for $d^{13}C$ and $d^{15}N$ values of fish. To date, there is potential for the use of stable nitrogen isotopes to define exposure of biota to oil sands processed-material in surface waters and in cases where groundwater seepage containing oil sands processed-water enters surface water receiving environments.

The effects of oil sands constituents on fathead minnow (*Pimephales promelas*) reproduction. *R.J. Kavanagh[1], R. Frank[1], A. Farwell[2], D. G. Dixon[2], K. Burnison[3], M. D. Mackinnon[4], J. Headley[5], K.R. Solomon[1] and G. Van Der Kraak[1](PL)*

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Previous work suggests that oil sand constituents may alter the reproductive physiology of fish. In order to determine if fluid tailings would impair fish reproduction, 21 d fathead minnow reproduction assays were used. Fathead minnows were held in Gregoire Lake water (reference site) for 14 to 21 days to gather baseline data on fecundity, fertility, and hatching success. Fathead minnows were then held in water taken from Syncrude's and Suncor's tailings ponds for 21 days. Spawning was reduced in fish that had been exposed to fluid tailings and male fathead minnows had tubercles that were reduced both in size and number. Naphthenic acids, which are natural constituents of oil sands, are one of the contaminants suspected of being responsible for the reproductive impairment observed in fathead minnows. Laboratory studies with naphthenic acids extracted from fluid tailings provide support for this theory. These studies show that oil sands tailings have the potential to affect the reproductive physiology of fish.

Are oil sands affected wetlands functioning systems? Measuring ecological integrity with plant decomposition rates. *J. Hornung[1] and C. M. Wytrykush[2](PL)*

[1]Department of Renewable Resources, University of Alberta, Edmonton, AB; [2] Department of Biological Sciences, University of Windsor, Windsor, ON

Decomposition of dead plant matter is an integral process that drives primary productivity in wetlands. How rapidly aquatic plant matter is broken down within a wetland can indicate the potential for productivity and, by extension, the adequate functioning of aquatic ecosystems. The purpose of this project is to examine leaf litter breakdown and biomass accrual in natural and oil sands process affected wetlands (OSPW) in northeastern Alberta. These wetlands contrast in water origin (OSPW vs. natural), sediment origin (OSPW vs. natural), sediment organic content (high vs. low), and age (older vs. young). We assigned 31 suitable wetlands into 14 categories that represent combinations of the above 4 contrasting factors. Oil sands process materials contain enriched levels of sulphate ions, ammonia, polycyclic aromatic hydrocarbons (PAHs), and naphthenic acids. In high concentrations, these compounds are potentially toxic, and are considered here as environmental stressors. We will determine how these stressors affect decomposition rates in the above wetlands. We placed mesh bags containing approximately 5g of dried cattail and 20g of damp sphagnum moss (5g dried weight) in 31 natural and constructed wetlands to monitor the rate at which biomass was lost to decomposition, as measured by changes in dried weight. Preliminary results show no significant difference in the loss in dry weight for cattail or moss between the 14 treatments over 5 rounds (intervals 0, 3, 8, 33, and 55 days). The cattail litter bags showed an overall decrease in biomass. New growth was observed in the moss decomposition bags, although this did not translate into a significant difference in dry

weight accrual overall, or between the 14 categories. Results analyzed thus far indicate no difference with respect to decomposition rates between OSPW wetlands and natural reference wetlands. Despite these results we predict that OSPW wetlands will show decreased decomposition rates of cattail, and decreased moss accrual rates. The observed overall decrease in cattail dry weight may result only from the leaching of readily soluble compounds. Once the breakdown of biomass is determined more by algal/microbial biofilm activity, which we predict is more sensitive to OSPM, we anticipate differences in decomposition among our wetlands to be significant.

The aquatic toxicity of salts present in Alberta oil sands process affected water. *N. Toor[1], K. Liber[1] and M. D. Mackinnon[2](PO)*
[1] Toxicology Centre, University of Saskatchewan, Saskatoon, SK; [2]Syncrude Canada Ltd., Edmonton, AB

Oil sands process affected waters (OSPW) in northern Alberta, Canada, contain a mixture of organic and inorganic constituents, including naphthenic acids (NAs) and salts. In the past, NAs have been shown to have inhibitory or toxic effects on a variety of organisms and appear to be responsible for most of the observed aquatic toxicity of OSPW. In the current study, 7-d *Ceriodaphnia dubia* chronic toxicity tests using both NAs-containing and NAs-free OSPW have identified salinity (e.g., Na^+, Cl^-, SO_4^{2-}, HCO_3^-) as a potential contributing factor to the toxicity of this complex mixture. Historically, other bioassays using various biota (bacteria, zooplankton, and fish) have not demonstrated a similar effect. A series of *C. dubia* tests, conducted using artificial OSPW (reconstituted water with similar salt content, but free of the other constituents) gave a LC50 value similar to that obtained for the OSPW sample collected in the field. Next, the relative role of the dissolved organic and inorganic fractions on *C. dubia* will be assessed using dose-response experiments with *C. dubia* for individual salts (e.g., NaCl, Na_2SO_4, $NaHCO_3$, $CaCl_2$, and $MgCl_2$) and extracted NAs (in reconstituted water). These results will be used to prioritize the contribution of each component to the total *C. dubia* toxicity of OSPW.

Do chironomid (*Diptera Chironomidae*) polytene chromosomal puffs reflect instantaneous growth? An *in situ* bioassay of oil sands mine process waters in constructed wetlands. *J. Martin[1], J. J. H. Ciborowski[1]and C. Wytrykusk[1] (PO)*
[1] Department of Biological Sciences, University of Windsor, Windsor, ON

Zoobenthic community composition and/or production are commonly used indicators of wetland ecosystem condition but their measurement is time consuming and labour intensive. Chironomid larvae possess giant chromosomes in their salivary glands whose size and condition reflect metabolic processes. We assessed whether chromosomal puffing could be used as a reliable indicator of chironomid growth. By extracting the polytene chromosomes from the salivary glands of *Chironomus* larvae and evaluating the relative diameter of the nuclear organizer, instantaneous growth can be potentially determined from a single sample. Groups of 20 first instar *Chironomus riparius* larvae were introduced into108 PVC pipes (7.6 cm diameter by 60 cm tall with mesh-covered windows) in each of six 10 m x 50 m x 30-cm deep constructed wetlands, three of which contained fresh water (reference) and three of which contained oil sands mine process affected water (Conductivity > 2,000 uS). Some tubes were harvested after 5 days. Using a reciprocal transplant design, all other tubes were removed from their trench and

transferred to the original or to complementary trench. These tubes were harvested 5 days later. Chironomids were sorted from sediments, enumerated and preserved in chilled Carnoy's solution (3:1 v/v absolute ethanol: glacial acetic acid). In the laboratory, total length of each larvae will be measured. Salivary glands will be excised, squashed, and Giemsa stained. Relative nucleolar diameter (RND) of each larva will be determined using image analysis of video-projected slide mounts. We expect that 5-d old *C. riparius* from the reference treatment will exhibit greater survival, larger size (faster growth) and a larger RND than those from the experimental treatment. We also expect that RND will be a better indicator of the recent exposure history of 10-day old *C. riparius* than survival or size. This assay is one of two experiments designed to demonstrate and quantify the relationship between RND and instantaneous growth in *C. riparius*.

Assessment of the effects of petroleum coke amendments in constructed oil sands wetlands. *L. Baker[1], J. J. H. Ciborowski[1] and M. D. Mackinnon[2](PO)*

[1] Department of Biological Sciences, University of Windsor, Windsor, ON; [2]Syncrude Canada Ltd., Edmonton, AB

Ecotoxicology integrates ecology and toxicology - the objective is to understand and predict the effects of chemicals on natural communities under realistic exposure conditions. Lab-based, toxicological studies are usually conducted with standard "indicator" organisms, using organic solvents to artificially elevate chemical concentrations. However, they fail to consider the presence of site-specific constituents that can influence bioavailability of contaminants. Consequently, water quality criteria derived from these studies may be toxicologically correct, but not ecologically relevant. Oil sands operators of Fort McMurray, Alberta produce approximately six million tonnes of petroleum coke per year as a by-product of oil sands mining. The use of this waste product to stabilize clay-dominated mine tailings in constructed wetlands is currently being studied as an option for landscape reclamation. We studied the *in situ* effects of petroleum coke as a sediment amendment on the invertebrates and macrophytes of three constructed wetlands. We further determined whether or not adding a surface layer of peat would affect community establishment. The concentration of metals and naphthenic acids in amended sediments, native species of invertebrates and macrophytes was also measured. Concurrent laboratory studies showed that water leached from this coke contains potentially concerning levels of vanadium, nickel, cadmium, zinc, and molybdenum; oxygen depletion in test sediments, and some physiological stress in standard lab invertebrates and macrophytes as a result of exposure to petroleum coke. We detected no direct effect of the amended petroleum coke sediments on resident macrophyte and invertebrate communities of constructed wetlands, at the scale of this study, and minimal evidence of metal uptake. The disparity in these results may reflect the presence of many organic and inorganic constituents only found in the wetland sediments and water (peat, naphthenic acids and other dissolved organic carbon species, elevated salinity), which can complex with metals, making them biologically unavailable. Such findings would be consistent with the Biotic Ligand Model.

Characterization of complex naphthenic acid mixtures and their microbial transformation by capillary HPLC/QTOF-MS. *M. Bataineh[1], X. Han[1], P. Fedorak[1], A.C. Scott[1] and J. Martin[1](PO)*
[1]Department of Biological Sciences, University of Alberta, Edmonton, AB

A rapidly expanding oil sands industry in Canada produces and indefinitely stores large volumes of toxic aqueous tailings containing high concentrations of naphthenic acids (NAs); a complex mixture of naturally occurring aliphatic or alicyclic carboxylic acids. Although there is a need to reduce the environmental risks posed by NAs, little is understood about their environmental fate due to a lack of appropriate analytical methods. A dilute-and-shoot reverse-phase capillary HPLC/QTOF-MS method was developed that combines high specificity and sensitivity, quantitative capabilities, the ability to detect transformation products, and which provides new qualitative structural information within each NA isomer class. For analysis of water samples, the chromatographic step increased analytical sensitivity up to 350-fold and retention times provided additional specificity compared to existing infusion techniques. For tailings water, an interlaboratory study revealed many differences in NA isomer-class profiles compared to an established GC/MS method, much of which was attributed to the misclassification of oxidized NAs (e.g. NA+O) and matrix interferences by GC/MS. HPLC/QTOF-MS enabled the simultaneous detection of oxidized products in the same chromatographic run, and Van Krevelen diagrams were adapted to visualize the data. A marked leftward shift of retention times was evident when comparing a commercial mixture to Syncrude tailings water, suggesting that tailings water is dominated by highly persistent alkyl-substituted isomers. Application to a biodegradation study revealed new information that tailings water microorganisms preferentially deplete the least alkyl-substituted fraction and may be responsible for the NA profile in aged tailings water.

Stress effects on ecosystem processes: Net primary productivity of the Alberta oil sands wetlands. *C. Wytrykush[1] and J. J. H. Ciborowski[1](PO)*
[1] Department of Biological Sciences, University Of Windsor, Windsor, ON

Environmental pressures cause stress, which is a measurable alteration of an organism's steady state. Stress from natural or anthropogenic environmental pressures can affect individuals, populations, or communities. Stress can affect ecosystem processes and this can be evaluated by examining primary productivity. The purpose of my research is to examine environmental stress response in natural and constructed wetlands in the oil sands region of Northeastern Alberta. These wetlands contrast in condition (oil sands process affected vs. natural), level of sediment organic content (low vs. high), and age (young vs. older). Oil sands process materials (OSPM) are enriched with several types of compounds including sulphate ions, ammonia, polycyclic aromatic hydrocarbons (PAHs), and naphthenic acids. In high concentrations, these compounds may be toxic to aquatic invertebrates, and are considered here as environmental stressors. A pilot study conducted in 2005 indicated differences in primary production measured using *in situ* dissolved oxygen probes. Young OSPM wetlands were generally more productive than natural wetlands of the same age, but these differences were less distinct in older wetlands. Continuously-recording dissolved oxygen probes were deployed in oil sands wetlands throughout the summer of 2006. Diel changes in oxygen concentration of the water will be converted to net primary production and compared between wetlands contrasting in condition, organic content and age.

The potential use of black worms (*Lumbriculus variegates*) to assess surface-ground water interactions in the Alberta oil sands. *M. Boutsivongsakd[1], A. Farwell[1] and D. G. Dixon[1](PO)*
[1]Department of Biology, University Of Waterloo, Waterloo, ON

Bitumen is recovered from the Athabasca oil sands through a mining process that produces large amounts of wastewater containing naturally occurring compounds such as polycyclic aromatic hydrocarbons (PAHs) and naphthenic acids (NAs). Aquatic organisms may be exposed to varying levels of PAHs and NAs in addition to ammonia as a function of the reclamation strategies or seepage of process-affected groundwater into surface water environments. The objective of this study was to assess whether black worms (*Lumbriculus variegates*) would be useful for examining potential surface-ground water interactions in the oil sands. Black worms have been found at natural sites on the oil sands deposits, however based on limited available data, they appear to be absent in reclaimed systems. To assess the usefulness of this species, their sensitivity to oil sands processed material was determined using laboratory and field-based 7 d exposures. Preliminary laboratory studies indicate that black worms are sensitive to MFT (~50 % mortality) which is used as construction material in reclaimed ponds. Sediments collected from reclaimed ponds showed varying levels of toxicity to black worms. Field exposures examined the sensitivity of black worms to both process-affected water and sediments. This study will determine if black worms are suitable organisms for *in situ* studies of surface-groundwater interactions.

Impeded aquatic plant production in oil sand affected wetlands - delaying reclamation timelines? *J. Hornung[1](PO)*
[1]Department of Renewable Resources, University of Alberta, Edmonton, AB

Aquatic macrophytes are important components of any wetland ecosystem. How aquatic plants like cattail (*Typha latifolia*) grow and accrue carbon under the stress toxic oil sands process materials (OSPM) can exert is important information for the eventual remediation of the aquatic habitats affected by oil sands production. Leaf production and photosynthesis was measured in 96 transplanted cattail plants placed in 5 gallon plastic buckets containing four combinations of growing substrate: 1) pure consolidated tailings (CT) a by-product of the oil sands extraction process, 2) a soil / peat mixture atop CT (a potential remediation option), 3) the soil / peat mixture atop sterilized sand (a control for the potentially toxic constituents in CT), and 4) a pure soil / peat mixture. These four combinations were replicated four times in each of six constructed wetlands; each wetland was filled with either CT-affected water (another oil sands process by-product) or natural wetland water (three wetlands with natural and three wetlands with CT water). Production was estimated by measuring the length and width of every leaf and by tracking new growth by marking already measured leaves. We used a CO_2 gas analyzer to measure photosynthesis (Licor 6400 Photosynthesis meter) of all plants. Preliminary results show that production of leaf biomass was significantly greater in those cattail that were unaffected by oil sands process materials. The rate of carbon accrual (photosynthesis) in cattail affected by OSPM was decreased, although a significant difference was not detected. The observed negative affect of OSPM on cattail suggests that the time needed for OSPM-affected wetlands to return to a natural, reclaimed state will be longer than observed in wetlands not affected by these materials.

Evaluation of oil sands coke leachate toxicity using *Ceriodaphnia dubia*. *N. Puttaswamy[1] and K. Liber(PO)*

[1]Toxicology Centre, University of Saskatchewan, Saskatoon, SK

The thermal upgrading of oil sands bitumen produces enormous volumes of coke as a byproduct. Previous research has shown that coke can release significant levels of metals under different environmental conditions. Therefore, coke could be a potential reservoir of leachable metals if placed inappropriately in aquatic or terrestrial reclamation landscapes. To investigate this, two tank lysimeters (circular prefabricated plastic storage tanks used as net percolation collection tanks) were built on the Mildred Lake Coke Watershed. The lysimeters were filled with the same coke excavated to place the tanks and were covered with either a thick or thin layer of till (deep and shallow lysimeter, respectively). Both lysimeters were covered with a 15-cm layer of peat. Piezometers were installed in the centre of each lysimeter to record water depth and to facilitate sample collection and water removal. The toxicity of the coke leachate water was then examined with 7-d *Ceriodaphnia dubia* static-renewal toxicity tests over a 1-year period. Coke leachate was found to have a significant effect on survival and reproduction, and leachate water from the deep lysimeter was more toxic than water from the shallow lysimeter. Coke leachate toxicity did not decrease over the 1-year period evaluated. Analysis of coke leachate and results from past coke leaching experiments suggest that vanadium could be at-least partially responsible for the observed toxicity.

Diamond Mining/Extraction des Diamants

Session Co-chairs/Présidents: Karsten Liber and Jodi Hunt

Sublethal toxicity of two wastewater treatment polymers used at the Ekati diamond mine to lake trout fry. *K. Liber[1], L.P. Weber[1] and C. Levesque[1](PL)*

[1]Toxicolgy Centre, University of Saskatchewan, Saskatoon, SK

Lake trout fry (*Salvelinus namaycush*) were exposed in laboratory experiments to two wastewater treatment polymers, one anionic (MagnaFloc® 156) and one cationic (MagnaFloc® 368; Ciba Speciality Chemical), to determine if these chemicals, which were used and discharged by the Ekati diamond mine in the Northwest Territories, pose a hazard to juvenile fishes. The cationic polymer was more toxic to lake trout fry than the anionic polymer, with 96-h LC50 estimates of 2.08 and >600 $mg \cdot L^{-1}$, respectively. Separate 30-d exposure experiments yielded no observed and lowest observed effect concentrations, respectively, of 0.25 and 0.5 $mg \cdot L^{-1}$ for MagnaFloc® 368 and 75 and 150 $mg \cdot L^{-1}$ for MagnaFloc® 156. Behavioural responses were the most sensitive endpoints. Gill pathology appeared within a few days of exposure to both polymers, apparently as a result of localized hypoxia. Acute (4 d) effects included cloudy swelling of epithelial cells, increased gill vascularization and thickening and shortening of the gill lamella. Chronic (30 d) exposure produced only slightly greater pathological effects than acute exposure, with comparable responses observed at >1.0 $mg \cdot L^{-1}$ MagnaFloc® 368 and 150 $mg \cdot L^{-1}$ MagnaFloc® 156, suggesting that the fish displayed some level of both behavioural and physiological adaptation to the respiratory stress imposed by the two polymers.

Acute and chronic toxicity of nitrate to early life stages of lake trout and lake whitefish. *M.D. McGurk[1], F. Landry[1], A. Tang[2] and C. C. Hanks[1](PL)*

[1]Rescan Environmental Services Limited, Vancouver, BC; [2]Nautilus Environmental Limited, Burnaby, BC

The acute and chronic toxicity of the nitrate ion (NO_3^-) to the embryos, alevins, and swim-up fry of lake trout (*Salvelinus namaycush*) and lake whitefish (*Coregonus clupeaformis*) were tested in laboratory aquaria. The acute (96-h) lethal concentration 50% (LC50) for swim-up fry was 1,121 mg $NO_3^-N \cdot L^{-1}$ for lake trout and 1,903 mg $NO_3^-N \cdot L^{-1}$ for lake whitefish. The chronic (~130 - 150-d) LC50s for the embryo to swim-up fry were 190 and 64 mg $NO_3^-N \cdot L^{-1}$, respectively. Sublethal effects on development timing and fry body size were observed at concentrations of 6.25 and 25 mg $NO_3^-N \cdot L^{-1}$, respectively, in the chronic tests. These results confirm that the Canadian nitrate water quality guideline of 2.9 mg $NO_3^-N \cdot L^{-1}$, which was derived from chronic tests on a temperate-zone amphibian, is applicable to the early life stages of two species of Arctic fish. However, it does not support the use of the guideline for acute exposures to early life stages of salmonid fish, or for acute or chronic exposures to adult fish, which are known to be relatively insensitive to nitrate.

Water only testing protocol for *Hyalella azteca*. *S.E. Goudey[1](PL)*

[1]HydroQual Laboratories Ltd., Calgary, AB

Diavik Diamond Mines Inc. operates a mine in the N.W.T. In 2003 Diavik applied for an amendment to the total ammonia discharge limit. During the public review of the application an intervener suggested that regulatory acute toxicity using *Hyalella azteca* would be more appropriate than tests with Rainbow trout. The rationale was that they understood *Hyalella azteca* was more sensitive to total ammonia than rainbow trout and that rainbow trout are not relevant because they do not exist in the mine receiving environment. An "Experts Group" (Dr. Uwe Borgmann (EC) and Dr. Chris Ingersoll (USGS)) developed the protocol in consultation with an "Ammonia Working Group" (Federal regulators, Aboriginal community representatives and Diavik). The protocol was evaluated by conducting parallel tests at three commercial labs using two types of water. Funding for two of the three tests was provided by the Department of Indian and Northern Affairs. The resulting mean 10-d LC50 values were consistent with literature values. Differences in 10-d LC50 values between labs were about a factor of four. *Hyalella azteca* was not found to be more sensitive than rainbow trout. This presentation provides an overview of the protocol and the results from the parallel testing.

Benthic invertebrate colonization of kimberlite tailings from the Ekati diamond mine. *S. de Rosemond[1], E. Irving[1] and K. Liber[1](PL)*
[1]Toxicology Centre, University of Saskatchewan, Saskatoon, SK

The EKATI™ Diamond mine, located ~300 km NE of Yellowknife, NT, disposes its fine processed kimberlite tailings (FPKT) into the Long Lake Containment Facility (LLCF). The LLCF is divided into cells, with Cells A to D consisting of tailings partially covered by water and Cell E, the last cell in the series, acting as a final polishing pond. The objective of this project was to determine if FPKT deposited into the LLCF would provide a suitable habitat for benthic invertebrates. Plastic trays (4.4 L) containing either FPKT or natural lake sediment were inserted into the sediment of Cell E of the LLCF from August 2001 to July 2003. Trays were retrieved on three occasions to evaluate the benthic communities that colonized the trays and to collect substrate samples for chemical analysis and laboratory toxicity testing using the amphipod, *Hyalella azteca*. Trays containing natural sediment (control) had a benthic invertebrate community very similar in composition to unmanipulated, natural sediment (reference) within 12 months of deployment. Total invertebrate abundance and community composition were very similar between the control trays and the FPKT trays for all three post-deployment sampling times. Further analysis suggested that the ability of FPKT to successfully support a representative benthic community *in situ* was contingent upon the development of a naturally-occurring floc layer on the surface of the substrate in the trays.

Mining/Extraction Minière

Session Co-chairs/Présidents: Monique Dubè and Carrie Rickwood

Evaluating the potential for thiosalts to contribute to toxicity in mine effluents. *M. Schwartz[1], B. Vigneault[1] and J.C. McGeer[1](PL)*
[1]Natural Resources Canada, CANMET, Ottawa, ON

The processing of sulfide ores can result in the formation of sulfur oxyanions, which may be released into the aquatic environment. These partially oxidized anions, known as thiosalts, can occur in mine effluents at concentrations up to, and sometimes exceeding, 700 $mg \cdot L^{-1}$. While the potential impacts of acidification as thiosalts degrade after discharge is recognized, very little is known about their direct toxicity. The toxicity of thiosulfate and tetrathionate was determined for all of the Metal Mine Effluent Regulation Environmental Effects Monitoring (MMER-EEM) sublethal toxicity test species. It was found that thiosulfate had the greatest potential for toxicity to these organisms, since in all cases it was found to be more toxic than tetrathionate. *Ceriodaphnia dubia* was the most sensitive of the species tested, with an IC25 of 57 $mg \cdot L^{-1}$ for thiosulfate, and is therefore likely to be the organism of most concern when addressing mine effluent toxicity test failures. We then collected effluent toxicity and chemisty data from participants in the Thiosalts Consortium (lead by CANMET-MMSL, NRCan) in 2004 and 2005 to investigate any link between toxicity data and thiosalt concentration, pH depression or other effluent characteristics. Toxicity caused by the effluents studied does not appear to be largely due to the presence of thiosalts. In some instances thiosalt levels are high enough to cause toxicity to *C. dubia*, but concentrations seldom exceeded levels found to cause toxicity to the other MMER-EER species. Some

correlation with other parameters were also observed. For the studied effluents, other constituents such as elevated hardness may be a more likely cause of the observed sublethal toxicity.

A case study on application of generic water quality guidelines and problems .
N.K. Nagpal[1](PL)
[1]British Columbia Ministry of Water, Land and Air Protection, Victoria, BC

British Columbia has developed and published water quality guidelines (WQGs) to protect aquatic life in the province. The British Columbia's protocol to develop WQGs is similar to that of the Canadian Council of Ministers of the Environment (CCME) with minor differences. The users responsible for protecting the environment had criticised the guidelines for a number of reasons; e.g., (a) they are over-protective, (b) key studies used in the generic guideline development are not accurate or valid, (c) the data generated at a particular laboratory to substantiate literature results are not valid. Often, they ignore to pay attention to details behind the key studies. A case in point is the recent criticism of the BC's sulphate water quality guideline to protect aquatic life. This paper will discuss the sulphate case arguing a need for education of users on the application of the generic water quality guidelines.

Near real-time water quality monitoring at mining operations in Newfoundland and Labrador.
R. Paterson[1], A. Khan[1] and H. Khan[1](PL)
[1]Newfoundland Department of Environment and Conservation, St. John's, NL

The rich mineral resources found throughout Newfoundland and Labrador (NL) has lead to an extensive and expanding mining industry in the province. Effectively monitoring and protecting the abundant natural water resources surrounding the mining operations is a high priority for the Government of Newfoundland and Labrador. The Water Resources Management Division within the NL Department of Environment and Conservation has established a network that utilizes near real-time technology to effectively monitor the water quality in and around mining operations. Surface water quality monitoring stations are established at specific locations in order to follow the impact on water quality resulting from the various mining processes. Additionally, surface water and groundwater stations are established to assess the effectiveness of the tailings containment areas to ensure protection of the surrounding natural environment. Near real-time water quality monitoring provides continuous water quality information and a clear picture of water quality for a particular water body over time. This technology also allows for the implementation of automated alert systems as well as web-based reporting. It is an effective and pro-active approach to monitoring and managing water resources. The purpose of this paper is to provide insight into the state of the art near real-time water quality monitoring technology along with its potential application for effective monitoring at mining operations. It will present the challenges encountered in establishing and operating these stations and the issues that may arise in applying this technology to monitoring at mining operations. Case studies will be presented describing the current real-time water quality monitoring networks at two mining operations in the province.

Towards a better understanding of the cause of mine effluent growth inhibitions to the macrophyte *Lemna minor*. *B. Vigneault[1], J. Beyak[1] and M. Schwartz[1](PL)*
[1]Natural Resources Canada, CANMET, Ottawa, ON

The Metal Mine Effluent Regulation (MMER) includes a sublethal toxicity test using *Lemna minor* as part of the required environmental effect monitoring. Data collected since 2002 indicate that *L. minor* (based on frond number) appears to be one of the most sensitive EEM test species. The sensitivity of *L. minor* to trace metals, as well as flotation and wastewater treatment reagents/by products was studied in the context of the MMER - EEM. *L. minor* is sensitive to trace metals with 25 % growth inhibition concentrations ranging from about 20 to 200 $\mu g \cdot L^{-1}$ for cadmium, copper, nickel and zinc. However, *L. minor* is generally less sensitive to trace metals than other EEM sublethal toxicity test species. Also, *L. minor* was not very sensitive to elevated hardness in contrast to other EEM sublethal test species. In addition, *L. minor* was not particularly sensitive to sulfoxyanions that compose thiosalts present in some effluents. Finally, growth inhibitions were observed for a flotation reagent and a flocculent at concentrations in the range of few $mg \cdot L^{-1}$. Dry weight was much more sensitive than frond number for the synthetic reagents studied and limited information is available regarding their use and the actual residual concentrations in final effluents. The information gathered so far does not provide a clear explanation of the high sensitivity of *L. minor* to mine effluents compared to the other EEM sublethal test species. *L. minor* may however be particularly sensitive to synthetic reagents but this remains to be validated.

Integrated responses of juvenile northern pike (*Esox lucius*) collected downstream of a metal mining effluent. *J. M. Kelly[1] and D.M. Janz[1](PL)*
[1] Department of Veterinary Biomedical Sciences, University of Saskatchewan, Saskatoon, SK

The objectives of this study are to assess biochemical and histopathological endpoints in juvenile northern pike (*Esox lucius*) living downstream of a uranium mill effluent discharge and to further investigate differences in bioenergetics among exposure and reference lake pike. The effluent is characterized by a number of metals, some of which can possibly generate reactive oxygen species and induce histopathological lesions in freshwater fishes. The potential for oxidative stress in kidney and liver of juvenile pike, due to an increase in reactive oxygen species, will be determined by measuring the activities of the antioxidant enzyme glutathione peroxidase and the levels of reduced and oxidized glutathione. Liver and kidney, plausible target organs of metals, will be semi-quantitatively scored for histopathological alterations. A previous study from our lab reported that fishes living downstream of the effluent discharge have elevated levels of stored lipids compared to reference fish. Nutrient enrichment due to nitrogen compounds in the effluent may be a causative factor, however, findings to date provide only partial support for this argument. Lipids in the form of triglycerides as well as glycogen were significantly higher in the livers of pike collected from exposure lakes compared to the reference. Triglyceride stores in spottail shiners were also significantly elevated whereas lower trophic level organisms, such as omnivorous (Orders: Diptera, Trichoptera, and Heteroptera) and carnivorous (Order: Odonata) aquatic insects, did not exhibit this trend at exposure lakes. To further investigate possible factors influencing bioenergetics in the pike, infection by intestinal parasites was also examined. These organisms take up

nutrients that would otherwise be available to their host; this loss of nutrients could cause lower level of stored energy in the form of triglycerides in infected fish. The total number of intestinal parasites among lakes showed a significant negative correlation with the concentration of triglycerides in pike liver. The weight of intestinal parasites among lakes, however, did not exhibit any significant trends. The prevalence of infection varied considerably between the reference lake (100% of pike infected) and the low and high exposure lakes (64% and 0% of pike infected, respectively). These results indicate a potential impact of uranium milling effluent on parasite communities as well as a possible link between parasitic infection and pike bioenergetics.

Responses of juvenile rainbow trout (*Oncorhynchus mykiss*) exposed to effluents from a molybdenum mine. *B.J. Galloway[1], B. Riordan[2], C. Fraikin[1] and R. Robinson[1](PL)*
[1]Golder Associates Ltd, Calgary, AB; [2]Thompson Creek Mining Ltd., Fraser Lake, BC

As part of the Metal Mining Effluent Regulations (MMER) under the *Fisheries Act*, mines are required to conduct a tiered Environmental Effects Monitoring (EEM) program. The objective of the EEM program is to evaluate effects of mine effluent on fish, fish habitat (i.e., benthic invertebrates), and use of the fisheries resource. The Endako Mine is an open-pit molybdenum mine located on the Nechako Plateau in central British Columbia, about 160 km northwest of Prince George. For Endako's Cycle One EEM program, a non-lethal survey of juvenile rainbow trout was conducted to assess the potential impacts of mine effluents discharged into lower Sweetnam Creek (exposure area) on fish survival, condition, growth, and reproduction relative to fish collected from a reference area (Allin Creek). Results of the non-lethal fish survey will be discussed as well as challenges associated with designing and conducting environmental monitoring programs for existing and future mining operations in this area of British Columbia.

Assess effects of metal mining effluent on fathead minnow (*Pimephales promelas*) reproduction in a field-based trophic-transfer artificial stream system. *C.J. Rickwood[1], M. G. Dubé[1], L. P. Weber[1], K.L. Driedger[1] and D.M. Janz[2](PL)*
[1]Toxicology Centre, University of Saskatchewan, Saskatoon, SK;[2]Department of Veterinary Biomedical Sciences, University of Saskatchewan, Saskatoon, SK

The Junction Creek watershed, located in Sudbury, ON, Canada receives effluent from three metal mine waste-water treatment plants, as well as a municipal waste-water discharge. Effects on fish have been documented within the creek e.g. decreased egg size, increased metal body burdens. However, identifying the cause of these effects has been difficult due to the confounded nature of the creek. The objective of this investigation was to assess the effects of an individual metal mine effluent (Copper Cliff mine effluent: CCME) and a combined mixture of CCME and municipal waste-water (CCMWW) on fathead minnow (FHM; *Pimephales promelas*) reproduction in an artificial stream system on-site. In addition, a trophic-transfer system was developed on-site to assess the importance of food as a source of exposure of CCME and CCMWW to FHM. In the water-only exposures, egg production and spawning events significantly decreased in the CCME and CCMWW treatments. However, in the trophic-transfer system, a significant increase in egg production and spawning events occurred in the CCME and CCMWW treatments. It was concluded that the effects of CCME and

CCMWW on adult FHM were more apparent in the water-only exposures. The lack of adverse effects in the trophic-transfer system by comparison may have resulted from reduced toxicity of the effluents, possibly due to increased nutrients and organic matter, which may have reduced metal bioavailability. More detailed examinations of metals in the sediments, water column and body burdens of FHM is recommended to get an understanding of the speciation of potential causative compounds within the different aquatic compartments.

The adoption and application of the mining EEM program in Peru. *B. Fraser[1] and D. Farara[1](PL)*

[1]EcoMetrix Inc., Brampton, ON

Peru's mining industry has had a renaissance in the last fifteen years and is now among the world's leading mineral commodity producers. The renaissance has been driven by both external forces and, more importantly, by changes in government policy and programs that have made foreign investment not only possible but also economical viable and secure. In total, the Peruvian mining industry accounted for about 55.5% of total national export revenues in 2004. The Ministry of Energy and Mines (MINEM) has the responsibility to implement the laws and regulations comprising the national environmental legal framework for mines. Among other things MINEM is charged with creating environmental protection policy, permitting mine facilities and operations, establishing criteria for potentially deleterious substances in effluents and overseeing issues related to the operational impacts of mines (and imposing administrative sanctions if appropriate). At present however, the national environmental legal framework is not applied on a consistent basis, nor are there national standards *per se* that relate to evaluating mine performance from an environmental perspective. Moreover, local, regional, federal and even international stakeholder issues make it difficult for mine environmental managers to address all concerns through routine environmental monitoring programs. In response to this need EcoMetrix Incorporated has developed routine monitoring programs at a number of mine and mine-related port facilities. We have married the Mining EEM framework with local issues to devise monitoring programs that have gained regulatory approval (and to a certain extent are being adopted as a standard) and have withstood expert peer-review. In this presentation, case studies are provided that demonstrate how the Mining EEM program framework has been applied and how the notion of marrying local concerns with a scientifically rigorous monitoring program design has gained agency acceptance.

Do upstream mining activities alter fish communities beyond a reference condition defined for the South Nahanni River and Nahanni National Park? *D.W. West[1], P. Spencer[2] and M.G. Dubé[1](PL)*

[1]Toxicology Centre, University Of Saskatchewan, Saskatoon, SK; [2]Indian and Northern Affairs Canada, Operations Directorate, Yellowknife, NT

The South Nahanni River, NWT, Canada is a Canadian Heritage River and one of Canada's premier National Parks, the Nahanni National Park Reserve, is contained in it's middle to lower reaches. As a large part of the catchment upstream is outside any protection afforded by the park there are concerns that activities upstream will affect aquatic biota in the Park. In the summer of 2006, we sampled fish communities, sentinel fish populations (slimy sculpin *Cottuscognatus* Richardson, 1836), macro-invertebrates,

water quality and instream habitat at upstream, near-field and far-field areas of two mining operations discharging effluent upstream of the Park, using a control impact (C/I) experimental design typical of the Environmental Effects Monitoring (EEM) Program. To determine if any changes in aquatic indicators due to mining activity fell outside of a broader reference condition, 35 sites matched on catchment size were sampled for fish communities, sentinel fish populations (slimy sculpin), macro-invertebrates, water quality and instream habitat using the Reference Condition Approach (RCA). Analysis of RCA and C/I samples from the same sites will provide insights into efficacy of different sampling methods and intensities for assessing mine-related effects in northern river ecosystems relative to local and watershed determinations of a reference condition. This study will also provide life history information that will aid in the future use of non-lethal slimy sculpin sampling to determine effects in rivers of Northern Canada. In this presentation, our fish community and sentinel species results will be discussed including comparisons between fish community and sentinel fish population indicators, and comparisons between non-lethal and lethal indicators for our sentinel species, slimy sculpin.

Reclamation of strip mines in Saskatchewan: Wetland water quality and biodiversity. *L.M. Levesque[1], D.B. Donald[1] and B. Aitken[1](PL)*
[1]Environment Canada, National Water Research Institute, Saskatoon, SK

Coal strip-mining often destroys or alters natural wetlands, and has been shown to increase levels of toxic metals and PAHs in aquatic ecosystems. Wetland construction has been used as a technique for the reclamation of strip-mined landscapes. This study was conducted to determine if reclaimed wetland ecosystems return to a relatively natural state within decades and whether they pose toxicity threats to biota. Water quality, zooplankton and benthic invertebrate samples were collected from 40 wetlands in old strip-mined, reclaimed and "natural" landscapes of south-eastern Saskatchewan. Preliminary analyses indicate that wetland invertebrate communities in reclaimed wetlands differ from those in natural wetlands. Major ions are generally higher in concentration in waters of unreclaimed wetlands than in those of reclaimed and natural wetlands. Analysis of metal and nutrient concentrations will provide an indication of the toxicity of the wetland waters to aquatic life.

Metal mining environmental effects monitoring: Overview of the national assessment of the first monitoring phase. *S.L. Walker[1], R. B. Lowell[1], A. Willsie[1], S. Moffatt[1], M.E. Bowerman[1], C. Tessier[1], D. Gautron[1] and K. Hedley[1](PL)*
[1]Environment Canada, Science and Technology Branch, Gatineau, QC

Metal mines that deposit to Canadian waters frequented by fish are subject to the 2002 *Metal Mining Effluent Regulations*, under the *Fisheries Act.* One of the conditions of deposit for metal mines is that an environmental effects monitoring program must be undertaken to assess mine-related effects in aquatic environments receiving mine effluent. The monitoring program consists of two parts. Part 1 includes studies on effluent characterization, water quality monitoring and sublethal toxicity testing. Part 2 consists of biological studies including a fish survey, a benthic invertebrate community

survey to assess effects on fish habitat, and a survey of mercury levels in fish tissue to examine effects on the use of fisheries resources. Mines subjected to the *Metal Mining Effluent Regulations* submitted their first interpretive reports for their biological studies in June of 2005 and June of 2006. Mines that submitted historical reports were required to submit their first interpretive reports one year later than mines that did not have historical data. An overview the National Assessment of the Metal Mining EEM data is presented. The studies for the first monitoring phase are summarized including the numbers and types of studies undertaken, alternatives utilized, and exemptions obtained. In addition, the types and incidence of issues encountered with the fish and benthic community surveys are summarized. A national analysis of mercury in fish tissue is provided.

National assessment of magnitudes and patterns of effects on fish and invertebrates exposed to metal mining effluent. *R. B. Lowell[1], A. Willsie[1], M E. Bowerman[2], C. Tessier[1], S. L. Walker[2], D. Gautron[2] and K. Hedley[2](PL)*

[1]Environment Canada, National Water Research Institute, Saskatoon, SK; [2]Environment Canada, Science and Technology Branch, Gatineau,QC

The National Environmental Effects Monitoring (EEM) Program has recently completed the first phase of metal mining monitoring, which tracks the effects of mining effluents across the country. The National EEM Office has been analyzing the results of the fish and benthic invertebrate community surveys to investigate relative magnitudes and patterns of effluent effects at a broad geographic scale. Meta-analyses and effect size summaries are being used to examine effects on receiving water biota. The key response variables are the magnitudes of measured effects on core fish (condition, relative gonad and liver size, age, size-at-age) and invertebrate (density, taxon richness, evenness, Bray-Curtis Index) endpoints. These, in turn, are being evaluated within the context of a number of influencing variables such as ore type, habitat, fish species and gender, and the frequency of effluent discharge. Statistical comparisons among different mine groupings allow questions to be addressed that can not be evaluated at the level of the individual mine. These analyses serve as a baseline against which to compare future monitoring results. They will also be used as part of the review process to improve subsequent monitoring efforts.

Canadian metal mining environmental effects monitoring - program review. *R. Prairie[1], K. Hedley[2], E. Gardiner[3], S.L. Walker[2] and D. Gautron[2](PL)*
[1]Falconbridge, Saint-Laurent,QC; [2]Environment Canada, Science and Technology Branch, Gatineau,QC ; [3]Mining Association of Canada, Ottawa, ON

Since the promulgation of the *Metal Mining Effluent Regulations* (MMER) under the *Fisheries Act* in 2002, all mines subject to the MMER are required to conduct an Environmental Effects Monitoring (EEM) program to evaluate the effects of metal mine effluents on fish, fish habitat and the use of fisheries resources. EEM is a scientific monitoring approach that can be used to help determine: a) the effects in aquatic ecosystems caused by metal mine effluent; and b) the effectiveness of environmental protection measures. When the EEM program was being developed under the new MMER, Environment Canada committed to reviewing the overall effectiveness of the program, approximately three years after its commencement. To meet this commitment,

Environment Canada has established a multi-stakeholder working group to review all aspects of the EEM program. This group, the Metal Mining EEM Review Team, was formed in December 2005, with a mandate to formulate recommendations to Environment Canada in order to improve the effectiveness, efficiency and scientific defensibility of the metal mining EEM program. The team includes representatives from Environment Canada and other federal departments, industry, Aboriginal and Environmental Non-Government Organizations and the Canadian Nuclear Safety Commission. The presentation will provide an overview of the review team's workplan, including the process to date, main topics under discussion, and projected timelines for delivery of results.

Summary and trends of 2003 to 2005 metal mining environmental effects monitoring (EEM) effluent characterization and water quality monitoring data in Québec. *I. Matteau[1], É. Lacroix[1] and S.Sirois[1](PO*
[1]Environment Canada, Environmental Stewardship Branch, Montréal, QC

Under the Metal Mining Effluent Regulations (MMER), metal mines discharging into the aquatic environment are required to conduct effluent characterization and monitor water quality in a reference and exposure area for each final discharge point. Since 2003, mines have submitted their annual data by March 31 the subsequent year. This poster will present a summary of the 2003 to 2005 data submitted by 20 regional mines located in Quebec. Trends and differences in effluent characterization and receiving water quality among different mining groups (i.e. Base metal, gold and others) will be identified and discussed. Results will also be compared to water quality criteria.

Guidance for the use of multiple-spawning, small-bodied fish species in environmental effects monitoring programs. *B.J. Galloway[1] and K. Munkittrick[2](PO)*
[1]Golder Associates Ltd, Calgary, AB; [2] Department of Biology and The Canadian Rivers Institute, University of New Brunswick, Saint John, NB

Fish species used as sentinels in monitoring programs are selected based on perceived stakeholder value, relative abundance, and knowledge of basic life history information. Fish species, however, should not be excluded from use when life history characteristics are not fully understood. In many large rivers, multiple wastewater effluents are discharged in close proximity. Attributing responsibility to a specific industry for observed impacts within a river responding to multiple stressors is difficult. The fish species selected should offer the greatest potential for defining the relative impacts of individual stressors in sections of rivers receiving multiple stressors. In Canada, there has been a shift from using large-bodied fish (e.g., sucker *spp.*) to small-bodied fish (e.g., cyprinids/cottids) for monitoring the impacts of stressors. The use of small-bodied fish in monitoring programs has increased since they are relatively abundant, easy to capture and many exhibit site fidelity. The main disadvantage of using small-bodied fish in monitoring programs is the lack of basic life-history information. This hinders study design and data interpretation. Some species may not be suitable as sentinel species, given the high variability seen in reference populations during the reproductive season. Western Canada and the Canadian north are active areas of exploration and development related to the petroleum and mining industries. Many rivers and lakes in these areas have species for which basic life history information is lacking. General guidelines for factors to consider when selecting sentinel species will be discussed.

An initial assessment of As mobilization in an area of historic gold mining in Nova Scotia, Canada and bioaccumulation of As and Hg in resident fish. *, V.P. Palace[1], C. L. Baron[1]S. Kollar[1], R.E. Evans[1], L. Peters[1], K. G. Wautier and M. Parsons[2](PO)*

[1]Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, MB; [2] Natural Resources Canada, Geological Survey of Canada, Dartmouth, NS

Historic gold mining activities in the MegumaTerrane of Nova Scotia have enriched As and Hg in surrounding terrestrial and aquatic habitats. Diffusion samplers (peepers) were deployed at four locations surrounding the Seal Harbour area to estimate sediment pore water concentrations of the two inorganic forms of As (arsenate and arsenite) at 1 cm intervals below and above the sediment-water interface. Comparisons of the pore water profiles of arsenate and arsenite and reference to surface water concentrations of As suggest that runoff is the primary source of elevated As rather than remobilization of As from sediments to the overlying water column. The most prominent fish species in the area, American eel (*Anguilla rostrata*), were collected from the same four locations where peepers were deployed. Results from the analysis of As in liver and muscle and total Hg in muscle tissues show relatively high concentrations at two of the four sites. Consumption limits of 25-200 $g \cdot d^{-1}$ have been derived from accepted guidelines, but the applicability of these limits to other resident species needs to be validated.

Preliminary qualitative ecological risk assessment of marine environmental impacts of former gold mining operations in Nova Scotia. *R. Mroz[1], K.G. Doe[2], K. Tay[1] and J. Cameron[1](PO)*

[1]Environment Canada, Environmental Protection Branch, Dartmouth, NS; [2]Environment Canada, Environment Conservation Branch, Moncton, NB

From about 1860 to 1940, gold was produced from 64 mining districts in Nova Scotia. At that time, most of the gold was recovered using mercury amalgamation techniques. The waste from the milling process (tailings), were contaminated by mercury as a result of losses in the process and were also often high in other naturally occurring contaminants such as arsenic. In addition, tailings were often deposited without any form of control into natural water bodies or into low lying areas next to water bodies.

In 2003, Natural Resources Canada initiated a study to examine the distribution of metals surrounding 11 former gold mines in Nova Scotia. Project partners included GSC-Ottawa, NSDNR, Geomatics Canada, and several universities. The field studies confirmed that most of those sites contain large volumes of unconfined tailings that in some cases have been transported large distances offsite through local drainage systems. The study also showed that gold mine tailings throughout Nova Scotia contain elevated levels of mercury, arsenic and other metals.

In 2004, the Seal Harbour gold district located on the eastern shore of Nova Scotia was selected for a more comprehensive multidisciplinary follow-up study. Environment Canada was invited to participate in that follow-up study to help assess the environmental impacts associated with past practices at this abandoned mine site. Analysis of the data indicated elevated concentrations of arsenic and mercury in sediment samples, some sediment toxicity, lower number and biomass in benthic biota and significant uptake of arsenic in soft shell clams (*Mya arenaria).* Additional sampling was warranted in 2005 to delineate the tailings in Seal Harbour and to expand the field program to include nine other gold mine sites which had the potential to impact marine receiving environments. Sediment and water samples were collected at each site.

Clams, mussels and periwinkles were also collected at each site, where present. Elevated arsenic concentrations in sediment (above CCME Probable Effects Level) were present at 3 of the 9 sites sampled.
Total arsenic concentrations in clam tissue collected from Seal Harbour in 2004 were elevated when compared to control clams and, as a result of these elevated concentrations, Seal Harbour was closed to shellfish harvesting by DFO and CFIA.
In 2005, clam and mussel tissues from potentially impacted areas had elevated concentrations of arsenic when compared to the reference site. Histological assessmentof the clam tissues collected in 2004 show evidence of germ cell necrosis and ovarian inflammation in those clams collected from areas of tailings deposition when compared to control clams. Assessment of the clam issues collected in 2005 is pending. Additional field work is pending for August 2006.

Pharmaceuticals and Personal Care Products/Produits Pharmaceutiques et de Santé Personnelle

Session Co-chairs/Présidents: Thorsten Hebben and Ève Dussault

Status Report: Pharmaceuticals, personal care products, and other compounds of concern in rivers and riverine sediments of Alberta. *T. Hebben[1](PL)*

[1]Alberta Environment, Environmental Monitoring and Evaluation Branch, Edmonton AB

During 2002 and 2003, Alberta Environment undertook a survey of pharmaceuticals, personal care products, and various other organic wastewater contaminants (OWCs) in wastewater treatment plant effluents and major receiving rivers of the province. The results of this study led to the development and implementation of a monitoring program for four rivers, upstream and downstream of large urban centres. Currently, the program comprises quarterly assessments of 54 compounds in the Oldman, Bow, Red Deer, and North Saskatchewan Rivers. The list of tested OWCs includes a fairly broad range of pharmaceuticals, musks, antibacterial agents, and nonylphenol ethoxylates. This suite of analytes is subjected to an extensive QA/QC process and undergoes regular updates to incorporate additional compounds as new information and analytical capacity become available. To date, trace concentrations of several compounds have been detected with a fair degree of regularity at downstream sites. Data from this comprehensive monitoring initiative, 2004 to present, will be presented and discussed. In addition, Alberta Environment has completed a preliminary investigation of the same suite of OWCs in sediment samples collected immediately downstream of wastewater treatment facilities on the Bow and North Saskatchewan rivers. As might be expected, several compounds with stronger adsorptive tendencies, typically below detection in water samples, were detected at trace levels in sediments. These data will also be presented.

Livestock pharmaceuticals in agricultural streams of Alberta: A scoping study. *F. Forrest[1], J. Keenliside[2], J. Kendall[2], T. Thompson[2], D. Noot[2] and J. Wuite[2](PL)*
[1]Alberta Agriculture, Food and Rural Development, Conservation and Development Branch, Edmonton, AB; [2]Alberta Agriculture Food and Rural Development, Agri-Food Laboraotory, Edmonton, AB

Pharmaceuticals are commonly used in the livestock industry for growth promotion, disease prevention and disease treatment. There is limited knowledge on fate and transport of parent drugs and their metabolites in the environment. Studies have demonstrated that persistent pharmaceuticals can reach receiving water bodies through runoff and leaching of manure. The objective of this study was to determine the concentration and frequency of occurrence of some commonly used livestock pharmaceuticals in streams with agricultural activity in their watersheds across Alberta. A list of target analytes was established based on usage, treatment type, potential impact to mammals and laboratory capabilities. Samples were collected monthly and following storm events in 22 streams during the summer and fall of 2005. The streams drained watersheds with varying agricultural intensity, climate and runoff potential across the province. Overall, trace concentrations (< 1 $\mu g \cdot L^{-1}$) of pharmaceuticals were detected in 38% of the samples (44 of 116). Seventeen of the 22 watersheds had between one and four different compounds detected. Monensin and sulfamethazine were the most frequently detected (29% and 11% of samples, respectively). Results from this study can be used in future monitoring programs and toxicity studies to better evaluate potential risks to aquatic ecosystems and human health.

Spatial distribution of endocrine disrupting chemicals in the South Saskatchewan River Basin, Alberta, Canada. *K.M. Jeffries[1] and L.J. Jackson[1](PL)*
[1] Biological Sciences, University Of Calgary, Calgary, AB

Endocrine disrupting chemicals (EDCs), many of which have estrogenic properties, have been widely detected downstream of major point sources globally. However, the spatial distribution of EDCs in rivers is often unknown. These compounds likely act synergistically and consequently impose greater estrogenic effects on aquatic organisms. In fish, males will produce the egg-yolk protein precursor vitellogenin when exposed to estrogenic compounds. We sampled 30 commonly occurring EDCs at eight sites on three rivers to determine the spatial distribution of these compounds in the South Saskatchewan River Basin, Alberta. We then compared the EDC concentrations to vitellogenin levels of male longnose dace, an endemic minnow in Southern Alberta rivers. Preliminary analyses suggest a correlation between concentrations of estrogenic chemicals and sites suspected of reproductive impairment.

Using goldfish as bioindicators of PPCPs in municipal wastewater and re-use water.
G.G. Goss[1], J.L. Kerr[1], Z. Guo[1], D. Smith[1] and M. Belosevic[1](PL)

[1] Department of Biological Sciences, University of Alberta, Edmonton, AB

It has been known for decades that treated wastewater contains a myriad of chemicals that can impact living organisms. However, current waste treatment regimes are not designed to remove these contaminants and recent advances in analytical chemistry have revealed the extent of the problems. These contaminants, either alone or in combination, have been shown to have many harmful effects on aquatic life. In addition, use of secondarily treated membrane filtered effluent as a potable water source has

occurred in many water restricted environments. This "toilet to tap" approach, while not palatable, is a major source of drinking water in many regions of the world. Despite the known existence of PPCPs and other chemicals in wastewater, the potential health impact of direct ingestion of this water has not been investigated to any great extent. To address this concern, we exposed goldfish for 90 days to one of three different treatment regimes to examine both the presence of specific chemicals in wastewater and the efficacy of either membrane filtration or membrane filtration in combination with charcoal filtration to remove these contaminants. The three treatment regimes were A) membrane filtered water, B) membrane and charcoal filtered, or C) final sewage effluent from Goldbar Waste Treatment Plant in Edmonton, Alberta. We tested for the presence of various pharmaceuticals, personal care products, herbicides and pesticides and report on these measures. In addition, at different time points from onset of exposure, fish were killed and tissues collected for various assays including immune cell proliferation, environmental contamination biomarker 7-ethoxyresorufin de-ethylase (EROD) activity, and RT-PCR for gene expression of key hematopoietic genes. In addition, a number of effluent-exposed fish were infected with the protozoan parasite *Trypanosoma danilewskyi* to assess the ability of fish to mount an immune response against the parasite. In this talk, we will present some of the early results of this study.

Benthic invertebrate family planning: Chronic toxicity of the synthetic hormone ethinylestradiol. *È.B. Dussault[1], V.K. Balakrishnan[2], K.R. Solomon[1] and P.L. Sibley[1] (PL)*
[1]Department of Integrated Biology, University Of Guelph, Guelph, ON; [2]Environment Canada, National Water Research Institute, Burlington, ON

Exposure to environmental levels of estrogens has been demonstrated to have significant impacts on aquatic vertebrates, notably via stimulation of vitellogenin synthesis in juvenile and male fish, change in sex steroid levels, alteration of gonadal structure, and feminization of fish. Although several studies have linked estrogens to these responses in vertebrates, studies investigating effects on aquatic invertebrates are scarce, particularly benthic invertebrates, which can be exposed to contaminants via both water and sediments. In this study, the chronic effects of the synthetic hormone ethinylestradiol (EE2) were investigated in the freshwater shrimp, *Hyalella azteca*. Measured endpoints included survival, growth, reproduction, sex ratio, and the presence of deformities in the adults, as well as survival, growth, sex ratio and deformities in the offspring. Exposure to 3.4 mM EE2 resulted in delayed growth, but little to no mortality in the first 3 weeks. However, significant delayed mortality was observed in the following 3 weeks of the experiment, once the animals reached reproduction size. The calculated LC_{50} was approximately 3.5 mM. Although a few mating pairs were observed, reproduction was unsuccessful at 3.4 mM EE2. Exposure to EE2 also caused a concentration-dependent decrease in the number of offspring. Effects on sex ratio, growth and deformities are currently under investigation. The results of this study indicate that risks to *H. azteca* exposed to EE2 are minimal.

Effects of pharmaceutical products and municipal wastewaters on temperature-dependent mitochondrial electron transport activity in *Elliptio complanata* mussels.. *F. Gagné[1], C. [1], C. André[1] and M. Salazar[2](PL)*

[1]Environment Canada, Aquatic Ecosystem Protection Research Division, Montréal, QC; [2]Applied Biomonitoring, Seattle, WA, USA

The advent of global warming has given rise to the issue of how temperature impacts the susceptibility of ectothermic organisms to pollution. The purpose of this study was to examine the effects of pharmaceutical products and domestic wastewaters on temperature-dependent mitochondrial electron transport activity in the freshwater mussel *Elliptio complanata*. Mitochondria from mussels were freshly prepared and exposed to increasing concentrations of various pharmaceutical products known to be found in municipal effluents for 30 minutes at 4, 12 and 20^{o}C. Electron transport activity as well as lipid peroxidation and DNA strand breaks were determined in the mitochondria. Next, mussels were placed in the aeration lagoons of two municipal wastewater treatment plants for 30 days. Mitochondrial electron transport (MET), temperature-dependent MET (MET_T) and gonad lipid peroxidation were then determined. The results show that all products were able to increase MET activity, but at two different ranges of threshold concentration. Certain pharmaceutical products (i.e. ibuprofen, cotinine, fluoxetine, coprostanol and trimethoprim) increased MET_T at a lower threshold concentration than observed at 20^{o}C. Products of lesser potency in reducing lipid peroxidation were those that produced more DNA strand breaks in mitochondria. Both MET and MET_T were significantly increased in mussels exposed to aeration lagoon effluents. Lipid peroxidation was also increased in the gonad and was significantly correlated with MET and MET_T activities. The data indicate that pharmaceutical products and municipal effluents increase respiration rates in isolated mitochondria, such that interaction with temperature could enhance the susceptibility of mitochondrial energy production and oxidative stress in environments contaminated by domestic wastewater.

Population responses of wild fish exposed to municipal wastewater effluents in Ontario, Canada. *G. Tetreault[1], M.E. McMaster[1], K. Oakes[2] and M. Servos[2](PL)*

[1]Environment Canada, National Water Research Institute, Burlington, ON; [2]Department of Biology, University of Waterloo, Waterloo, ON

An emerging issue in Canada involves the effects of municipal wastewater effluents (MWWE) in aquatic receiving environments. MWWE or sewage is a mixture of household waste, ammonia, inorganic chloramines, textile mill effluents (TMEs), nonylphenol and its ethoxylates and pharmaceuticals and personal care products (PCPPs), all of which have been detected in environmental samples. The Grand River Watershed receives the outflow of 26 sewage treatment plants, in addition to runoff from other sources. At low flow periods, it is estimated that the Grand River below Brantford has a high percentage of treated sewage, making it an excellent location to study sewage effluents in Canada. In 2004, field studies assessed sentinel fish responses in terms of growth (condition factor), reproduction (*in vitro* sex steroid biosynthetic capacity, and gonadosomatic indices) and survival. Comparisons were made between fish collected upstream and downstream of the Kitchener and Brantford municipal wastewater treatment plants where existing National Water Research Institute (NWRI) studies have measured detectable levels of a number of pharmaceuticals. Feral

fish (johnny darters (*Etheostoma nigrum*) and bluntnose minnows (*Pimephales notatus*)) collected downstream of both plants exhibited decreased liver mass when compared to reference fish collections, and demonstrated alterations in sex steroid production. Similar trends in fish health were found in the fall of 2005, from greenside darter (*Etheostoma blennioides)* collected downstream of the Kitchener and Guelph municipal wastewater plants. Enrichment of the stable isotopes (^{13}C and ^{15}N) in dorsal muscle tissue will also be discussed. In 2005, field studies were complimented with caging of rainbow trout at the same locations as wild fish collections. The next stage of this study is to assess if exposure to wastewater effluents alters the fish community structure in these receiving environments.

Perchlorate and pharmaceuticals in wastewater, biosolid, effluent, and surface waters for existing and emerging contaminants in the environment via ABI 4000 Qtrap LCMS analysis. *E. Desilva[1], S. Jenkins[1], P. Wang[1], C. Laman[1] and E. Hoffman[1](PL)*

[1]Activation Laboratories, Ancaster, ON

Perchlorate is a known environmental contaminant that has been extensively observed in drinking water from around the world. A water soluble salt that is highly stable in the environment, perchlorate is believed to inhibit thyroid function in humans, which can affect metabolism in adults and development in children. Although no safe limit has been established, the EPA has developed method 331.0 using liquid chromatography mass spectrometry (LCMS) for the analysis of drinking water. We will discuss our work expanding the scope of this method to include the analysis of soils, surface waters, wastewaters, biosolids, and effluent. Pharmaceuticals have been observed in ever increasing levels in the environment posing a risk to both humans and wildlife. Sources of these pharmaceuticals are consumer wastes from over-the-counter (OTC) and prescription drugs going into sewer systems and sewage treatment plant products, surface waters, and from chemical production facilities. Of particular concern are endocrine disruptors - such as ethynylestradiol found in birth control pills - which are highly potent molecules capable of affecting development in both humans and wildlife. We will discuss our work developing highly sensitive LCMS methods capable of quantifying ethynylestradiol and fifteen other prevalent pharmaceuticals in surface water, wastewater, biosolids and effluent.

Do pharmaceutically active compounds have an ecological impact? *O. Enick[1] and M. Moore[1](PL)*

[1]Department of Environmental Management, Simon Fraser University, Burnaby, BC

Pharmaceutically active compounds (PhACs) are used in human and animal medicine as therapeutics and in agriculture as growth-enhancing agents. They are discharged directly to the environment following animal excretion, or indirectly via wastewater treatment plants following human use. The US and Europe now require various levels of environmental impact assessments (EIA) for new pharmaceuticals seeking market approval, and Health Canada is currently developing a framework for the environmental risk assessment of new PhACs regulated under the Food and Drug Act. This

presentation will examine the current theory and practice of EIAs of PhACs in Europe and the US: specifically, the process and methods to assess bioaccumulation, environmental persistence and risk management strategies, and the value of acute and chronic toxicity tests. Using the antiepileptic drug carbamazepine as an example, it will be shown that despite a 98% removal efficiency in wastewater treatment facilities, it remains one of the most common (and potentially very toxic) PhACs in the environment. Furthermore, the presentation will show how our definitions and characterizations of impact, risk, assessment and environment evolve according to socially constructed values. Focusing on antibiotic growth promoters, it will be demonstrated how the inherent assessment values in the US and Europe are linked with resulting policy decisions. This study indicates that due to the inherent uncertainty and value-laden nature of risk assessment, the precautionary principle and the integrated risk assessment approaches should direct further research and policy development.

Pharmaceuticals: Lethal and sublethal impacts on the freshwater oligochaete, *Lumbriculus variegatus*. *N. Tytka[1], L. Hornung[1], R. Karaga[1] and P. Dehn[1](PO)*
[1]Department of Biology, Canisius College, Buffalo, NY, USA

Pharmaceuticals are in sewage effluents, surface water, and ground water. The benthic, freshwater oligochaete, *Lumbriculus variegatus* was exposed to five different pharmaceuticals (carbamazepine-CAR, clotrimazole-CLO, diclofenac-DCF, propranolol-PRP, triclosan-TRI). Ninety-six hour LC50s were determined. From these data, sublethal exposure concentrations (0.5mM CAR, 0.01mM CLO, 0.05mM DCF, 0.05mM PRP, 0.001mM TRI) were selected to study effects on helical swimming and body reversal behaviors (days 0, 4, 7), and growth/regeneration rates over 7 days following mid-body ablation. TRI (LC50 0.0025mM) was the most toxic, followed by CLO (0.014mM), DCF (0.06mM), PRP (0.077mM) and CAR (1.35mM). Helical swimming was a more sensitive indicator of exposure than body reversal. PRP decreased helical swimming 100% when compared to the solvent controls on day 4, followed by CAR (97.4%), DCF (78.6%), and TRI (39.8%). By day seven, worms exposed to CAR, CLO, & PRP did not respond to stimuli, and CLO was toxic (5 worms survived to day 4). Growth/regeneration rates were depressed in worms exposed to all pharmaceuticals except DCF. CLO produced the most severe effects (92% reduction in the absolute growth rate with only 3 worms surviving the 7-d period), followed by TRI (32% reduction, n=5), PRP (98% reduction, n=9), and CAR (39% reduction, n=10), while DCF produced a 42% increase (n=5). Absolute growth rates ranged from 0.413 to 1.10 segments d^{-1} relative to respective solvent controls. These results indicate this benthic worm may be an excellent bioindicator for aquatic contamination, and both the change in behavior and changes in growth/regeneration rates may be potentially useful biomarkers of exposure.

Exposure of zebrafish to fluoxetine reduces egg production. *A. Lister[1], C. Regan[1], and G. Van Der Kraak[1](PO)*

[1]Department of Integrated Biology, University of Guelph, Guelph, ON

Fluoxetine is a widely prescribed anti-depressant that acts as a selective serotonin reuptake inhibitor (SSRI). It is the active ingredient in the drug, Prozac™. Recently, fluoxetine has been measured in sewage effluents and surface waters, and detectable levels of fluoxetine have been measured in the tissues of fish residing within municipal effluent contaminated streams. The objective of our study was to investigate the effects of fluoxetine on the reproduction of breeding groups of sexually-mature zebrafish. Groups of 14 zebrafish (8 females, 6 males) were exposed to 0.32, 3.2, or 32 $\mu g \cdot L^{-1}$ of fluoxetine for 7 days. Two other groups were included: a solvent control group and a group exposed to 10 $ng \cdot L^{-1}$ ethynyl estradiol. Each treatment group had three replicates. Eggs were collected daily during the exposure and tissues were collected in order to measure levels of sex steroids, prostaglandins, and gene expression. Our results indicate that the medium and the highest dose of fluoxetine decreased egg production compared with the control group, but gonadosomatic indices were not affected by any treatments. Currently, our focus is on the analysis of mRNA levels for genes involved in the production of steroids and prostaglandins in order to elucidate a possible mechanism by which fluoxetine influences egg production.

A human hepatocellular carcinoma (HepG2) bioassay for PPCPs: Single compound exposures. *R. Karaga[1], N. Tytka[1] and P. Dehn[1](PO)*

[1]Department of Biology, Canisius College, Buffalo, NY, USA

Pharmaceuticals and personal care products (PPCPs) are in sewage effluents, surface water, and ground water. Cytotoxicity (neutral red assay) and biotransformation responses (cytochrome P4501A1/2 (EROD) and 2B (PROD) activities) of a human bioassay, exposed to low-levels (0.0001-10 mM) of single PPCPs for 96 h were assessed. Of the seven PPCPs tested, clotrimazole (CLO) and triclosan (TRI) were the most cytotoxic (70% and 68% viability, respectively) compared to the solvent controls at 0.01mM, followed by clofibrate (CLF-74% at 0.1mM), diclofenac (DCF) and propranolol (PRP) (79% and 16%, respectively, at 0.25mM), carbamazepine (CAR- 86% at 0.75mM), and phenobarbital (PB-23% at 10mM). CAR and TRI at 0.001mM significantly stimulated (115% and 132%, respectively) cell growth above solvent controls. Cells exposed to CLF &TRI (0.001mM) and DCF (0.05mM) exhibited apoptotic-like morphology when exposed to PPCPs, often in the absence of significant cytotoxicity. EROD and PROD activities were significantly increased by all PPCPs. PRP and TRI increased EROD activity (112% and 181%, respectively, at 0.05mM) followed by CLF, CLO, and DCF (177%, 205%, 113%, respectively, at 0.1mM), CAR (154% at 2.5mM), and PB (241% at 10mM), while for PROD, CLO and TRI increased activity at the lowest concentrations (128% and 640%, respectively at 0.01mM), followed by CLF and PRP (119% and 183%, respectively at 0.1mM), DCF (407% at 0.25mM, CAR (159% at 0.75mM), and PB (272% at 10mM). CLO alters membrane permeability, thus a cytotoxic response at low concentration was not unexpected. CAR, PRP and PB are known substrates for CYP2C8 and 3A4, 2C19 and 2D6, and 2C9 and 2C19, respectively, yet only PB and CAR have been shown to induce CYP2B6 and 3A4 or 3A4, respectively, in humans. Our data indicates that all PPCPs tested can induce CYP1A1/2 and 2B, which are common biomarkers of exposure in field/epidemiological studies.

A human hepatocellular carcinoma (HepG2) bioassay for PPCPs: Mixture exposures. *N. Tytka[1], R. Karaga[1] and P. Dehn[1](PO)*
[1]Department of Biology, Canisius College, Buffalo, NY, USA

Pharmaceuticals and personal care products (PPCPs) are in sewage effluents, surface water, and ground water. The purpose of this study was to examine cytotoxicity and biotransformation responses of a human bioassay, exposed to PPCP mixtures, known to affect these responses from single compound studies. Cytotoxicity (neutral red assay) and biotransformation responses (cytochrome P450 1A1/2 (EROD) and 2B (PROD) activities) were assessed. Of the five mixtures tested the 0.05mM CAR/0.05mM CLO or DCF mixtures were the most cytotoxic (18% and 63% viability, respectively in comparison to the solvent controls), followed by 0.5mM CAR/0.1mM PRP (33%), and 0.1mM CLO 0.05/0.25mM PRP (16%). The CLF/TRI significantly stimulated cell growth (109% at 0.05mM CLF/0.01mM TRI). Although not exhibiting a significant cytotoxic effect, cells appeared apoptotic in response to PPCP mixtures at 0.001mM CLF/0.0005mM TRI, 0.001mM CLO/0.01mM PRP, 0.05mM CAR/0.01mM PRP, and 0.1mM CAR/0.01mM CLO or DCF. EROD and PROD activities were significantly increased by all but the CLF/TRI mixture which depressed both. EROD activity was induced at a lower concentration of CLO/PRP (0.01mM/0.05mM vs 0.1mM/0.25mM) than was PROD. For all other combinations tested EROD & PROD activities were stimulated at the same concentrations. Combinations of CAR/CLO showed interference-like effects on PROD as concentrations required to induce activities were higher than those producing similar responses in single compound studies, while EROD was stimulated by lower concentrations than those producing similar responses in single compound studies. Further work is needed to determine the effect PPCP mixtures will have on cells. These studies support the use of the HEPG2 cell line as a bioassay for toxicity testing.

Ecologically-relevant Sublethal Toxicity Endpoints/Point d'Extrémité Écologiquement Pertinent de Toxicité Sublétale

Session Co-chairs/Présidents: Chris Kennedy and Keith Tierney

Making sense of fish estrogenicity data from refinery experiments. 111. Vg data: Ugly or just plain? *J. P. Sherry[1], S. Munro[2], T.S. Moran[3], B. Zajdlik[4] and T. Kierstead[3](PL)*
[1]Environment Canada, National Water Research Institute, Burlington, ON ; [2]Sarnia-Lambton Environmental Association, Sarnia, ON ; [3]Pollutech EnviroQuatics Limited, Point Edward, ON ; [4]Zajdlik & Associates Inc., Rockwood, ON

At ATW 2005 we presented a two-prong strategy to investigate the potential of wastewaters from several Ontario refineries to induce estrogenic responses in juvenile rainbow trout (RT) (*Oncorhynchus mykiss*). The potencies of end-of-pipe wastewaters were tested in 21-d bioassays using a static full-renewal design. Caged RT were used to assess the recipient waters for estrogenicity and anti-estrogenicity in a pilot experiment. Estrogenicity was measured as induced vitellogenin (Vg) in the plasma of the exposed fish. Anti-estrogenicity was measured as depressed induction of Vg in 17β-estradiol

primed RT. Statistical analysis of the data led us to remark that they were "as ugly as we have seen". Although, we did shield the audience from a direct view of the data. A legitimate question that was posed at the time was whether the data's ugliness was typical of Vg data in general, or peculiar to the present study. In this presentation, we shall look closely at the data and explore how the analytical method with its inherent limitations contributed to the data's appearance. Of particular interest will be the issue of data points that fall below the practical detection limit (PDL) of the analytical method - the so-called censored data. The imposition of censorship can conceal much that is ugly from the observer. The converse also applies. But is that ugliness real or artifactual? Is it inherent or unusual? Does it weaken our relationship with the data? Can censorship, considered by some to be a necessary evil, allow a clearer view of the bigger picture? Or, do we grapple with the data in all of its ugliness, in order to understand it better?

The effect of PCBs and temperature on the thyroid status in rainbow trout (*Oncorhynchus mykiss*). *A.H. Buckman[1,2], A. Fisk[3], J.L.Parrott[2], K.R. Solomon[1] and S.B. Brown[2](PL)*

[1]Department of Integrated Biology, University Of Guelph, Guelph, ON; [2]Environment Canada, National Water Research Institute, Burlington, ON ;[3] Department of Biology, University of Windsor, Windsor, ON

Juvenile rainbow trout (*Oncorhynchus mykiss*) (initial weights ~80g) were exposed to dietary concentrations of PCBs (3 Aroclor® mixtures: 1242, 1254, & 1260) for 30 days followed by 300 days of depuration with uncontaminated food at 8°C, 12°C, and 16°C. We assessed bioaccumulation, thyroid histology, liver deiodinase activity, plasma thyroid hormone concentrations, and liver ethoxyresorufin-O-deethylase (EROD) activity. Concentrations of PCBs were detected above the limits of detection for 92 PCBs. Thyroid epithelial cell height (TECH) was inversely related to water temperature. This relationship between TECH and temperature was eliminated by day-30 of exposure to Aroclor® mixtures with augmented epithelial cell height in fish from the 16°C and 12°C exposure groups and returned to relationships that were similar to pre-dosing by day-20 of depuration. T_4 outer-ring deiodinase activity (ORD) was greater at greater temperatures before any dosing. At day 30 of exposure to Aroclor®, the natural gradient between temperature and ORD was diminishing by PCB exposure similar to effects of PCBs on TECH and returned to similar pre-dosed gradient activity by day 20 of depuration. There were no differences in T_3 inner-ring deiodinase (IRD) and plasma concentrations of T_3 and T_4. EROD activity was elevated in the treatments that were induced with CYP 1A inducing PCB congeners as well as treatments that included congeners known to induce CYP 2B activity in mammals. The exposure of rainbow trout to PCB mixtures attenuated thyroidal responses to temperature, but these changes were within the compensatory scope of the thyroid system because circulating hormone concentrations were maintained.

Development of retene-induced blue sac disease in Japanese medaka (*Oryzias latipes*). *J. A. Scott[1] and P. V. Hodson[1](PL)*

[1]Department of Biology, Queen's University, Kingston, ON

Chronic exposures of the early life stages of fish to alkyl-substituted PAHs, such as retene (7-isopropyl-1-methylphenanthrene), produce dioxin-like toxicity characterized by signs of blue sac disease (BSD). The hallmark signs of BSD include: pericardial edema (PE), yolk sac edema (YE), cardiovascular dysfunction, craniofacial and spinal deformities, haemorrhaging and fin rot. The signs of toxicity are well documented; however, the etiology of the disease is not well understood. To elucidate the mechanism of toxicity, medaka were exposed to retene and observed daily from fertilization (0 d post-fertilization (dpf)) to swim-up (16 dpf). Retene did not affect the rate of embryonic development until 2 days prior to hatch, when embryogenesis was nearly complete. The first observable sign of toxicity (PE) was detected 7 dpf. As PE increased, a decrease in blood flow, thinning of yolk sac vasculature, and an alteration in heart morphology and function were observed. Our results suggest that heart morphology (i.e. tube heart formation) may be a consequence of mechanical stretching resulting from an expanding pericardial cavity. Silent ventricles were observed in severely affected hearts, suggesting a disruption in atrioventricular conduction. Other signs of BSD (YE, craniofacial deformities, fin rot) were observed post-hatch. Altering the onset of retene exposure to 3 dpf significantly reduced the signs of toxicity, suggesting that: the target is more accessible between 0-3 dpf; metabolism is not required for toxicity; or that retene is being sequestered and/or concentrated until a functional cytochrome P450 system is developed.

Potential impacts of an orimulsion spill on marine (Atlantic herring; *Clupea harengus*) and estuarine (mummichog; *Fundulus heteroclitus*) fish species in Atlantic Canada. *S.C. Courtenay[1], M. Boudreau[1], M. Sweezey[1], K. Lee[2] and P.V. Hodson[3](PL)*

[1]Department of Fisheries and Oceans at The Canadian Rivers Institute, University of New Brunswick, Fredericton, NB; [2]Fisheries and Oceans Canada, Centre for Offshore Oil and Gas Environmental Research, Dartmouth, NS; [3]Department of Biology, Queen's University, Kingston, ON

The growing potential of orimulsion, an emulsion of 70% bitumen in 30% water, use in North America warrants assessment of possible environmental impacts of this new fuel. In the event of a spill at sea orimulsion may contact animals throughout the water column rather than only at the water surface as expected by conventional heavy fuel oils. In this study we tested orimulsion toxicity during the embryonic development of an estuarine (mummichog; *Fundulus heteroclitus*) and a marine (Atlantic herring; *Clupea harengus*) fish species in duplicate assays for each species. Air injection and varying salinities were included in the herring assays to examine their effects on orimulsion toxicity. Water-accommodated fractions (WAF) of No. 6 fuel oil were also tested in the mummichog assays to compare orimulsion toxicity to that of a heavy fuel oil. Significant impacts were observed at the lowest tested concentration of 0.001% orimulsion in both species. In the more sensitive of the two species, herring, this concentration produced 100% abnormal larvae. Similar abnormalities were produced in both herring and mummichog, including reduced growth, pericardial edema and spinal deformities. These

are also the same types of abnormalities produced by heavy fuel oils and PAHs. The initial and most prominent abnormality was pericardial edema, which was usually accompanied by haemorrhaging at its base in mummichog. Orimulsion-exposed fish also suffered from increased mortality, reduced heart rates, premature hatch and reduced lengths. The toxicity of orimulsion was over 300x greater than #6 fuel oil (WAF). Although effect of salinity on orimulsion toxicity in herring was unclear, air injection greatly reduced toxicity.

Ecologically relevant sub-lethal toxicity endpoints: Be careful of blind trust. *J.F. Payne[1](PL)*

[1] Fisheries and Oceans Canada, Science Branch, St. John's NL

Chemical analysis alone is presently recognized to be of limited value for assessing risks of environmental contaminants and there is increasing emphasis on the use of biochemical, physiological and pathological indicators of toxicity. Such biological indicators are increasingly being incorporated into laboratory based chronic toxicity studies as well as field monitoring programs in many jurisdictions worldwide. Nevertheless, in Canada there seems to be a "shyness" by some agencies towards use of biological indicators of contaminant stress with reliance being given to more coarse endpoints such as fish and gonad growth. I will discuss that reliance on such endpoints may represent too much of a "blind trust" with considerable potential for missing important ecotoxicological effects be it in relation to mining, pulp and paper, or other effluents, or more broadscale ecological impacts.

Toxicology meets Ecotoxicology/Toxicologie Rencontre Écotoxicologie

Session Co-chairs/Présidents: Jim Sherry and Erin Kelly

Exploring the linkages between human health and ecosystem health. *J.P. Sherry[1](PL)*

[1]Environment Canada, National Water Research Institute, Burlington, ON

There is much current interest in both the potential for humans to impact the health of aquatic ecosystems, and the potential for contaminants in aquatic environments to adversely affect human health. The possible linkages, however, between the health of aquatic ecosystems and human health in neighboring terrestrial ecosystems have received scant attention. Most of us have, or think we have, a clear concept of what is meant by the terms "human health" and "population health". Paradoxically, the term "ecosystem health" is less clearly understood and accepted by scientists, than by the general public. Prominent ecologists and ecotoxicologists are divided on the advisability and utility of applying the human health metaphor to complex, multi-trophic, multi-organism, multi-population, and multi-community systems. Nevertheless, there is ample evidence that environmental stressors, be they chemical or physical, have the potential to affect both the aquatic biota and human populations. Sublethal stressors that act via

similar mechanisms in humans and wildlife have the potential to cause similar health effects. Biochemical or physiological responses to such stressors, can be used to look for potential linkages between the impaired health of aquatic biota and human health problems. Factors to be considered in any exploration of such linkages are the different routes and modes of exposure of humans and wildlife to stressors, the bioavailability of contaminants, pharmacokinetic barriers, and the consequences of exposure. It is also worth considering the different importance that society attaches to the health of individual humans and individual fish. Current studies of fish and wildlife health in the Great Lakes' Areas of Concern will generate data that when considered in conjunction with epidemiological studies of the surrounding areas may well generate some useful hypotheses for more focused research into possible links between ecosystem and human health.

Industry rationale for a community environmental health study in Sarnia, Ontario.
S. Munro[1], R. Menzies[2] and R. Van Hemmen[3](PL)
[1]Sarnia-Lambton Environmental Association, Sarnia, ON; [2]Imperial Oil Limited, Sarnia, ON; [3]Nova Chemicals Limited, Sarnia, ON

Sarnia, Ontario has been a host community for refineries, petrochemical facilities and related operations for more than a century. Rapid expansion continued from the mid-1940s through the 1970s, followed by a period of consolidation, realignment and modest expansion. Since 1952, there has is an extensive record of environmental and ecological monitoring, establishing long-term trends of air, water and sediment quality improvement consistent with reductions in emissions and discharges from the operating facilities. Epidemiological studies of workers have been completed or are ongoing at a number of individual facilities; however, there has been surprisingly little study of community health related to environmental stressors. This paper will review the driving forces that led a co-operative of 20 local industries to propose a community environmental health study led by a multistakeholder steering team; the phased study envisioned; and, the current status of the multi-year project.

Aquatic toxins: Targeting the neuron.
C.L. Reinisch[1](PL)
[1]Marine Biological Lab, Falmouth, MA, USA

Environmental toxicology includes examining the targets of specific chemicals on the genes, cells and tissues of organisms. One major gap in this field is defining the impact of specific environmental chemicals on the embryonic nervous system at the cellular and molecular levels. This is essential in understanding the etiology of developmental disorders in the human such as autism and attention deficit disorder. Using marine embryos, we defined how specific neuronal development is impaired by a triple mixture of chemicals found in the well water in Brick, NJ. where unusually high rates of autism had been reported. We specifically examined the impact of bromoform, chloroform and tetrachloroethylene on *Spisula solidissima* embryos using quantitative confocal and immunoblotting techniques. Surprisingly, the most sensitive and selective target of these chemicals was a cAMP dependent subunit of protein kinase known to be essential for normal neuronal development. Perhaps more importantly, we must also understand whether or not critical gene familes such as p53 are irreversibly altered during exposure

to toxins. Applying invertebrate and vertebrate data to developmental disorders in the human remains one of the major challenges in the converging fields of molecular ecotoxicology and developmental biology.

Effects of pharmaceutical products on the immune system in freshwater mussels-finding critical mechanisms of toxicity. *F. Gagné[1], M. Fournier[2], C. Blaise[1] and P.D. Hansen[3](PL)*

[1]Environment Canada, Aquatic Ecosystem Protection Research Division, Montreal, QC; [2]Environment Canada, Centre St. Laurent, Montreal, QC; [3]Berlin Polytechnical University, Berlin, Germany

Municipal wastewaters are recognized as a major source of pharmaceutical and personal care products to the aquatic environment, thereby exposing biota to unknown chronic effects. This study sought to examine the immunotoxic effects of pharmaceutical and urban waste products on the freshwater mussel *Elliptio complanata*. Hemolymph samples were collected and treated *in vitro* with increasing concentrations of various drugs (bezafibrate, carbamazepine, fluoxetine, gemfibrozil, morphine, naproxen, novobiocin, oxytetracycline, sulfamethazole, sulfapyridine and trimethoprim) and urban waste related chemicals (coprostanol, caffeine, cotinine) for 24 h at 15^{o}C. In a parallel experiment, mussels were caged and placed in two final aeration lagoons for the treatment of domestic wastewaters. At the end of the exposure period, hemolymphs were tested for phagocytic activity, intracellular esterase activity, cell adherence and lipid peroxidation (LPO). The products that most increased phagocytosis were bezafibrate, gemfibrozil and trimethoprim, while novobiocin and morphine reduced activity. Intracellular esterase activity was reduced most strongly with sulphamethazole, novobiocin, gemfibrozil, bezafibrate and carbamazepine. Cell adherence was decreased by oxytetracycline, novobiocin and naproxen, and increased by gemfibrozil, bezafibrate and sulfapyridine. Exposure to these products also modulated LPO in hemocytes. Coprostanol and naproxen were more potent to reduce LPO while novobiocin and sulfapyridine were the most potent to induce LPO. The potential to induce LPO was positively correlated with the number of functional groups on the molecule (i.e., its nucleophilicity). Mussels exposed to domestic wastewater treatment plant aeration lagoons had decreased intracellular esterase and phagocytic activity as well, suggesting immuno-suppression. PPCPs (pharmaceuticals and personal care products) that are recognized to disrupt cytokine signalling network by the nitric oxide pathway and cell permeability were generally the most potent ones. The data suggest that PPCPs have the potential to cause adverse effects on the immune system of bivalves.

Were fish in Lake Wabamun exposed to spilled oil after the train derailment in 2005? *P.V. Hodson[1] and W. Shaw[1](PL)*

[1] Department of Biology, Queen's University, Kingston, ON

A train derailment along the north shore of Lake Wabamun, AB, caused a spill of bunker C and pole-treating oil on August 3, 2005. In addition to oiled shoreline adjacent to the spill, the eastern and southeastern parts of the lake were oiled by the prevailing wind. Crude and partially-refined oils are complex mixtures of hydrocarbons that may pose a risk to fish of toxicity. The extent of that risk will vary with the life stage exposed, the

toxicity of the components, and the extent of exposure. Polycyclic aromatic hydrocarbons (PAH) are constituents that can induce the synthesis of cytochrome P450 (CYP1A) enzymes in tissues of fish. The increase in activity of liver CYP1A enzymes, particularly ethoxyresorufin-o-deethylase (EROD), is a sensitive biomarker of PAH exposure. Assuming that the oil spilled in L. Wabamun contained PAH, we measured EROD activity in the livers of lake whitefish, northern pike, and white sucker as an index of exposure to spilled oil. The fish were captured by Federal and Provincial biologists August 18-20, 2005, at 10 inshore and offshore locations. CYP1A activity ranged from reference values (<1 pmol resorufin mg protein^{-1} min^{-1}) to those associated with PAH exposure (up to 49 pmol mg^{-1}min^{-1}). However, there was no clear geographic pattern of increased EROD activity; mixtures of induced and un-induced fish were caught at all sites. Similarly, there were no differences between sexes or among species in the patterns of response, although data were sparse for pike and suckers. Because EROD induction is transient unless PAH exposure is continuous, the combination of induced and un-induced fish suggests that many fish were exposed to PAH just prior to capture. Most fish sampled were large (mean of 960 g), and it is possible that oil-exposed and un-exposed fish were mixed by random foraging in this relatively small lake (about 12 km long). Hence, the EROD signal was ambiguous because of the two-week delay in sampling and the subsequent migration of fish throughout the lake. To ascertain whether fish were exposed to oil from this derailment would require that fish be sampled within a few days of the accident.

Mercury accumulation in Canadian Rocky Mountain lake food webs. *E. N. Kelly[1], D. W. Schindler[1], V. L. St. Louis[1] and D. B. Donald[2](PL)*

[1] Department of Biological Sciences, University of Alberta, Edmonton, AB; [2]Environment Canada, Natioanl Water Research Institute, Saskatoon, SK

Methylmercury (MeHg) is a vertebrate neurotoxin that can bioaccumulate in aquatic food chains and cause serious health problems for aquatic biota, wildlife, and humans. Although natural sources of mercury (Hg) exist (*e.g.,* rock weathering), an important anthropogenic source is coal combustion. Inorganic Hg can be transported long distances, deposited and biologically transformed into MeHg. Remote lakes, far from point sources, can contain fishes with MeHg concentrations that range from very low to those that exceed wildlife and human consumption guidelines. In this study, lakes previously not examined for Hg contamination in the Canadian Rocky Mountain parks were sampled to determine: 1) the distribution of Hg in organisms and 2) factors that affect the Hg distribution. Results indicate that Hg concentrations vary widely within and among fish species, and can exceed guidelines for the protection of human and wildlife health. As expected, factors (i.e., atmospheric Hg deposition, catchment geology and morphology, lake water chemistry and productivity, fish trophic position, age, growth rate, interactions with other trace elements in fishes, etc.) that could affect Hg concentrations in fishes were variable, except for pH. Selenium, arsenic, copper and zinc concentrations in some fishes also exceeded guidelines for the protection of human and/or aquatic organism health. Forest fire, a landscape disturbance, resulted in increased mercury accumulation by several fish species. These results were used to produce a predictive model that should allow Park managers to identify lakes containing fishes with elevated Hg concentrations.

Development of a province-wide framework for source water protection - to protect existing and future drinking water sources in Ontario. *M. Nowierski[1] and T. Fletcher[1](PL)*

[1]Ontario Ministry of the Environment, Ecological Standards Branch, Toronto, ON

The Ontario government has introduced Bill 43 (the proposed "Clean Water Act, 2005") to protect drinking water at the source, as part of an overall commitment to protect human health and the environment. Protecting "source water" is the first step in a multi-barrier approach to ensuring the quality, and sustainability, of our drinking water supply. A key focus of the government's legislation is the production of locally-developed, science-based assessment reports and source water protection plans. Guidance documents have been drafted that will aid in the development of assessment reports. The assessment reports will identify and categorize the land uses that pose a risk to municipal drinking water sources. The assessment reports will identify the risks that will be addressed in the source water protection plans.

Are feral fish in Areas of Concern on the Canadian side of the Great Lakes exposed to environmental estrogens? *J. P. Sherry[1], C. Tinson[1], R. Stacey[1], H. Liisa[1], M. E. McMaster[1] and S.B. Brown[1](PL)*

[1]Environment Canada, National Water Research Institute, Burlington, ON

As part of a broader assessment of wildlife health in Areas of Concern (AOC) on the Canadian side of the Great Lakes we have examined feral and caged fish for evidence of exposure to both environmental estrogens (EEs) and possible anti-estrogens. For the purpose of this study we divided each AOC into upstream, impact zone, and downstream sites. At each site we sought to capture 20 adult male and female specimens of a bottom dwelling and a pelagic fish species. We were able to meet our quota at most, but not all, AOCs. After a general health assessment a blood sample was taken from each fish. Vg was measured by means of a sensitive gel electrophoresis technique that used silver staining to reveal the protein bands. Presence of Vg in the plasma of male fish is indicative of exposure to EEs. A decreased concentration of plasma Vg in female fish from the impact zone compared with concentrations in females from the reference location could indicate that the fish have been exposed to anti-estrogens, among other possibilities. We present the results for the Wheatley Harbour, Detroit River, and St. Clair River AOCs for bottom brown bullhead (*Ictalurus nebulosus*) and shorthead redhorse sucker (*Moxostoma macrolepidotum*) and water column goldfish (*Carassius aruatus*) and yellow perch (*Perca flavescens*)) feeders. The data suggest that feral fish at the St. Clair and Detroit River AOCs have had some exposure to EEs. Contrasts between the data from fish of differing feeding habits could help distinguish between stressors that are predominantly waterborne and those that may have partitioned into the sediment.

Facilitated discussion on links between human toxicology and ecotoxicology. *J.P. Sherry[1] and E.N. Kelly[2] (PL)*
[1]Environment Canada, National Water Research Institute, Burlington, ON ; [2] Department of Biological Sciences, University of Alberta, Edmonton, AB;

The Ecosystem Health Network under the Bilateral Agreement for Science & Technology between Canada and Germany proposed to the organizing committee of ATW 2006 that a special session on the topic of "Toxicology Meets Ecotoxicology: Narrowing the Gap Between Environmental and Human Health Issues" be held at the 33rd Workshop. The proposal, which was supported, was to explore the potential for links between stressor related health effects in aquatic wildlife and measures of health in humans from nearby ecosystems. An interesting and stimulating session ensued with 7 platform presentations and 4 posters. The final component of the session was an open discussion among the participants. The open discussion, which lasted for about 2.5 hours, covered a wide range of issues as the participants explored the potential for links between the disciplines of ecotoxicology, toxicology, and epidemiology. The discussion was more free-ranging than structured, the feeling being that a more focussed sorting and development of ideas could follow at a later date. There was discussion of various exposure scenarios that could lead to adverse responses in both humans and wildlife. Such scenarios could provide the basis for some pioneering case studies. Several speakers mentioned that they had waited years for such a session at ATW. The main ideas from the discussion were captured and will be circulated among the participants in the form of a working document that can be amended and updated as we proceed. The consensus was that follow-up activity, such as workshops and further conference sessions, are needed to identify and prioritize the knowledge gaps, scientific challenges, and the necessary steps to advance this area of emerging interest. It will be important to actively engage epidemiologists if we are to succeed.

Endocrine disruptors: Evaluation and measurement of exposure in Québécois houses. *L. Parent[1], S. Thibault[2], B. Vaillancourt[3](PO)*
[1]UER Sciences et Technologies, *Universté du Québec à Montréal, Montréal, QC; [2]Scible Communcation Scientifique, Montreal, QC; [3]Téluq, Universté du Québec à Montréal, Montréal, QC*

The environment exposes living creatures to compounds having an effect connected with that of certain hormones and interfering with the operation of natural hormones. These compounds are identified as endocrine disruptors (ED), defined as exogenic substances or mixtures which deteriorate functions of the endocrine system and by consequence, cause unfavourable effects on health.
The effects of the EDs on human health are not yet well characterized. Their study is complex from their great diversity, their omnipresence with various concentrations in the immediate environment of humans and the heterogeneity of populations which are exposed. Human exposure to EDs varies from one medium the other and according to behaviour. The total characterization of the exposure is a question seldom tackled in the studies published. Indeed, studies often limit this variable to a source of single exposure (e.g. fish consumption, proximity of an agricultural zone) and not to the total sources of exposure. However, it is probable that the interaction of different EDs is determining of their effect.

Important gaps persist as well on the level of the sex-specific effects as of the effects of the chronic exposure to a cocktail of low-dose substances. Although the question of the potential threat for health that represent the EDs has been carried to the attention of public health authorities and to scientists, the global portrait of these problems has still not been drawn up.
We propose a global approach which aims at reducing the exposure of the population to EDs in the daily and domestic activities. By establishing a portrait of the human exposure, it will be possible to evaluate the impact of these compounds on health, and therefore to adapt our research efforts in order to better include/understand the mechanisms of action and the interactions of the EDs.

Utilization of a commercial ELISA to assess microcystin levels in Lake Erie sport and pan fish. *R. Schuster[1], J. Telecky[2] and P. Dehn[1](PO)*
[1]Department of Biology, Canisius College, Buffalo, NY, USA; [2]New York State Department of Environmental Conservation, Bufflao, NY, USA

Cyanobacterial toxins are stored in fish muscle, and can pose a potential health risk to humans and other organisms who consume contaminated tissues. The purpose of this study was to assess microcystin levels in muscle tissue of common sport and pan fish from the eastern end of Lake Erie utilizing a commercial enzyme-linked immunosorbent assay (ELISA, EnviroLogix). Yellow perch (6), small mouth bass (7), lake trout (5), and adult (6) and yearling (9) walleye were collected, fillets were homogenized, extracted in methanol, and analyzed for microcystin. Microcystin (μg kg^{-1} wet tissue) was present in all fish and species examined (yellow perch 7.3 $\pm$ 1.6, walleye yearling 9.5 $\pm$ 1.1, small mouth bass 9.7 $\pm$ 1.7, lake trout 10.4 $\pm$ 0.7, and adult walleye 6.1 $\pm$ 3.0). Based on EPA's meal size of 227g, all mean levels exceeded the World Health Organization's tolerable daily intake (TDI) guidelines of 0.04 μg kg^{-1} day^{-1} or 2.8 μg for a 70 kg individual. One meal of Lake Erie fish provides levels of microcystin at least one order of magnitude higher than this TDI (yellow perch 23.6 $\pm$ 5.1, walleye yearling 30.7 $\pm$ 3.6, small mouth bass 31.5 $\pm$ 5.4, lake trout 33.6 $\pm$ 2.1, and adult walleye 19.7 $\pm$ 10.9). Since previous studies have shown methanol extraction removes only unbound microcystin, our results under-represent actual levels, indicating consumption of one Lake Erie fish meal may lead to significant human health effects and warnings regarding consumption of Lake Erie fish with respect to microcystin are necessary.

Cadmium affects F-actin cytoskeletal structure in a human hepatocellular (HepG2) cell Line: LPA & culture age effects. *L. Hornung[1], E. Hogan[1] and P. Dehn[1](PO)*
[1]Department of Biology, Canisius College, Buffalo, NY, USA

Cadmium (Cd^{2+}), an environmental contaminant, and the extracellular ligand, lysophosphatidic acid (LPA), alter actin cytoskeletal structure (e.g., thick bands, retraction fibers, mesh-like cytoplasm (MESH), cable-like structures (Cables), microspikes (MS), and actin bundles. LPA may function via a calcium (Ca^{2+}) dependent signal transduction pathway (STP). Cd^{2+} may compete with Ca^{2+} in this pathway. Using fluorescence microscopy this study addresses two questions: 1) Can LPA counteract the effects of Cd^{2+} on the actin cytoskeleton? 2) Does the age of the cell culture impact this response? Two passages of HepG2 cells (p3 & p5) were exposed to Cd^{2+} or to

Cd^{2+}+ LPA for 8 h, while the solvent controls were exposed only in serum-free media. Both Cd^{2+} and Cd^{2+}+ LPA stimulate peripheral F-actin intensities (PFAI's) (p3 & p5) and Cables (p5) when compared to the solvent controls; suggesting LPA and Cd^{2+} may work cooperatively via the same STP for PFAI's and Cables. PFAI's were higher in p3 Cd^{2+}+ LPA cells after 8 h when compared to Cd^{2+} only cells; indicating LPA increases peripherally localized F-actin in younger Cd^{2+} treated cells. Although not significant, Cd^{2+} decreased all other structures in both p3 & p5 cells when compared to the solvent controls. After 8 h, p3 Cd^{2+}+ LPA cells increased significantly in MESH & MS, while p5 Cd^{2+}+ LPA cells increased significantly in MESH when compared to Cd^{2+} only cells; indicating LPA and Cd^{2+} may work antagonistically for MESH and MS in young cells. These changes in cytoskeletal structure indicate Cd^{2+}'s toxicity and LPA's ability to reorganize the cytoskeleton in Cd^{2+} treated cells depends on cell age.

Sublethal effects of imidacloprid on adult mayfly body size. *A. Alexander[1],J. Culp[2], K. Liber[3], D. Baird[2], A. Cessna[2](PO)*

[1]Department of Biology and The Canadian Rivers Institute, University of New Brunswick, Fredericton, NB; [2]Environment Canada, National Water Research Institute, University of New Brunswick, Fredericton, NB ; [3] Toxicology Centre, University of Saskatchewan, Saskatoon, SK

Soluble agricultural insecticides can impair the development and growth of larval mayflies, and have broad impacts on the success of benthic invertebrate populations. Employing field-deployed mesocosms, we examined the effects of 24-h pulse and 20-d press (continual) exposures of the common agricultural insecticide, imidacloprid, on mayfly body-size metrics. Benthic invertebrate communities with the mayfly genera, *Baetis* spp. (Family Baetidae) and *Epeorus* spp. (Family Heptageniidae), were exposed to sublethal concentrations (0, 0.5, 1, 5, 10 $\mu g \cdot L^{-1}$) of imidacloprid to examine this insecticide's effects on larval development and adult body size. MANOVA analyses indicated that exposure to imidacloprid significantly reduced head length of *Baetis* males ($F(5,96)=3.05$; $p<0.05$) and thorax length of *Epeorus* males ($F(5,44)=2.61$; $p<0.05$). Females of neither genus were significantly impacted with respect to body-size metrics as a result of the pulse or press exposures. Larval *Epeorus* also exhibited reduced development (wingpad length to width ratio) in 1 $\mu g \cdot L^{-1}$press exposures ($F(3,178)=7.21$; $p<0.01$), but were not affected by a 10-fold increase in concentration (10 $\mu g \cdot L^{-1}$) of imidacloprid delivered in a 24-h pulse. Because fecundity is positively related to invertebrate development and body size, sublethal doses of this widely applied agricultural insecticide have the potential to reduce reproductive success of mayfly populations.

Incorporating Traditional Environmental Knowledge/Incorporées nos Connaissances Environnementales Traditionnnelles

Session Chair/Président: Craig Candler

Incorporating traditional ecological knowledge. *C. Candler[1](PL)*

[1]Golder Associates, Victoria, BC

Traditional ecological knowledge (TEK) is receiving increased recognition in research, policy, and practice as a vital resource for understanding and managing aquatic ecosystems. While cultural differences, tight timelines and other constraints can make collaboration with communities and incorporation of TEK challenging, involvement of First Nations and sharing of TEK ultimately provides the foundation for stronger monitoring programs, more effective and efficient management strategies, and healthier communities and ecologies. Such efforts necessarily involve celebrating the overlaps and bridging the gaps between science and community. In keeping with the upstream/downstream theme of the workshop, this session will involve First Nations representatives from both upstream and downstream communities, ranging from the mountain communities of Jasper's watersheds to the coastal communities of Vancouver Island. The session will be facilitated by cultural resource specialists from Golder Associates Ltd. The session format will include a round table discussion between scientists, managers (both aboriginal and non), and First Nations elders. We will begin with a panel discussion of introductory issues and case studies that address TEK in environmental impact and ecological risk assessments, and the importance of First Nations consultation for successful projects given recent court decisions and government policy developments. The session will then move towards an open discussion of community and scientific perspectives, and the kinds of knowledge, values, challenges, and methods involved in successfully bridging TEK and the science of aquatic toxicity. Participants will be asked to share their knowledge of how local and aboriginal communities, and TEK, are becoming involved in understanding and dealing with issues of water, toxicity, and environmental quality.

Use of Toxicity Information in Ecological Risk Assessment of Chemical Substances/ Utilisation de l'Information sur la Toxicité dans l'Évaluation des Risques Écologiques des Substances Chimique

Session Co-chairs/Présidents: Ken Taylor and Sarah Reid

Ecological assessment of existing substances under the Canadian Environmental Protection Act, 1999. *K. Taylor[1](PL)*

[1]Environment Canada, Science and Technology Branch, Gatineau, QC

The Canadian Environmental Protection Act, 1999 (CEPA 1999) provides the legal tool for assessing substances in Canada and for addressing those that can cause harm to the environment or to human life or health. Environment Canada and Health Canada jointly identify, prioritize, and assess the risks resulting from existing substances. The objective of an ecological risk assessment is to determine whether a substance is entering or may enter the environment in a quantity or concentrations or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity, or constitute or may constitute a danger to the environment on which life depends. An ecological assessment has four main phases: 1) Pre-screening or problem formulation 2) Entry, fate and exposure characterization 3) Effects characterization 4) Risk characterization. CEPA 1999 requires the use of a weight-of-evidence approach in assessments of existing substances. Rather than relying on a single approach to ecological risk assessment, evaluators should examine separate lines of evidence in each phase of an assessment in order to determine if a substance meets the definition of "toxic" as presented in Section 64 of CEPA 1999.

Risk assessment and the OECD test guidelines program. *W.M. Windle[1](PL)*

[1]Environment Canada, Science and Technology Branch, Gatineau, QC

The Organisation for Economic Co-operation and Development (OECD) is an intergovernmental organisation in which representatives of 30 industrialised countries meet to co-ordinate and harmonise policies, discuss issues of mutual concern, and work together to respond to international problems. Most of the OECD's work is carried out by more than 200 specialised committees and working groups composed of member country delegates. One such Working Group is the National Coordinators of the Test Guidelines Program (WNT). The objective of the Working Group is to direct and oversee the work on: (i) Test Guidelines, including as appropriate, their development and validation; (ii) Guidance Documents on testing issues; and (iii) Detailed Review Papers on the state-of-science of defined hazard areas, taking into account the regulatory need for test methods as well as animal considerations. The WNT works towards the development of draft Test Guidelines based on consensus and the Mutual Acceptance of Data principle. This presentation will introduce the WNT and describe how the test guidelines produced by WNT are used in risk assessment programs in countries such as Canada.

Introduction to the proposed new national protocol for the derivation of Canadian Water Quality Guidelines for the protection of aquatic life. *U. Schneider [1], R. Casey[2], T. Fletcher[3], I. Guay[4], N.K. Nagpal[5], M.J. Demers[1], J.R.Hill[1], K. Potter[1] and S.L. Roe[1](PL)*

[1]Environment Canada, National Guidelines and Standards Office, Gatineau, QC; [2]Alberta Environment, Edmonton, AB; [3] Ontario Ministry of the Environment, Ecological Standards Branch, Toronto, ON; ; [4]Ministère de l'Environnement du Québec, Quebec, QC ; [5]British Columbia Ministry of Water, Land and Air Protection, Victoria, BC

The Canadian Council of Ministers of the Environment's Water Quality Task Group comprised of Provinces, Territories, and the Federal Government is revising the protocol for the derivation of Canadian Water Quality Guidelines for the protection of aquatic life (CWQG-PAL) (CCME 1991) with input from other experts. By incorporating new developments in aquatic toxicology, the existing methodology will be expanded, and additional ways of Guideline derivation will be employed, thereby further improving on the usefulness of the CWQG-PALs as environmental management tools. New procedures for CWQGs for short-term exposure scenarios will also be derived in addition to the traditional long-term exposure scenarios. CWQG-PAL will preferentially be derived using a distribution-based statistical analysis of all relevant toxicological data (species-sensitivity distribution). However, the 1991 methodology will still be used where data are limited, i.e., the lowest scientifically-defensible effects concentration divided by a fixed safety factor. Where possible, the influence of toxicity modifying factors (e.g., pH, hardness) will be incorporated into the recommended CWQG-PAL values, thereby allowing for more situational variability and site-specificity. This presentation will outline the proposed new protocol, the rationale behind some of the decisions taken, and future steps.

Re-thinking the background approach to setting site-specific water quality guidelines (SSGs). ***S**.L. Roe[1], J.R. Hill[1], U. Schneider[1] and L.G. Swain[2](PL)*
[1] Environment Canada, National Guidelines and Standards Office, Gatineau, QC; [2]Tri-Star Environmental Consulting, Victoria, BC

Canadian Water Quality Guidelines (CWQGs) are national values developed to address issues related to contamination and are derived primarily from toxicity studies. Under the Canadian Environmental Sustainability Indicator (CESI) program and the proposed revised Protocol for CWQGs it is recommended that national guidelines be adjusted to the natural background level when this level exceeds the guideline, since it is not practical, nor desirable to set water quality goals better than what occurs naturally. Current national guidance from CCME lists current practices (e.g., mean + 2SD, percentile) for calculating natural background but does not provide detailed review or recommendations. The applicability of five different statistical methods (normal range; iterative two-standard deviation; four standard deviation outlier; calculated distribution function; and mode analysis) was evaluated using a case study approach that examined options for re-configuring the data to yield natural background concentrations as well as the use of particular percentile estimators (e.g. 95th percentile). This presentation will compare the case-study results of these statistical approaches and discuss their potential usefulness in estimating accurate natural background for SSGs. The ultimate goal of this continuing investigation is to establish a nationally-consistent framework for natural background estimation.

Can industry develop Canadian Environmental Quality Guidelines? *S.L. Roe[1], K. Potter[1], U. Schneider[1] and D. Spry[1](PL)*

[1] Environment Canada, National Guidelines and Standards Office, Gatineau, QC

Most Canadian Environmental Quality Guidelines (CEQGs) are developed through the Water Quality and Soil Quality Guidelines Task Groups of the Canadian Council of Ministers of Environment (CCME). CCME encourages the development of CEQGs by third parties (i.e., stakeholders who are not CCME members such as industry, academia, NGOs), and in 2001 in response to a request from industry, developed the "Process for Contributed Third-Party Guidelines". CCME recognizes that while this process could accelerate guideline development there is also an investment by jurisdictions to ensure continued high quality of CEQGs as well as the requirement to meet the priorities of the jurisdictions. This presentation will detail the experience of the National Guidelines and Standards Office of Environment Canada with third-party guideline development using as case studies two chemicals from the oil and gas sector (di-isopropanolamine [DIPA] and sulfolane) and make recommendations for how the process might be made more effective and efficient for both 3rd party contributors and CCME.

Application of comprehensive effects datasets for ecological risk assessment of wildlife. *C.E. Mackintosh[1] and P. J. Allard[1](PL)*

[1]Azimuth Consulting Group, Inc., Vancouver, BC

Effects assessments in ecological risk assessment (ERA) for wildlife often rely on single point estimates such as toxicity reference values (TRVs) to define levels of maximum acceptable exposure (or intake doses). However, there are several challenges faced when deriving and applying TRVs. These include: 1) using NOAEL and LOAEL vs. ECx single point estimates, 2) defining protection goals (the ECx) for different land uses and different receptors (rare and endangered species vs. common species), and 3) uncertainty in extrapolating laboratory-based dose-responses to wild organisms (e.g., allometric scaling, extrapolation factors). Another important issue is that calculation of a hazard quotient based on a TRV only measures hazard - the possibility of an effect; not potential *risk* to wildlife. To address some of these challenges, we present a tiered risk characterization approach incorporating both single point estimates (to evaluate hazard) and multiple dose-responses (to evaluate risk). Our intent is to generate discussion on ways to improve transparency and consistency when conducting effects assessment and, ultimately, risk characterization in ERAs. This approach is applied to a case-study at a mercury contaminated site.

Environmental impacts of hydrazine in aquatic effluents at Ontario CANDU stations. *D. Rodgers[1](PL)*

[1]Kinectrics, Toronto, ON

Hydrazine (N_2H_4) is used to reduce corrosion by maintaining both low dissolved oxygen concentrations and an alkaline pH in the boiler, steam feedwater and ancillary systems of CANDU Stations. Ontario CANDU stations were consistently among the leading hydrazine emitters reporting to National Pollutant Release Inventory, with total annual hydrazine releases of 1.2 to 2.9 tonnes y^{-1}. Greater than 90% of the hydrazine was released as waterborne emissions with < 10 % released to the atmosphere. Hydrazine at the station outfalls is consistently > 10 $\mu g \cdot L^{-1}$, an order of magnitude below the OME effluent limit. However, Ontario's MISA regulations, also require that effluents must meet toxicity limits at point of discharge and hydrazine was a factor in the toxicity of Radioactive Liquid Waste (RLW) effluent of Ontario CANDU Stations. At one Station, hydrazine in RLW is removed by treatment with sodium hypochlorite, then passed through granular activated carbon before discharge. At other Stations, occasional elevated hydrazine concentrations in RLW are usually reduced through recirculation and aeration, while higher concentrations are treated through ion exchange. Because of its high chemical reactivity, hydrazine should neither persist nor bioaccumulate in the environment. Hydrazine was among compounds identified as "Chemicals of Concern" in screening or Tier 1 level assessments of ecological risk at Ontario CANDU stations, but concerns were resolved in more detailed Tier 2 assessment (risk quotient < 1.0). In the event of a spill in the station outfall, the maximum predicted levels of hydrazine could exceed 2 $mg \cdot L^{-1}$, which exceeds acute LC50's (48-96 h) for many freshwater fish and invertebrates, but concentrations would decrease to > 0.06 $mg \cdot L^{-1}$ within 2 h through dilution and dispersion.

Facilitated discussion on the use of toxicity information in ecological risk assessment of chemical substances. *K. Taylor[1](PL)*

[1]Environment Canada, Science and Technology Branch, Gatinaeu, QC

There were seven platform presentations and two posters in this interactive session.
In the 40-min discussion period, Rita Mroz, Environment Canada, gave a brief overview of her poster, “Development of a Background Soil Chemical Toxicological Database”.
Scott Kirby, Pest Management Regulatory Agency, then gave a brief overview of his poster, “Proposed Framework for Aquatic Risk Assessments of Pesticides”.
These were followed by a discussion period for the entire session, including presentations and posters. Most of the discussion focused on the derivation of environmental guidelines.
On the topic of the presentation, "Re-thinking the Background Approach", a statistician in the audience said that he favoured distribution-based approaches over percentiles to estimate the threshold of natural background and wondered why these were not recommended. Jonathan Hill, National Guidelines and Standards Office, replied that the sample data sets examined in the case study did not permit the use of the distribution approaches as the majority of these did not conform to normal or log-normal distributions. However, Hill stressed that the distribution approaches may be a useful tool in future cases and need to be evaluated further.
On the topic of the presentation, "Can industry develop Canadian Environmental Quality Guidelines?", an audience member expressed concern over continuity if policy makers

changed positions or if the priorities altered over time. Susan Roe, National Guidelines and Standards Office, explained that Federal, Provincial and Territorial representatives on CCME task groups do not change positions frequently and project continuity is maintained through the use of multi-year work plans. If a project is begun, it is extremely rare that a project is not completed.
On the topic of the presentation, "Introduction to the proposed new national Protocol for the Derivation of Canadian Water Quality Guidelines for the Protection of Aquatic Life", several members of the audience asked Uwe Schneider, National Guidelines and Standards Office, why the 5th percentile of the Species Sensitivity Distribution approach and 95% confidence limits were chosen. Uwe explained that the Water Quality Task Group examined many different approaches and on a consensus basis, agreed that this combination provided the most scientific defensibility as well as a meaningful level of protection consistent with the CCME guiding principles.

Development of a background soil chemical/toxicological database. *R. Mroz[1], D. Rae[2], B. Drover[1], K. Tay[1] and G. Worthman[1](PO)*

[1]Environment Canada, Environmental Protection Branch, Dartmouth, NS; [2]Jaques Whitford Environmental Limited, Fredericton, NB

One of the key principles of the Federal Contaminated Sites Action Plan (FCSAP) is the application of ecological and human health risk assessment processes in the development of site specific target levels (SSTLs) at federal contaminated sites. An initial step in the risk assessment process is to compare soil data collected from a site against established benchmarks (eg. CCME's Canadian Environmental Quality Guidelines) or background soil quality data to determine if there are requirements to further assess risks posed by chemicals in the soil. If available, the use of local background data to screen the potential contaminants of concern is often preferred as the data is more relevant to site specific ecological and geochemical characteristics. While other Canadian provincial jurisdictions have initiated databases for background soil chemistry, only sporadic background data exists in the Atlantic region. Environment Canada - Atlantic is undertaking the development of a database of background chemical and toxicological soils data in order to compliment the ecological and human health risk assessment processes. By collecting samples at various locations across the region, a set of "reference sites" will be created with detailed chemical and toxicological data available for each site location, including metals, PAHs, grain size, pH, total petroleum hydrocarbons and/or pesticides. Soil toxicity tests will include earthworm (acute & chronic), *Collembola* (acute & chronic) and three plant emergence assays (alfalfa, lettuce and Northern wheatgrass). The region has been divided into thirty-three distinct soil zones and soil samples will be collected within each zone following a sampling protocol that has been developed for the project. To date, soil samples have been collected in four of these thirty-three zones and chemistry and toxicity testing of these soils are ongoing.

Proposed framework for aquatic risk assessments of pesticides. *S. Kirby[1], L. Avon, P. Delorme[1], D. François[1], C. Hart[1], T. Kuchnicki[1], H. Mulye[1], R. Sebastien[1], H. Simmons[1], J. Villeneuve[1] and J. Whall[1](PO)*

[1] Health Canada, Pest Management Regulatory Agency, Ottawa, ON

Health Canada's Pest Management Regulatory Agency (PMRA) is responsible for the regulation of pest control products in Canada. The Environmental Assessment Division of the PMRA is revising the approach used for aquatic risk assessments and is proposing a new framework that incorporates advances in risk assessment methods. The proposed framework uses a science-based, tiered approach that considers both the inherent toxicity of the pesticide as well as the potential for exposure to that pesticide. Initial tiers (screening levels) use a deterministic approach with conservative exposure scenarios for various taxonomic groups including aquatic macrophytes, algae, pelagic and benthic invertebrates, and fish. This approach allows those pesticide uses that do not pose any significant risk to the environment to be rapidly identified. The screening level also allows for the identification of taxonomic groups not at risk from the proposed pesticide use. Subsequent tiers of the risk assessment focus on refining exposure estimates using more sophisticated fate models with specific regional scenarios. This new framework makes better use of PMRA resources while providing a scientifically sound approach to characterizing the potential risks of pesticides to aquatic systems.

Science and Environmental Management/Science et l'Aménagement Environnemental

Session Co-chairs/Présidents: Shannon Bard and Colleen Mercer-Clarke

Biological indicators - then and now. *P. V. Hodson[1](PL)*

[1] Department of Biology, Queen's University, Kingston, ON

The concepts, approaches and tools used for assessing chemical effects in aquatic ecosystems have evolved from simplistic models of the 1960's to complex programs of environmental effects monitoring. Early studies of biomarkers were based on medical models in which 'magic bullet' diagnostic tests would reveal the nature of a chemical stress and its potential cause and ecological effect. Current approaches are much more realistic, combining assays of chemical exposure with arrays of bioindicators that range from the molecular to the ecological. The design and interpretation of monitoring results depends heavily on a detailed knowledge of environmental chemistry, modes of toxic action, population biology, and ecosystem function. The successful application of indicators requires the recognition of multiple and interacting stressors; an understanding of background conditions, variability, and the natural factors that control background; the ability to work across multiple levels of organization; and experimental designs that efficiently discriminate among possible causes by a process of elimination. The challenges for the future will be to link the latest molecular methods to physiological and ecological impacts; to develop approaches for assessing complex mixtures; to transform research methods into standard methods with appropriate QA/QC; to express monitoring data in terms that the public and environmental managers can understand; to understand the causes of normal environmental variation; and to cope with baselines that shift in response to other factors, such as global climate change.

Information synthesis and initial assessment of the status and health of aquatic ecosystems in Alberta - outcomes and challenges. *E.C. Irving[1], K. Kroeker[1], M. Cooley[1], K. Munter[1], F. Westcott[2], P. Mitchell[3] and D. Andrews[2](PL)*
[1]North/South Consultants Inc., Calgary, AB; [2]Clearwater Environmental Consultants Inc., Calgary, AB; [3]Patricia Mitchell Consulting, Canyon, BC

One of the three primary management goals identified by the Alberta's Water for Life Strategy is "healthy aquatic ecosystems" (HAE). To facilitate achievement of this goal, existing information within Alberta related to water and sediment quality and non-fish biota was reviewed and synthesized. To this end, appropriate indicators of aquatic ecosystem health were identified and, where possible, an initial assessment of aquatic health was conducted for each of the seven major river basins. An important component of this study was to identify data/information gaps; and formulate recommendations to facilitate a more integrated and comprehensive assessment in the future. Thus, the intent of the study was to provide a 'stepping stone' to a more comprehensive assessment and associated monitoring. This presentation focuses on the main findings of this study in relation to aquatic health assessment in Alberta, and the challenges faced in the conduct of the study.

Development of chemical indices of coastal zone eutrophication. *S. Ryan[1], J.C. Roff[1] and P. Yeats[2](PL)*
[1]Department of Biology, Acadia University, Wolfville, NS ; [2] Fisheries and Oceans Canada, Bedford Institute of Oceanography, Dartmouth, NS

We are developing an index of coastal zone eutrophication for the Atlantic coast of Nova Scotia. Though regionally developed, it should be applicable around the world. Measurements of nitrate, ammonia, phosphate, chlorophyll *a*, total nitrogen, and total phosphorous are being taken at an extensive series of bays and estuaries along the Atlantic coast of Nova Scotia throughout the summer of 2006. Collected data will be displayed on a nitrogen: phosphorous phase space diagram that should clearly indicate thresholds between impacted inshore and un-impacted reference offshore waters. The historical problem of temporal variability in nutrient levels due to phytoplankton activity will be accounted for using an amalgamation of the Redfield nutrient ratios and the coastal Carbon: Chlorophyll *a* ratio. We expect that this amalgamated ratio will allow us to accurately convert between measured levels of nutrients and chlorophyll *a* (an indicator of phytoplankton biomass) throughout the year. Results from this study will be related to indices of land use in Nova Scotia (a separate and parallel research undertaking by Colleen Mercer-Clarke) in order to establish a better understanding of coastal zone eutrophication along the Atlantic coast of Nova Scotia.

Criteria development for determining tumor epizootics in fish: Lessons from the Great Lakes Areas of Concern. *P.C. Baumann[1](PL)*
[1]US Geological Survey, Columbus Field Station, Columbus OH, USA

Areas of Concern (AOCs) in the Great Lakes were designated using Beneficial Use Impairments (BUIs), one of which concerned the prevalence of liver and skin tumors in fish. Such tumors have been associated with exposure to polynuclear aromatic hydrocarbons (PAHs). The AOCs could delist this BUI once the incidence rates of fish tumors "did not exceed rates at unimpacted control sites". Now that many AOCs have undergone remediation and are in recovery, the protocol for determining tumor prevalence at "unimpacted control sites" has become crucial. A series of workshops and reports by committees of experts have resulted in protocols for determining background tumor rates. Species selected as indicators are the brown bullhead and the white sucker. Specifics concerning sampling methodology; pathology nomenclature; effects of age, gender, and season on tumor prevalence; and statistical methodology have been widely accepted, and most are (or will soon be) available in publication or on line. While both liver and skin neoplasms would be used, preneoplastic lesions would not be part of the criteria. Also a consensus has been forming that a single background prevalence or criteria should be developed for each of the Great Lakes, using an international data base of surveys. These protocols could be applied outside of the Great Lakes basin, for instance using fish from regional watersheds in areas of oil sand, where extraction could also generate PAHs.

Developing biocriteria as a national water quality assessment tool in Canada. *S.S. Dixit[1](PL)*
[1]Environment Canada, National Guidelines and Standards Office, Gatineau, QC

The Water Quality Task Group of the Canadian Council of Ministers of the Environment (CCME) commissioned a scoping assessment study to review the biocriteria currently used in Canadian and international jurisdictions and evaluated the potential of using biocriteria for assessing the ecological integrity of Canadian waters. The concept of using biocriteria to measure the health of aquatic ecosystems has been widely accepted. The numeric or narrative biocriteria complement chemical-based guidelines and standards and have been successfully incorporated into water quality monitoring programs. Worldwide, multimetric and multivariate approaches are used for defining biocriteria, and benthic macroinvertebrates are the most commonly-used organisms, followed by fish and aquatic plants (e.g., algae, macrophytes). The scoping assessment identified that the bioassessment approaches used in defining biocriteria vary among Canadian jurisdictions and that there would be considerable utility in adopting nation-wide biocriteria values to assess the environmental quality and ecological integrity of surface waters. In addition to providing the national consistency under federal and provincial programs, nation-wide biocriteria values would also provide a useful framework for monitoring and reporting the health of aquatic ecosystems on a national level. The proposed biocriteria initiative needs to be flexible so that it incorporates features of ongoing programs.

What do littoral fish assemblages tell us about the health of estuaries in the southern Gulf of St. Lawrence? The Community Aquatic Monitoring Program (CAMP). *S.C. Courtenay[1,2], M. Boudreau[2], A. Turcotte[3] and J. Weldon[2](PL)*
[1]Department of Fisheries and Oceans at The Canadian Rivers Institute, New Brunswick, Fredericton, NB; [2]Fisheries and Oceans Canada, Science Branch, Moncton, NB; [3]Fisheries and Oceans Canada, Tracadie-Sheila, NB,

The Community Aquatic Monitoring Program (CAMP) began in 2003 as a partnership between community environmental groups and the Department of Fisheries and Oceans to quantify faunal assemblages in estuaries and bays of the southern Gulf of St. Lawrence. In addition to raising awareness of estuarine ecology, the objective was to test the hypothesis that the numbers and types of animals present reflect marine environmental quality. From four pilot sites sampled in 2003, the program expanded to 24 sites throughout New Brunswick, Nova Scotia and Prince Edward Island in 2004. In each site, six stations are beach-seined once per month between May and September. Juvenile and adult fish, shrimp and crabs are enumerated by species or genus and released live at the point of capture. Data are also collected on water temperature, salinity and oxygen content, as well as plant coverage and the grain size and organic content of sediments. Preliminary analyses of 2004 data revealed significant temporal and spatial variance in community structure. Sites sampled in New Brunswick during August showed more juvenile Atlantic silversides (*Menidia menidia*) and fewer crustaceans than more easterly sites sampled in Nova Scotia and Prince Edward Island. The generality of these patterns across months and years, and their relationship to environmental quality is the subject of ongoing data collection and analysis.

Design of a monitoring program to measure and report on aquatic ecosystem health in Alberta: Water and sediment quality and non-fish biota. *A. Anderson[1], R. Casey[1], C. Fraser[1], L. R. Noton[1] and D. O. Trew[1](PL)*
[1]Alberta Environment, Environmental Assurance Environmental Monitoring And Evaluation Branch, Edmonton, AB

Ensuring “healthy aquatic ecosystems (HAE)” is one of the outcomes of the Water Strategy in Alberta. To assure HAE we need to develop a provincial-scale program that will monitor, assess, and report regularly on the status of aquatic ecosystems in Alberta. Healthy aquatic ecosystems involve suitable water and sediment quality, adequate physical habitat with respect to flows and riparian buffers, and diverse and resilient fish and non-fish biota. This paper will outline the thought process involved in designing a monitoring program for water and sediment quality, and non-fish biota, that is required, considering the diversity of rivers, lakes, streams and wetlands, and issues in the province. Approaches to assess and report on AEH will be discussed.

Facilitated discussion on science to management: selection and application of indicators of aquatic ecosystem health. *C.S. Mercer- Clarke[1] and S.M. Bard[1](PL)*

[1]Environmental Programmes, Dalhousie University, Halifax, NS

Assessment of aquatic ecosystem health has long relied on data obtained from the measurement of change in specific performance parameters, or indicators, most of which have historically been drawn from studies of water chemistry and fish and invertebrate toxiciology. Integrated approaches to ecosystem management have concluded that indicators of change must include a wider array of factors capable of assessing ecosystem health in a broader context. Decision-makers concerned with sustainable management of our communities, our resources and our environment need useful information on changes in ecosystem health as well as on the potential for linked effects to the well being of human communities, all delivered in a timely and comprehensible context. Despite the growing need for this critical information, there are still serious limitations to the human and fiscal resources available to support monitoring and research programs in aquatic ecosystem health. Given these challenges, the selection and application of indicators of ecosystem health must be not only capable of delivering critical information in a timely manner to the appropriate audience, but must deliver benefits appropriate to the costs of their development.

In his keynote address, Peter Hodson (Queen's University, Ontario) stressed society's need for bioindicators that are highly relevant to ecosystem structure and function and that measure the state of the environment at higher levels of organization. While recognizing the important role of environmental chemistry, Hodson quoted Murray Johnson's (1974) statement that "ppm is not a meaningful measure of ecosystem health". Hodson went on to review current application of biomarkers and bioindicators and the need to better understand the role of these monitoring tools in contributing to a larger understanding of cause and effect relationships in highly complex environments that may contain multiple stressors. Also included within this larger picture is the need for better understanding of the mechanisms by which substances cause an effect to organisms, especially when in the presence of additional stressors. Hodson noted the need for multiple lines of evidence, including epidemiology, and an improved understanding of the role such knowledge can play when appropriately linked within risk assessment processes, legislative action and in strategies for environmental management. He also placed considerable emphasis on the need for effective and timely communication of the findings of ecotoxicology to a wider audience.

In addition to the keynote address, the session included six presentations on related topics. Elaine Irving of North/South Consultants, Inc. spoke on the "*Water for Life*" management goal in Alberta which seeks to sustain rivers and streams through examination of a range of indicators (water quality, sediment quality, non-fish biota, community composition, biomass, invasive species) that provided an overall assessment of Aquatic Ecosystem Health.

Scott Ryan of Acadia University in Nova Scotia presented early findings of his research towards the development of eutrophication indices in coastal zone waters**.** Recognizing that world-wide coastal marine habitats are dump sites for anthropogenic wastes, eutrophication of coastal waters has been linked to collapsing coastal fisheries, algal blooms, paralytic shellfish poisoning, reduction in marine biodiversity, and deteriorating aesthetic conditions. Given the high degree of spatial and temporal variation in nutrient concentrations caused by the multiple inputs and complex processes that characterize these environments, there is as yet no satisfactory way to index marine eutrophication. Using the Scotian Shelf region as a reference area, Ryan is developing a coastal

nutrient index that is derived from the Redfield ratios developed for the relationship between carbon, nitrogen and phosphorus in offshore oceanic waters, but that includes cholorphyll *a* in the relationship.

Paul Baumann, of the USGS and the University of Ohio provided an overview of his research in the development of criteria for evaluating tumour incidence in an indicator fish species, brown bullhead, affected by effluents from a coke plant in the Lake Erie region. International panel of veterinary pathologist and researchers has concluded that new standard protocols should be established to document histologically verified neoplasm prevalence for skin, biliary and hepatic cancers. However, pre-neoplasms, altered foci, and other diagnostic categories are not useful measures due to observer bias and non-standard recording methods. Baumann noted that data on reference site conditions are limited, making it difficult to establish what might be considered the background level of tumours occurring in unimpacted populations. He suggested that an international database was needed to standardize information on background conditions.

Sushil Dixit of Environment Canada spoke of recent efforts in the development of biocriteria as a water quality assessment tool in Canada. He summarized the results of a review of similar approaches being used in Europe, the United States and Australia, and their potential for application in Canada

Simon Courtenay of the Fisheries and Oceans Canada and University of New Brunswick-Fredericton discussed the role of local stewardship volunteers in the collection and reporting of data on fish assemblages at a number of sites throughout the southern Gulf of St. Lawrence. Participation by the local community is important because it provides badly needed monitoring resources, improves the availability of baseline data, provides opportunities for science and government linkages with local residents, and raises ecological awareness within the community.

Anne-Marie Anderson, Alberta Environment, provided an overview of the design of a monitoring program to measure and report on aquatic ecosystem health in Alberta, with specific attention to water and sediment quality and non-fish biota. The program is based on a working definition that describes a healthy aquatic ecosystem as being "sustainable and resilient to stress, maintaining its ecological structure and ecological structure and function over time similar to the natural (undisturbed) ecosystem of the region, with the ability to recover from disturbance".

Presentations were followed by two short sessions of interactive discussion focussed on the role of science in linking knowledge of ecosystem health and change to government policy and decision-making, and the role of government in identifying and supporting critical research and monitoring efforts. An estimated 60 or more persons participated in these discussions, indicating both a high level of interest and a willingness to participate more fully. A summary of the points raised is provided below.

Issues

- There is a paucity of data on the status of aquatic ecosystem health throughout Canada.
- There has been a decline in the collection of recent/current data and information.
- Reliance on chemical and physical parameters alone is insufficient to assess ecosystem health – more bio-monitoring is needed.
- There is a lack of large, regional scale data programs
- Marine environments, especially, are affected by the limitations and availability of existing data, and need direct assistance to improve the knowledge base.
- Scientists need more data to advance knowledge but are constrained by the level of funding available, especially for the collection of biological data.

- There are considerable difficulties in gaining access to existing data.
- We need to improve internal interaction and collaboration within the discipline to collectively identify and list the gaps in data, research activities, and research requirements.
- There is a need to better define and standardize the application of terms (jargon) commonly at use in the discipline of aquatic toxicology.
- We need criteria to better define beneficial use impairment, and we need the criteria to reflect current issues, knowledge and practice.
- There is a need to identify and work within the spatial scales at which decision-making is being made, i.e. watershed, coastal zone.
- We need to improve collaborative action with the discipline and networking and collaboration with other stakeholders at work in sustainable management of the environment and the community. This includes participation on interdisciplinary working groups and committees, and a more participatory and visible role with other sectors and with the community.
- We need early, timely, two way communication with government, including dialogue on identification of critical priorities for research, application of the findings of research, funding of research.
- Funding is a by-product of knowing what government and decision-makers need, and ensuing that policy has developed to support those actions.

Challenges

- What are the new bio-indicators and how are they being used for decision-making?
- Is the application of existing endpoints still relevant?
- Should the Aquatic Toxicity Workshop (ATW) provide a forum of scientists to identify and communicate gaps in data and knowledge to government?
- Do toxicologists have a role to play in both identifying new critical areas for action, and in delisting those issues and sites which are no longer considered to be a threat?
- Once critical knowledge gaps are identified, how is funding secured to support research in those areas?
- What is the current status of State of Environment (SOE) reporting? The last effort in Atlantic was conducted in 2004 through the Gulf of Maine Council. Most of the available data is now outdated, as are most of the existing SOE reports.
- Who does the Quality Assurance/Quality Control (QA/QC) on state of environment reporting by government? On indicator program selection and application? What is the role for scientists in the QA/QC of conclusions drawn by state of environment reporting?
- What are the critical knowledge and decision-making structures and processes that comprise the key management organizations that are users of science knowledge, that affect the manner in which science is funded and focussed?
- Is government/management aware of the limitations of existing data? Of existing ecosystem knowledge?
- Who does know about the paucity of data on which significant policy directions and decisions are made?
- What would constitute success in improving the science to management linkages?
- If you want someone to hear your message you must tell them six times. Are we communicating the knowledge gained from our research to the appropriate audiences in a meaningful way?

Conclusions of the Session

- ATW must put greater effort into reporting out on the findings of the research.
- ATW needs a working group that directly addresses these issues, and develops a program of action. Included within this type of strategic planning exercise would be definition of goals, structure and deliverables for a special session to be conducted at the next annual meeting of ATW 2007 in Halifax, NS. Emphasis should also be placed on the identification of critical issues to be addressed, anticipated individual and collective actions, and identification of potential collaborative projects and programs.

An alternative method for development of site specific water quality guidelines. *L. Hamilton[1], C. Wong[1], G. van Aggelen[1] and C. Buday[1](PO)*
[1]Environment Canada, Science and Technology Branch, North Vancouver, BC

The Canadian Council of Ministers of the Environment (CCME) have adopted the Water Quality Index (WQI) as a method for reporting on water quality. An Index calculation relies solely on specifying a benchmark against which ambient water chemistry is compared. Ideally, this comparison would be made against an established site-specific water quality guideline in order to account for the influence of local chemical, physical and biological characteristics of the watershed. In the absence of an established guideline, a site-specific guideline (SSG) based on background water chemistry is an alternative. A streamlined procedure for SSG derivation called the Rapid Assessment Approach (RAA) was developed for this purpose.
This study compared aquatic life SSGs for total copper developed using the RAA, the Biotic Ligand Model and Water Effects Ratio approaches to determine whether SSGs developed by RAA are sufficiently protective. Copper was selected as the target variable because the Biotic Ligand Model and Water Effects Ratio are furthest advanced for copper and there is a wealth of data on which the USEPA bases newly drafted site specific copper criteria. A long-term water quality monitoring site on the Sumas River in southwestern British Columbia was chosen for study as total copper is frequently elevated, and there are a number of other variables present which may influence copper toxicity.

Introducing the revised CCME protocol for the derivation of Canadian soil quality guidelines. *K. Potter[1], I. Mitchell[2], T. Nason[3] and D. Spry[1](PO)*
[1]Environment Canada, National Guidelines and Standards Office, Gatineau, QC; [2]Meridian Environmental Inc., Calgary, AB; [3]Alberta Sustainable Resource Development, Edmonton, AB

A protocol for the derivation of Canadian Soil Quality Guidelines for the protection of environmental and human health was originally published by the Canadian Council of Ministers of the Environment (CCME) in 1996. Since that time, lessons have been learned through the derivation of guidelines and their implementation, and through development of the Canada-wide Standard for Petroleum Hydrocarbons. In addition, toxicological science and exposure modeling has advanced. Therefore, the CCME Soil Quality Guidelines Task Group has recently revised and updated the protocol, and it was approved for publication by CCME in February 2006. Major changes and improvements to the protocol will be summarized in this presentation. Some of these include:

- a new preferred distributional approach for developing ecological direct contact guidelines based on EC_{25} values
- development of human health guidelines for carcinogenic substances at both 10^{-6} and 10^{-5} incremental lifetime cancer risk levels
- use of new groundwater models for protecting drinking water, aquatic life and livestock watering
- use of a vapour intrusion model to calculate guidelines for the protection of indoor air quality
- updated default values for numerous model parameters
- provision for non-toxicity based endpoints such as aesthetics, free product formation, etc., as check mechanisms
- consideration of secondary and tertiary consumers for substances that biomagnify
- development of separate guidelines for coarse and fine soils where appropriate

Selenium/Sélènium

Session Co-chairs/Présidents: David Janz and Jorgelina Muscatello

Bioaccumulation of selenium in the foodweb of six Alberta foothill streams. *C.L. Podemski[1], M. Dobrin[1], S. Kollar[1] and V.P. Palace[1](PL)*

[1]Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, MB

One of the most important factors affecting the toxicity of selenium in an aquatic ecosystem is the extent to which it bioaccumulates in the local food web. For many years it was believed that lotic systems were largely insensitive to selenium pollution and, as a result, scientific investigations have largely focused on lentic ecosystems. We present the first comprehensive survey of selenium concentrations in the foodweb of coldwater lotic ecosystems. Six, third-order streams in the foothills of the Alberta Rocky Mountains were sampled by kick-sampling; two of the streams were affected by coal mining activities and four were considered to be relatively pristine. Samples of water, periphyton, coarse particulate organic matter, macroinvertebrates and fish tissues were collected and analyzed for total Se. The structure of the food web in study streams was determined both by literature reports of known trophic relationships, functional feeding group membership and by stable isotopic analysis of carbon and nitrogen. Selenium concentrations in invertebrate tissues were significantly elevated in streams affected by coal mining but there was little effect of trophic level on Se concentrations.

Biotransformation of selenium species during uptake in *Chlorella vulgaris*. *D.B. Simmons[1] and D. Wallschlager[1](PL)*

[1]Watershed Ecosystems Graduate Program, Trent University, Peterborough, ON

Phosphate and sulfate are known to affect the uptake of selenium in algae and plants. While many biological factors can affect uptake of selenium in algae, it has also been suggested that ion transport of selenium across the plasma membrane is dependent upon chemical speciation, where the conclusion has always been drawn that sulphate inhibits uptake of selenium because selenate is the chemical species that was available for transport, likely via sulphate ion transporters. These uptake studies have always measured total selenium levels in media and have assumed that the initial species of selenium added in an experiment remained stable throughout, i.e; no confirmation of selenium speciation over time has ever been monitored during these studies. We will be presenting recent work where batch cultures of *Chlorella vulgaris* have been grown under low and high phosphorus and sulfur nutrient conditions. Under these different conditions, selenate and selenite were added individually to each culture at concentrations of 10 $\mu g \cdot L^{-1}$. The total concentration and speciation of selenium in the medium for each batch culture were monitored daily over 9 days. Changes in selenium speciation and concentration in the media and in cell lysates will be presented and discussed in terms of possible uptake mechanisms present in the plasma membrane of *Chlorella vulgaris*, from exposure to selenium chemical species and nutrient conditions.

Selenium accumulation in aquatic organisms downstream of a metal mining and milling area in Northern Saskatchewan, Canada. *J. Muscatello[1], A. Belknap[1] and D.M. Janz[1](PL)*

[1] Department of Veterinary Biomedical Sciences, University of Saskatchewan, Saskatoon, SK

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). Among these metals and ions selenium is unique in that dietary, as opposed to aqueous, exposure is the predominant route of bioaccumulation in aquatic consumers. A major implication of elevated environmental selenium levels is its propensity to bioaccumulate and biomagnify through aquatic food webs, having potential adverse effects (e.g., impaired reproduction) on top predators such as fish. The objective of the present study was to determine selenium concentrations in all major abiotic and biotic compartments (water, sediment, periphyton, plankton, benthic invertebrates, small-bodied forage fish and predatory fish) of a boreal aquatic ecosystem downstream of a uranium milling operation in northern Saskatchewan, Canada. In 2004 and 2005, water, sediment, plankton, periphyton, invertebrates and small body fish samples were collected from a reference lake and two exposure lakes, all within the same subwatershed. Exposure lakes were located approximately 2 km and 10 km downstream of the effluent discharge. Selenium concentrations were consistently higher for all trophic groups from both exposure sites in comparison with the reference site. Our results suggest that selenium was accumulated and magnified in the food chain even though the water concentrations were low (approximately 0.8-2.6 $\mu g \cdot L^{-1}$). This biomagnification process could generate high selenium concentrations in prey items and consequently impair reproduction in top predatory fish species, such as northern pike.

Speciation of selenium in stream insects using X-ray absorption spectroscopy. *R. Andrahennadi[1], M.E. Wayland[2] and I. J. Pickering[1](PL)*
1Department of Geological Sciences, University of Saskatchewan, Saskatoon, SK;
[2]Environment of Canada, Canadian Wildlife Service, Saskatoon, SK

Selenium (Se) contamination in the environment is a widespread problem affecting insects and other wildlife. In many terrestrial and freshwater food chains, insects occupy a critical middle link and aid in trophic transfer of Se. The mechanisms of uptake of Se through the food chain are poorly understood. In particular, biotransformation of Se to different chemical forms will greatly influence how toxic or benign the Se is to that organism or to its predators. Determining the chemical form traditionally involves destruction of the tissues. Newer methods, involving X-rays from synchrotron facilities such as the Canadian Light Source at Saskatoon provide direct methods of determining chemical speciation with minimal sample preparation. In Hinton, Alberta, coal mining activities have increased selenium levels in surrounding streams, raising questions about potential risks associated with exposure to elevated levels of Se. These streams are inhabited by insects such as mayflies, caddisflies, stoneflies and craneflies. Se levels in insects were high enough to be of potential risk to birds that eat them and probably caused deformities in larvae of a trout caught in one of these streams. An initial assessment determined that Se levels in trout from these streams might pose concern for people eating them in large quantities. Here we use synchrotron X-ray Absorption Spectroscopy (XAS) to identify the form of Se in insects and periphytes found in these streams. These results provide insights into how the insects cope with their toxic cargo, including how Se is biotransformed into organic forms, and how it can be eliminated from the insect. More broadly, the study demonstrates the strengths of XAS to probe the effects of heavy elements in an ecosystem.

Summary of recent studies of selenium behaviour and effects, Elk River watershed, BC. *P. Orr[1], C. Russel[1], S. Weech[1] and M.D. Paine[2](PL)*
[1]Minnow Environmental Inc., Mississauga, ON; [2]Paine, Ledge and Associates, North Vancouver, BC

Elevated selenium concentrations have been observed in the Elk River watershed, BC, downstream of five coal mines. Stable isotope and selenium analyses of samples collected in 2002-03 demonstrated that selenium uptake by aquatic primary producers and the length of aquatic food chains were comparable in lentic and lotic habitats. The study provided evidence that enhanced biotransformation of selenium to organoselenium, and subsequent uptake and cycling via sediment-detrital pathways likely account for higher fish tissue selenium concentrations in lentic than lotic areas (presented ATW 2004). In 2004-05, studies were undertaken to investigate whether elevated selenium concentrations are increasing incidences of deformities among Columbia spotted frogs and dwarf longnose sucker incubated from fertilized egg to larval stages either *in situ* (frogs) or at a field laboratory (sucker). Despite high mortalities among some egg batches of both species, 2,324 tadpoles and 6,858 larval sucker were ultimately assessed for deformities. For reasons not yet understood, some reference (low Se) groups showed elevated incidences of deformities similar to high Se groups, confounding interpretation of the potential Se-deformity relationship.

Identification of site-specific and species-dependent uptake of selenium in fishes of Saskatchewan: Implications for modeling and management. *D. G.Fitzgerald[1], B. Rodgers[1], R. Nicholson[1], P.M. Mckee[1] and K. Himbeault[2](PL)*

[1]EcoMetrix Incorporated, Brampton, ON; [2]Cameco Corporation, Saskatoon, SK

Selenium is an essential element for most animal species and is ubiquitous in the environment. In recent decades, concern over the role of selenium as a potentially toxic factor in aquatic environments, has increased dramatically. Different land use in Saskatchewan has led to a gradient of selenium concentrations and represents an opportunity to understand the accumulation dynamics of selenium in these aquatic environments. The existence of a data set on selenium in water and fish tissues for sites from Saskatchewan near uranium mines compared with other land uses allowed us to test the hypothesis that selenium uptake is site-specific and species-dependent. A regression analysis identified a simple linear relationship between selenium in water and fish tissues for sites near uranium mines and this was different from the linear relationship between water and fish tissue for the other land uses. This pattern suggests site-specific bioaccumulation of selenium in fishes. However, this analysis also identified that for individual lakes, the bottom-dwelling fish species like lake whitefish (*Coregonus clupeaformis*) and lake chub (*Couesius plumbeus*) had higher tissue concentrations of selenium than open-water species like northern pike (*Esox lucius*). These relationships indicate species-dependent differences in bioaccumulation factors for selenium. Habitat use represents one plausible and simple explanation for these bioaccumulation patterns, as bottom-dwelling species frequently consume sediment that contains high concentrations of selenium. This analysis revealed that site-specific and species-dependent relationships exist for bioaccumulation of selenium in fishes for aquatic environments of Saskatchewan and must be integrated within modeling exercises focused on management of water-borne selenium concentrations.

Understanding selenium in the environment - An industry case study. *K. Himbeault[1](PL)*

[1]Cameco Corporation, Saskatoon, SK

The Key Lake Operation was originally designed as a uranium mine and mill facility operating from 1981 through 1999 to process the ore from Key Lake. Since 2000, the Key Lake operation has been a mill facility only, processing uranium from the McArthur River operation. In the late 1990's milling of ore from the Deilmann pit resulted in increased releases of selenium to the environment. Since milling of McArthur River ore, the overall loading of selenium has been reduced but remains elevated above levels in the 1980's. The current environmental effects from the release of selenium to the aquatic environment are difficult to understand due to the historical loading from previous operations. Environmental modeling, risk assessment, research and monitoring studies have been completed to try and understand the behaviour of selenium in the receiving environment. On-going research programs are being designed through cooperative efforts with other industry partners and academics to advance our knowledge in this area.

Limitations of non-lethal sampling for determining spatiotemporal exposure to selenium in fish from mine impacted sites. *V.P. Palace[1], G. Sterling[2], P. Siwik[3], R. E. Evans[1], N. Halden[4], K. G. Wautier[1] and J. Holm[5](PL)*

[1]Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, MB; [2]Alberta Sustainable Resource Development, Edson, AB; [3]Environment Canada, Environmental Stewardship Branch, Edmonton, AB; [4]Department of Geological Sciences, University of Manitoba, Winnipeg, MB; [5]North South Consultants, Winnipeg, MB

Selenium (Se) is a trace element that is required in the diet of vertebrates. However, at concentrations only slightly higher than those required, Se can become a potent teratogen in oviparous vertebrates. Examination of this toxic effect has become an issue for several mining operations, including uranium, coal and precious and base metals. In each instance, determining fish residence and exposure to effluents and linking teratogenic effects specifically to Se are challenging. The utility of several non-lethal sampling methods to determine spatio-temporal exposure to Se were evaluated in fish, including quantitative population surveys, reproductive bioassays, muscle biopsies, and analysis of Se in scales and fin rays using laser ablation, inductively coupled plasma with mass spectrometery detection (LA-ICP-MS).

The effect of selenium on the physiological stress response and oxidative stress biomarkers in fish. *L.L. Miller[1], J. Rasmussen[1], V.P. Palace[2], F. Wang[3] and A. Hontela[1](PL)*

[1]Department of Biological Sciences, University Of Lethbridge, Lethbridge, AB; [2] Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, MB; [3]Department of Environment and Geography University of Manitoba, Winnipeg, MB

Selenium (Se), an essential element required for GPx, can bioaccumulate and reach toxic concentrations. It causes teratogenic deformities in rainbow trout but not brook trout; however, little is known about Se's effects on other physiological systems including the physiological stress response (PSR). PSR enables fish to respond appropriately to stressors (e.g. pollutants which may activate or impair the response). Oxidative stress biomarkers (OSB) may provide insight into a pollutant's toxicity mechanisms. The objectives of this study were to (1) determine the effect of Se on the PSR and OSB in fish, and (2) compare the responses of rainbow trout and brook trout. Juvenile rainbow trout were exposed to waterborne sodium selenite ($NaSeO_3$) for 96 hours or 30 days in the laboratory. Post spawning rainbow trout and brook trout were sampled from reference and Se contaminated streams. Indicators of the PSR and OSBs were measured in all fish. Se activated the PSR in juvenile rainbow trout (increased plasma cortisol), but fish appeared to acclimate after 30 days (PSR not impaired or exhausted). At high levels, Se decreased liver glutathione (GSH) in juvenile rainbow trout. In the field, rainbow trout and brook trout were acclimated to elevated Se (PSR and OSBs generally unchanged).

The effects of selenium on westslope cutthroat trout reproduction and development captured on site at a coal mining operation. *B. Rudolph[1] and C. Kennedy[1](PL)*

[1] Department of Biological Sciences, Simon Fraser University, Burnaby, BC

Research on selenium (Se) toxicosis in natural populations of cold-water fish populations is limited; therefore, we examined the effects of Se on the embryonic and larval development of Westslope cutthroat trout (WCT) (*Oncorhynchus clarki lewisi*) captured at an active coal mining operation. Elevated concentrations of Se were found in eggs from this site (range: 16.1 to 140.0 µg g^{-1} dw), which correlated well with adult muscle tissue. The major toxicological impacts of Se on fish are believed to arise through the maternal transfer of Se to eggs during vitellogenesis and the subsequent incorporation of Se into the larvae during yolk absorption, usually resulting in developmental anomalies. The results of this study surprisingly differed from the results of a similar, previous study with the same species and the same general mining area and do not appear to follow the current Se toxicosis paradigm. Eggs with Se concentrations >86.3 µg g^{-1} dw were not successfully fertilized, while eggs with concentrations >46 and <86.3 µg g^{-1} dw were fertilized (96%) but did not produce viable fry. Deformity analysis was therefore only performed on fry that developed from available eggs which had Se concentrations between 12.3 and 20.6 µg g^{-1} dw and exhibited the following deformity frequencies, most of which were graded as minor: 16.5 ± 2.2% skeletal deformities, 5.7 ± 1.0% craniofacial deformities, 7.5 ± 3.8% finfold deformities, and 87.7 ± 2.0% edema. No relationship between Se concentration in eggs and the frequency or severity of deformities or edema was found in this range of egg Se concentrations. These results, along with recent studies on other cold-water species, suggest that cold-water species of fish are less sensitive to the effects of Se than warm-water species; however, the correlation between high Se concentrations in muscle and eggs and reproductive effects of Se in adults and embryos before yolk absorption requires further investigation.

Impacts of hypersaline conditions on selenium toxicity in fish. *D. Schlenk[1](PL)*

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In the Central Valley of California the combination of arid landscape agriculture and naturally elevated soil concentrations of selenium provide a complex mixture of stressors on aquatic organisms. Previous studies have indicated that hypersaline conditions induce flavin-containing monoxygenase enzymes which oxidize seleno-aminoacids such as selenomethionine (SeMe) to the corresponding oxides. *In vitro* systems have indicated reduction of the oxides to selenide through oxidation of glutathione (GSH) which may lead to oxidative stress and cellular toxicity. Although no relationship was observed between GSH, lipid peroxidation and adverse effects in larval rainbow trout fed SeMe for 90 days, depletion of GSH in hepatic tissues of adult rainbow trout fed SeMe for 7 days and maintained at 4 salinities correlated with acute toxicity and showed that hypersaline conditions actually protected animals from the acute toxicity of SeMe. In contrast, when female Japanese medaka were fed SeMe- treated *Artemia* or when eggs treated with SeMe were maintained under varied doses of hypersaline conditions, significant dose-dependent reductions in GSH were observed which also correlated with reductions in hatchability, without significant increases in Se uptake by the eggs. Hypersaline conditions (particularly with high sulfate) may protect against the acute toxicity of selenium, but may exascerbate chronic effects such as reproduction and development in fish exposed to the mixture.

Monitoring and managing risks of selenium toxicity in the aquatic environment. *P.M. Chapman [1](PL)*

[1]Golder Associates Ltd., North Vancouver, BC

Selenium is a contaminant of particular concern for coal, phosphate, uranium and some precious and base metal mines. Regulators require reasonable assurances that environmental risks will be detected and ameliorated. Proponents require reasonable assurances regarding potential future liabilities. Provision of such assurances requires: identification of receptors of potential concern (for monitoring and investigative studies); generic and specific guiding principles; a three-tiered strategy (potential risk of impact?; realistic risk of impact?; any necessary management actions?); and, adaptive management. Primary levels of protection should be based on both appropriate whole body tissue (not water) guidelines (the present BC interim tissue guideline value is overly conservative), and background data (which can be naturally elevated). Background data should be used, where appropriate, as site-specific initial guidelines within the tiered strategy.

Is the sky really falling? Did Chicken Little get it right? Scale and perspective on ecological effects of selenium from coal mining in Alberta, Canada. *P.V. Hodson[1](PL)*

[1]Department of Biology, Queen's University, Kingston, ON

Open-pit coal mining in the foothills of the Rocky Mountains has introduced selenium to terrestrial and aquatic ecosystems. In small, headwater streams, fish reproduction is impaired, and local populations of bull trout, a unique local species, are threatened. However, there are no effects further downstream on fish or aquatic birds, such as Harlequin ducks or dippers. In contrast, extensive alpine meadows created by mine-site remediation support abundant herbivores such as bighorn sheep, which are unusually large and well-nourished, possibly because adjacent mountain ecosystems are selenium deficient. These contrasting effects raise difficult questions about priorities for research and appropriate management of mining. The relative importance of selenium is further obscured by a landscape perspective on mining. The construction of large access roads, the relocation of streams for environmental protection, the construction of lakes as settling ponds, and wholesale movement of mountains from one side of a valley to another creates ecological impacts on a scale that far exceeds toxicity to fish. On a regional and global scale, mining transfers carbon at more than 10,000 $T \cdot d^{-1}$ from geological sinks to the atmosphere via steel industry coking ovens. To the west, glaciers in a complex of Provincial and National Parks (e.g. Banff, Jasper) are melting at an unprecedented rate, and global warming scenarios predict warmer, drier climates for a region already short of water. Is the threat to fish an issue of selenium toxicity or the disappearance of headwater streams due to global warming? While selenium is an important issue, scientists risk 'fiddling as Rome burns' unless we tackle the more fundamental global issues of carbon dioxide emissions.

Selenium interactive workshop discussion *J.M. Muscatello[1] and D.M. Janz[1](PL)*

[1] Department of Veterinary Biomedical Sciences, University of Saskatchewan, Saskatoon, SK

Due to the bioaccumulative nature of selenium through aquatic food webs and potential adverse effects on populations of oviparous vertebrates such as fish, amphibians and birds, there is currently much focus and debate regarding the ecotoxicology of this element. One of the major concerns of chronic selenium exposure is developmental abnormalities in early life stages that have the potential to negatively affect recruitment into populations. This interactive session focused on recent selenium investigations in Canadian aquatic systems, primarily downstream of mining industry (coal, uranium) activities. Thirteen platform presentations, including 5 graduate student presentations, covered a range of topics including geochemistry, speciation, bioaccumulation, metabolism, toxicological effects in fish and amphibians, and risk assessment. Both laboratory and field research were presented. In addition to questions following each presentation, there were interactive discussions among all session attendees that took place at the end of the morning (40 minute duration) and afternoon (60 minute duration) sessions. Scientists from industry, consulting firms, provincial/federal government agencies and academia participated.

A number of research gaps and recommendations were identified during the interactive discussions. First, there is considerable controversy surrounding proposed (and likely future) tissue-based selenium chronic thresholds for the protection of fish populations. However the definition of what should be used as a threshold for selenium-induced developmental effects is yet unclear. Effective concentration (EC) values are considered to be the most useful threshold, but a consensus is needed on whether EC5, EC10, EC15 or EC20 values should be used. Second, it was agreed that when selenium research is being conducted, that moisture content always be determined in individual tissue samples so that selenium analyses can be expressed on a dry weight basis for each sample. A third discussion topic was the importance of establishing baseline selenium levels in abiotic and biotic compartments, since such baseline concentrations can in certain cases exceed proposed selenium tissue thresholds. Recommendations on non-lethal sampling were also discussed, and muscle plugs were identified as the most practical samples to collect for selenium analyses in adult fish. Finally, relative species sensitivities and possible differences between warm and cold water aquatic systems were discussed as factors influencing regulatory decisions. Related to this, the topic of selenium tolerance was also discussed. The potential importance of selenium metabolism (oxidation) *in vivo* was identified as a possible explanation for species differences, and further research was recommended in this area. However it was also recognized that in comparison to most other environmental toxicants, the known differences among species in sensitivity to selenium are very narrow (less than ten-fold). Overall, this session provided an important update and lively discussion on research activities surrounding the aquatic ecotoxicology of selenium in Canadian freshwater ecosystems.

A comprehensive selenium management model for coal mines. *P.M.Chapman[1], H. Ohlendorf[2], B. McDonald[1], A. de Bruyn[1] and R. Jones[3](PO)*

[1]Golder Associates Ltd., North Vancouver, BC; [2]Ch2MHill, Sacramento, CA; [3]Elk Valley Coal, Calgary, AB

Concentrations of selenium (Se) increase downstream of some coal mining operations as the natural process of Se release is accelerated by mining activities, and can reach levels at which adverse environmental effects to water birds and fish may occur. Unfortunately, major knowledge gaps currently hinder our ability to accurately predict

when Se effects may begin to occur in the environment, which can lead to management decisions being made with inadequate information. To adequately manage Se releases from coal mining (or other human activities) requires detailed understanding of the process involved, beginning with sources and progressing through conversion of inorganic Se to organic forms of Se and their accumulation through the food chain. Such a high level of understanding begins with a comprehensive conceptual model, based on the USEPA Data Quality Objective (DQO) process. Such a model is presented, to clearly show how the physical/chemical and biological/ecological components of the environment are related. It summarizes major fate and transport mechanisms, biogeochemical transformations, and food chain dynamics as they relate to potential Se inputs related to coal extraction. This model will be used by Elk Valley Coal in Canada to manage the Se issue at their various coal properties in British Columbia and Alberta. With appropriate modification of sources it would have similar utility for many other anthropogenic Se releases.

Selenium toxicosis in northern pike exposed to metal mining and milling effluent.
J. Muscatello[1] and D.M. Janz[1](PO)

[1] Department of Veterinary Biomedical Sciences, University of Saskatchewan, Saskatoon, SK

Elevated concentrations of selenium have been reported in water, sediments and fish tissues downstream of certain uranium mining and milling operations and may represent a toxicologically relevant hazard to fish populations. The objective of the present study was to determine potential larval deformities associated with selenium bioaccumulation in early life stages of a native fish species, northern pike (*Esox lucius*), exposed to uranium milling effluent. Spawning northern pike were collected from a reference site and a gradient of exposure sites (high, medium and low exposure) downstream of the uranium milling effluent discharge. Deformity analysis (edema, craniofacial, skeletal, and fin deformities) showed that northern pike fry originating from the high and medium exposure sites exhibited a higher incidence of deformities compared to those originating from the reference site. There were significant positive linear relationships between egg selenium concentrations and the frequencies of deformities observed in northern pike fry. Muscle, liver, kidney and bone selenium concentrations were also significantly greater in female pike collected from high and medium exposure sites compared to the reference site. Calculated EC values (1%, 5%, 10% and 20%) for selenium concentrations in egg and muscle (μg g^{-1} dry weight) ranged from 8.52 to 33.55 and 5.20 to 21.54, respectively. Our results suggest that maternal transfer of selenium to eggs was the causative factor for the increased frequency of deformities found in northern pike fry at this uranium milling operation.

Deformed fish or deformed conclusions? *B. Rudolph[1](PO)*
[1]Department of Biological Sciences, Simon Fraser University, Burnaby, BC

Recent studies, that have measured larval fish deformity as a result of the maternal transfer of selenium, indicate that the threshold for cold-water fish may be higher than that for warm-water fish. However, there are some limitations to comparing results of deformity analyses conducted by different technicians, especially if they are using different criteria. This study shows that assessment of both frequency and severity of deformities can be highly subjective, especially for slight deformities. A comparison of

results from two deformity analyses completed on the same batch of westslope cutthroat trout by two different technicians resulted in relative percent differences of 31% for the frequency of skeletal deformities, 71% for the frequency of craniofacial deformities, 32% for the frequency of finfold deformities and 156% for the frequency of edema. Surprisingly, the technicians were following the same guidance for assessing deformities. These results bring to question the accuracy of comparisons of deformities between studies that use different technicians to determine species sensitivity and threshold concentrations. Furthermore, as not all types and severities of deformities have equal effect on the surviving fish population, extrapolation of the results to determine ecological relevance is also a challenge.

Spills and Effects Monitoring/Surveillance des Déversments et Leurs Effets

Session Chair/Président: Leigh Noton

Effects of offshore oil drilling on the Grand Banks on sediment physical and chemical characteristics. *M.D. Paine[1], E. DeBlois[2] and D. Taylor[3](PL)*

[1]Paine, Ledge and Associates, North Vancouver, BC; [2]Jacques Whitford Environment Ltd., St. John's, NL ; [3]Husky Energy/DG Taylor, Inc., St. John's, NL

The Husky Energy White Rose offshore oil development is located on the Grand Banks, 300 km East of St. John's. Drilling began at two drill centres (northern and southern) in 2004, and at a third centre (central) in 2005. Both water-(WBMs) and synthetic-based (SBMs) drilling muds are used. As part of the White Rose Environmental Effects Monitoring (EEM) program, sediment physical and chemical characteristics were measured on samples collected at 48 stations in 2000 (baseline), 56 stations in 2004, and 44 stations in 2005. Barium and $>C_{10}$-C_{21} hydrocarbon (HC) concentrations increased in 2004-05 near the drill centres after drilling began. Barium is a major constituent of WBMs; $>C_{10}$-C_{21}HCs are major constituents of SBMs. Barium contamination extended 2-3 km from source (i.e., nearest active drill centre) and HC contamination extended 6-7 km from source. In 2005, redox levels were also reduced near the southern and central, but not northern, drill centres. Sulphur and fines levels were not elevated except at a few stations within 1 km of drill centres. Concentrations of barium and HCs, and the spatial extent of contamination, at the White Rose development were similar to those observed elsewhere. $>C_{10}$-C_{21}HCs were an excellent tracer and exposure measure (*X* variable) for analyses of biological responses (*Y* variables), incorporating directional effects and differences in magnitude and spatial extent of contamination among drill centres that were not captured by simple distance *X* variables (e.g., distance from nearest active drill centre).

Effects of offshore oil drilling on the Grand Banks on benthic macroinvertebrate communities. *M.D. Paine[1], E. DeBlois[2] and D. Taylor[3](PL)*
[1]Paine, Ledge and Associates, North Vancouver, BC; [2]Jacques Whitford Environment Ltd., St. John's, NL ; [3]Husky Energy/DG Taylor, Inc., St. John's, NL

The Husky Energy White Rose offshore oil development is located on the Grand Banks, 300 km East of St. John's. Drilling began at two drill centres (northern and southern) in 2004, and at a third centre (central) in 2005. As part of the White Rose Environmental Effects Monitoring (EEM) program, invertebrate communities were sampled at 48 stations in 2000 (baseline), 56 stations in 2004, and 44 stations in 2005. Invertebrate communities were dominated by polychaetes (75% of total abundance) and bivalves (17% of total abundance). After drilling began in 2004, total and polychaete abundances were reduced near the Southern drill centre relative to baseline (2000) abundances. Amphipod abundances were reduced near the southern and northern drill centres after drilling began there in 2004, and near the central drill centre after drilling began there in 2005. Analyses of distance effects underestimated the spatial extent of reductions of polychaete and amphipod abundances. Total, polychaete and amphipod abundances decreased with increasing concentrations of $>C_{10}$-C_{21} hydrocarbons (HCs), a major constituent of synthetic-based drill muds. Exposure-response relationships were stronger in 2005 than in 2004, with reductions occurring across all or most of the range of HC concentrations. Polychaetes are usually considered tolerant and have increased in abundance after the onset of drilling at other offshore oil developments. Adverse effects on amphipods, considered sensitive, occurred at much lower HC concentrations than at other developments and in laboratory toxicity tests. However, reductions in richness and diversity observed elsewhere did not occur at the White Rose development.

Developing a long-term plan for monitoring aquatic effects from an oil spill to Wabamun Lake. *B.G. Wernick[1], P.M. Chapman[1] and L. Patterson[2](PL)*
[1]Golder Associates Ltd., North Vancouver, BC; [2]CN Environment, Surrey, BC

A CN train derailment during the early hours of August 3, 2005 resulted in the release of Bunker 'C' Oil into the waters of Wabamun Lake. In response to the spill, Alberta Environment issued an *Environmental Protection Order* requiring CN to prepare a Long-term Monitoring Plan, one objective of which was to monitor the effects of the spilled oil on the aquatic environment. Wabamun Lake is currently subject to many stressors un-related to the oil spill, including: commercial and recreational overfishing; destruction of habitat; interference with natural fluctuations in lake level; cultural eutrophication; and inputs of metals and hydrocarbons from natural sources (e.g., coal deposits), local power plants, and recreational boat use. The development of the long-term effects monitoring plan took into account these stressors (which may confound the interpretation of any data collected) and greater focus was placed on lines of evidence that could be related directly to the constituents of the product spilled in the lake. The sampling activities were also selected to address the various aquatic ecosystem components (e.g., plankton, benthic invertebrates, fish) of Wabamun Lake and to take into account input received from Alberta Environment as well as other regulatory agencies and local residents. Sampling efforts were intensive initially and the results of the 2005 program are being used to focus subsequent sampling in future years.

The effects of an oil spill on the benthic invertebrate community of Wabamun Lake. *B.G. Wernick[1], P.M. Chapman[1] and L. Patterson[2](PL)*

[1]Golder Associates Ltd., North Vancouver, BC; [2]CN Environment, Surrey, BC

A CN train derailment during the early hours of August 3, 2005 resulted in the release of Bunker 'C' Oil into the waters of Wabamun Lake. As part of the Aquatic Effects Long-term Monitoring Plan designed to monitor the effects of the spilled oil on Wabamun Lake, a sediment quality triad (SQT) was conducted in the Fall of 2005. The sediment chemistry, sediment toxicity and benthic community lines of evidence of the SQT were tiered as follows. Nineteen transects, each with three stations placed at 1 m, 5 m and 20 m from shore, were established around the periphery of Wabamun Lake (including reference and exposure areas). Bulk chemistry from the 57 stations was used to focus further assessment via synoptic toxicity testing and benthic invertebrate taxonomy at a subset of 24 stations, which were selected to represent a range of hydrocarbon concentrations in the sediments and to take into account two dominant substrate types. The three lines of evidence were combined in a weight of evidence (WOE) framework for which decision criteria were established *a priori*. Because assessment of effects cannot only consider the magnitude of any observed adverse effects without consideration of underlying potentially causative factors related to those effects, relationships between chemistry data and measures of effect were further explored with multivariate statistical analyses.

Screening assessment of ecological effects following a rail-car derailment of sodium hydroxide into the Cheakamus River, BC - A tool towards recovery planning. *T.A. Watson[1], C. Totman[1], M. Long[1] and L. Patterson[2](PL)*

[1]Triton Environmental Consultants Ltd., Richmond, BC; [2]CN Environment, Surrey, BC

On August 5, 2005, the Cheakamus River was affected by a release of sodium hydroxide following a train derailment in the Cheakamus canyon approximately 15 km north of Squamish, British Columbia affecting 18 km of river. About 41,000 litres of sodium hydroxide was released and as the product was carried down the river it caused mortalities to fish and benthic invertebrates. After the spill the Cheakamus Ecosystem Restoration Technical Committee (CERTC) comprised of regulatory agencies, local government, the Squamish Nation and CN was formed to provide advice and guidance for recovery. Concerns were expressed by Committee members and the public that other animal species depending on fish and/or invertebrates may also have been affected by the spill. A screening level assessment of ecological effects was completed to understand the potential effects the spill may have had on receptors other than fish and benthic invertebrates. A preliminary list of 233 regional receptors representative of the assessment area's aquatic and terrestrial habitats was compiled and screened against selection criteria to obtain the final receptor list. A qualitative framework using ecological effects ranking categories was developed to characterize potential effects. The assessment results were used to develop and implement recovery plans for the river.

Benthic invertebrate recovery following a rail-car derailment of sodium hydroxide into the Cheakamus River, BC. *T.A.Watson[1], M. D. McArthur[1] and L. Patterson[2](PL)*
[1]Triton Environmental Consultants Ltd., Richmond, BC; [2]CN Environment, Surrey, BC

A rail-car derailment on August 5, 2005, resulted in the release of approximately 41,000 L of sodium hydroxide into the Cheakamus River approximately 15 km north of Squamish, BC affecting about 18 km of river. Sampling of drinking water in wells within 100 m of the river was implemented to determine if NaOH had affected water quality. Surface water and benthic macroinvertebrate samples were collected in the river to assess ecological effects and evaluate the potential for natural recovery. Water quality results in wells showed drinking water was not affected and the emergency drinking water ban was lifted by the local health authority within 48 hours of the derailment. Surface water samples confirmed sodium hydroxide traveled down the river as a pulse in less than 10 hours. Analysis and interpretation of benthic macroinvertebrate results followed the Canadian Aquatic Biomonitoring Network (CABIN) protocol and the Reference Condition Approach (RCA). Samples collected over the period August to December 2005 suggest recovery in community structure, abundance and biomass occurred within 2-3 months. Observed inter-annual and spatial variations in community structure and abundance were not attributed to the spill. Results of these monitoring programs have provided insight into the response and recovery of lotic environments to sodium hydroxide pulse contamination.

Oil Sands Monitoring/Surveillance des Sables Bitumineux

Session Co-chairs/Présidents: Wade Gibbons and Richard Kavanagh

Introduction to Regional Aquatics Monitoring Program. *P.J. McNamee[1], W. Gibbons[1], M. Davies[1], B. Kilgour[2], A. Stockwell[1] and D. Andrews[3](PL)*
[1]Hatfield Consultants Ltd., Vancouver, BC; [2]Stantec Consulting Ltd., Ottawa, ON; [3]Western Resource Solutions Inc., Calgary, AB

The Regional Aquatics Monitoring Program (RAMP), initiated in 1997, fulfills the aquatic monitoring needs of stakeholders of Athabasca oil sands development. The scope of RAMP is a function of scientifically-based and statistically-sound monitoring of the potential effects of Athabasca oil sands activities at a number of scales, oil sands development approval requirements, and local community concerns. RAMP incorporates both stressor- and effects-based monitoring approaches, with the stressor-based approach derived from oils sands EIAs, and the effects-based approach through monitoring biological indicators that reflect and integrate the overall condition of the aquatic environment. RAMP monitoring is conducted within a Regional Study Area (Regional Municipality of Wood Buffalo); detailed monitoring is conducted in the Focus Study Area, defined by all the watersheds in which oil sands development is occurring or planned. RAMP consists of six aquatic components: climate and hydrology; water and sediment quality; benthic invertebrate communities; fish populations; and water quality in regional lakes sensitive to acidification. Each component uses measurement endpoints to represent the health and integrity of valued environmental resources within the

component, as well as a set of criteria for determining whether or not a change in the measurement endpoints has occurred and is significant. Design and analysis relies upon a categorization of monitoring years and sampling stations into combinations of spatial and temporal treatments and controls.

Using earth observation technologies to monitor land change from oil sands development activities. *W. Gibbons[1], P.J. McNamee[1], A. Syed[1] and W. Dick[2](PL)*
[1]Hatfield Consultants Ltd., Vancouver, BC; [2]Mack, Slack & Associates Inc., Calgary, AB

Scientifically-based and statistically-sound environmental effects monitoring requires the measurement of environmental conditions in both baseline and operational areas. This is a challenge in the Athabasca oil sands region as oil sands developments are occurring over large, often remote areas and with an ever-increasing extent and pace of development. RAMP is meeting these challenges by using Earth Observation (EO) technologies. The location, magnitude, and type of land change is being estimated with EO satellite imagery ground-truthed with more detailed maps of Athabasca oil sands operations provided by RAMP industry members. Land change classification protocols are applied to 10 m resolution SPOT imagery to delineate areas of land change as cleared - logged; bare - little or no trace of vegetation remaining; developed - infrastructure facilities exist but surface hydrological connection remains with the surrounding landscape; enclosed - runoff to the natural hydrologic system has been limited (e.g., mines, tailings ponds, etc.); and reclaimed. The first three classes are further subdivided into whether or not the land change is caused by oil sands or non-oil sands development activities. The results of this classification are used to: (i) locate monitoring stations for future data-gathering; (ii) categorize monitoring stations into reference, potentially influenced-oil sands, and potentially influenced-other; and (iii) categorize data obtained from these stations into baseline and operational for purposes of data analysis. The calculated land changes are also used to estimate hydrologic effects of oil sands activities at the watershed and regional level.

Oil Sands Regional Aquatic Monitoring Program (RAMP): Water quality monitoring. *M. Davies[1], B. Kilgour[2], W. Gibbons[1] and P. McNamee[1](PL)*
[1]Hatfield Consultants Ltd., Vancouver, BC; [2]Stantec Consulting Ltd., Ottawa, ON

The water quality component of the Regional Aquatic Monitoring Program (RAMP) incorporates multiple, nested control-impact designs, gradient designs, and a regional reference approach, to assess potential effects of oil sands developments and other factors on regional water quality. The program samples over 40 different stations annually in numerous watersheds and sub-watersheds, includes seasonal sampling, and incorporates other, external data sources where appropriate. Approximately 80 measurement end-points are typically collected at each station. Station locations, measurement end-points, and analytical frameworks have been developed through a multi-stakeholder process, which included an external scientific peer review. Since 1997, a database of over 50,000 water quality observations has been developed, which has been compiled in a map-enhanced, web-accessible, relational database. Definition of regionally-defined reference baseline conditions has provided a way of ensuring robust comparisons of regional water quality in affected and unaffected waterbodies, where

issues of replication and statistical power are otherwise problematic. To date, the observed water quality within exposed watersheds has been found generally to fall within the natural range of temporal and spatial variability for the region.

Benthos monitoring in RAMP. *B. Kilgour[1], W. Gibbons[2], M. Davies[2] and P. McNamee[2](PL)*

[1]Stantec Consulting Ltd., Ottawa, ON; [2]Hatfield Consultants Ltd, Vancouver, BC

Surveys of benthic macroinvertebrates have been a component of the RAMP studies since 1997. Surveys of benthic invertebrates (sensitive bioindicators) were included in RAMP to address a regulatory requirement, and to compliment fisheries, water and sediment quality surveys by indicating the availability of food for fish, and environmental quality of the various waterbodies. The program has evolved from initial surveys of the mainstem Athabasca River (in 1997) to inventories of tributary reaches, the Athabasca River Delta (ARD), and lakes. The benthic invertebrate component of RAMP now consists of annual baseline sampling of selected tributaries and lakes over a three-year period, followed by continued monitoring at a frequency that is to be adjusted to the development schedules of nearby oil sands operations. The RAMP design for tributaries has evolved to become a combination of the regional "reference-condition-approach" (RCA) in which regional reference tributaries are used to characterize background variability, with the more classic before-after-control-impact (BACI) designs in which upstream reference sites provide a site-specific "control". The overall design has extremely high statistical power. Natural storm events have produced larger effects on the benthos of tributaries than have oil sands related developments.

Oil Sands Regional Aquatic Monitoring Program - Acid sensitive lakes monitoring. *D. Andrews[1](PL)*

[1]Western Resource Solutions Inc., Calgary, AB

The acid sensitive lakes (ASL) component of the Regional Aquatic Monitoring Program (RAMP) is designed to detect acidification of regional lakes exposed to acidifying emissions from oil sands industries. Fifty lakes are monitored annually for a range of water quality parameters including pH, Gran alkalinity, major ions and metals. The RAMP lakes are unusual in having very high levels of dissolved organic carbon, even in lakes with high alkalinity and high pH. The role of organic acids in the acid-base balance of these lakes was investigated and organic acids account for as much as 80% of the buffering capacity in low pH lakes. Critical loads of acidity were calculated using a modified Henriksen steady-state model that incorporates the effects of weak and strong organic acids on lake buffering. Critical loads exceedances by the modeled Potential Acid Input were observed in 17 of 48 lakes (35.4 %). This high rate of exceedance reflects the preferential selection of poorly buffered lakes for the ASL component. Metal concentrations were generally low and non-detectable with the highest concentrations in lakes from the upland regions (Birch and Stony Mountains). Seasonal sampling revealed significant changes in lake chemistry over a year, in particular, in shallow ponds where a large proportion of the water freezes during the winter. Trend analysis showed a number of significant trends in lake chemistry over the 7-8 years of monitoring, although these trends were inconsistent with any acidification scenario.

Oil Sands Regional Aquatic Monitoring Program (RAMP): Monitoring fish populations. *A. Stockwell[1] and C. Doherty[1](PL)*
[1]Hatfield Consultants Ltd., Vancouver, BC

The goal of the RAMP Fish Population Component is to monitor the health and sustainability of fish populations within the oil sands region. Monitoring activities focus on the Athabasca River and its main tributaries potentially influenced by current or future development. Fish populations are monitored because they are key components of the aquatic ecosystem and important ecological indicators that integrate effects from natural and anthropogenic influences. Fish also represent a highly valued recreational and subsistence resource. The specific objectives of the Fish Population component are to: (1) collect fish population data to characterize natural or baseline variability, assess EIA predictions, and meet requirements of regulatory approvals; (2) monitor fish populations for changes that may be due to stressors or impact pathways (chemical, physical, biological) resulting from oil sands development by assessing attributes such as growth, reproduction and survival; and, (3) assess the suitability of fisheries resources in the oil sands region for human consumption. The core elements of the Fish Population Component are: fish inventories and spawning surveys; tissue sampling for organic and inorganic chemicals; monitoring of fish health through evaluation of performance indicators in sentinel fish species; and, monitoring of fish population movements using fish fences. To date, the observed variation in fish population measurement endpoints has generally fallen within the natural range of temporal and spatial variability for the region.

In-stream Flow Need (IFN) assessments based on fish habitat simulation in the Athabasca River: Implications for monitoring in the data hungry reality of ecosystem modeling. *P. McEachern[1](PL)*
[1]Alberta Environment, Regional Environmental Management, Edmonton, AB

In-stream Flow Needs (IFN) determinations in the Athabasca River are based on modeling five related aquatic components; hydrology, water quality, habitat, connectivity and geomorphology each of which are data hungry. The purpose of this presentation is to share the experiences of a full modeling approach for establishing an IFN on the Athabasca River with a focus on data requirements and the on-going need for monitoring. Perhaps not surprisingly, currently available data for the lower Athabasca River are considered inadequate to ensure a sustainable ecosystem if water withdrawals are allowed during natural one-in-five dry periods despite several years of research and several million dollars spent. An IFN management framework for the Athabasca has thus taken an approach that relies on monitoring to provide both evidence that the aquatic ecosystem is sustained but also provides required evidence to test underlying hypotheses of IFN modeling. I will present a brief overview of the model assumptions for which data are lacking and summarize new monitoring programs being designed for the lower Athabasca River that will test model predictions and assumptions. Of primary importance is monitoring from a concept of process (e.g. river flow relations with fish distribution and habitat use) rather than change in a biotic end-point (e.g. diversity) for a river reach. Aquatic monitoring in the oil sands region is evolving to fill both monitoring and research roles with the growing reliance on what is being termed adaptive management in Alberta.

What makes an effect relevant and meaningful? *T. Van Meer[1], R.J. Kavanagh[2] and W. Gibbons[3](PL)*

[1]Syncrude Canada Ltd., Fort McMurray, AB; [2] Department of Integrative Biology, University of Guelph, Guelph, ON; [3]Hatfield Consultants Ltd., Vancouver, BC

The definition of an effect can be a matter of perspective. From a scientific and ecological point of view, factors such as the magnitude, toxicity, frequency/duration, spatial scale (site-specific, regional) and cumulative nature of potential effects must be considered. However, from an environmental management perspective, other aspects related to societal values and concerns, technical logistics, economics etc., also play a role in the assessment of the environmental quality of aquatic systems and development of management decisions. A panel representing environmental scientists, regulatory agencies, industry and public stakeholders will provide their specific perspective on how they define effects as relevant and meaningful. The discussion will focus on aquatic environments, particularly in the oil sands region, although it is recognized that the issue of defining an effect is broader in scope and lends itself to a wider ranging discussion.

Planktonic bacterial community production in oil sands affected wetlands. *C. Daly[1] and J. J. H. Ciborowski[1](PO)*

[1] Department of Biological Sciences, University of Windsor, Windsor, ON

The ecological suitability of oil sands constructed wetlands of varying ages and reclamation treatments was assessed using planktonic bacterial community production. Estimates of bacterial carbon production are an index of bacterial activity and can also determine the importance of the microbial loop since bacterial carbon production is a measure of the richness of dissolved organic matter (DOM) available to bacteria and the environment. Incorporation of ^{3}H-leucine into proteins was the tool used for measuring bacterioplankton secondary production. Production in wetlands ranged from 0.03-2.44 $\mu g \cdot C \cdot L^{-1} h^{-1}$. Production was 5 times higher in reference wetlands (n=5; 24.2 ± 9.4 $\mu g \cdot C \cdot L^{-1} d^{-1}$) than in oil sands process material (OSPM)-affected wetlands (n= 4; 4.7 ± 2.5 $\mu g \cdot C \cdot L^{-1} d^{-1}$) suggesting that materials associated with the oil sands process inhibit bacterial activity. Production was negatively correlated with oil sands associated compounds such as naphthenic acids (n=8; R^2=0.58, $p<0.05$) and salinity (n=9; R^2=0.61, $p<0.05$). Reduced metabolic activity in OSPM wetlands indicates a lower degree of DOM and environmental richness, perhaps in association with reduced bacterial diversity. Production was greater in wetlands with rich organic sediments (n=5; 21.1 ± 10.2 $\mu g \cdot C \cdot L^{-1} d^{-1}$) than in those with organic-poor sediments (n=4; 8.6 ± 4.6 $\mu g \cdot C \cdot L^{-1} d^{-1}$) suggesting that peat amendments to wetland substrates may lead to an influx of bioavailable DOC. Results are not consistent with macronutrients, such as ammonia (n=7, $p>0.05$), leaching from peat and stimulating bacterial production. Bacterial activity levels suggest DOM & environmental richness in OSPM-affected wetlands are lower than in reference wetlands; however, peat additions appear to stimulate bacterial metabolic activity closer to levels that approximate natural conditions.

New Methods in Aquatic Toxicology/Nouvelles Méthodes en Toxicologie Aquatique

Session Co-chairs/Présidents: Guy Gilron and Allison Squires

The development of standardized toxicity tests with the leopard frog (*Rana pipiens*). *P. M. Jackman[1], K.G. Doe[1], R.P. Scroggins[2], B.D. Pauli[2] and C. Fridgen[3](PL)*

[1]Environment Canada, Environmental Conservation Branch, Moncton, NB; Environment Canada, Science and Technology Branch, Ottawa, ON; [3] Department of Biology, Trent University, Peterborough, ON

Certain amphibian populations are declining in North America. 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*. A population of adult leopard frogs has been maintained since 2002. Several successful breeding trials have been conducted but conditions need further development. Test method conditions are being refined for conducting acute toxicity tests (4 days) with *Rana pipiens* tadpoles. To date 16 pesticides and four other chemicals of concern have been evaluated. These chemicals were used to determine whether native amphibians are typically more sensitive than standard test species (fish, invertebrates, plants, bacteria) to in-use pesticides and whether pesticide regulatory programs based on standard test species are protective of native amphibian species. Several chronic experiments were conducted to investigate the influence of diet, water quality, loading density, and pesticides. Effects on survival, growth, time to metamorphosis, and gonad development were evaluated for these tests.

Shellfish haemic neoplasia and the p53 family of proteins - Models for human health . *A.F. Muttray[1], E. Vassilenko[1], R. Cox[2], C.L. Reinisch[3], P. Schulte[1] and S. Baldwin[1](PL)*

[1] Dept. of Chemical and Biological Engineering, *University of British Columbia, Vancouver, BC; [2] Joint Centers for Systems Biology, Columbia University, New York, NY,USA; [3]Marine Biological Lab, Falmouth, MA, USA*

A number of shellfish species suffer from a disease of the haemolymph, called haemic or disseminated neoplasia, which has been likened to lymphoma in humans. There are likely multiple causes for this disease, but environmental factors are considered very important. The p53 family of proteins has been studied widely in mammalian cancer and cell cycle/apoptosis models, but has had comparatively little attention in invertebrate cancers. The genetic organization and function of the p53 family of proteins in molluscan models are the focus of this research. We have isolated several family members of the mussel (*Mytilus edulis* and *Mytilus trossulus*) p53 family. The sequence structure suggests that family members originate from one gene, in contrast to mammals, where differentiated genes exist. We investigated the relative mRNA expression levels of these

family members in mussels that were assessed to be either free of disease and in mussels with haemic neoplasia by real-time RT-PCR. Expression levels varied with disease, but between-animal variation was found to be high. Human *p53* has many mutational hotspots, which are nucleotide sites that are most frequently mutated in human cancers. We therefore also investigated whether mussel haemic neoplasia is correlated with mutations in the p53 family. The convergence and application of invertebrate and vertebrate data to human cancers and the elucidation of potential environmental effects are important parts of assessing the state of the natural environment and human health.

Rapid high throughput evaluation of chemical toxicity using fish cell lines and fish embryos. *L.E.J. Lee[1], V.R. Dayeh[2], J. L. Hermens[3], C. Hafner[4], S. Scholz[5], K. Schirmer[5] and N.C. Bols[2](PL)*

[1] Department of Biology, Wilfrid Laurier University, Waterloo, ON ; [2] Department of Biology, University of Waterloo, Waterloo, ON; [3] Department of Biology, Utrecht University, Utrecht, Netherlands; [4]Hydrotox, Freiburg, Germany; [5]UFZ Centre for Environmental Research, Leipzig-Halle, Germany

The toxicity of many chemicals or effluents discharged from industrial settings is mostly unknown. Regulatory testing requires fish lethality assays that can be time consuming, costly and labor intensive. Alternative evaluation methods for the testing of individual chemicals as well as of effluents have long been sought. One potential alternative are fish embryos, such as the *Danio rerio* (zebrafish) embryo test (DarT). DarT has undergone round-robin testing in Germany and as of 2005 has been implemented to substitute fish tests in the German national regulatory testing of waste water. Another potential alternative are fish cell lines. Compared to DarT, the maintenance and handling of cell lines is simpler, an animal facility is not needed and quantitative measures of toxicity can be obtained rapidly and effectively. However, while many studies with cell lines showed a good correlation between *in vitro* EC50s and *in vivo* LC50s, the use of fish cell lines have been limited. It is the goal of a newly initiated trans-Atlantic research project, funded by CEFIC-LRI (European Chemical Industry), to investigate the possibility of using DarT and fish cell lines as alternatives to the acute fish test. One issue to be addressed in both systems is the consideration of truly bio-available exposure concentrations of the test chemicals. Three additional points will be addressed for the cell line approach. These are the alteration of the exposure environment, a more mechanistically driven selection of toxicity endpoints as well as the application of recently developed fish cell lines that express certain origin-specific, differentiated functions.

The role of hydrophobic organic contaminants in static toxicity tests. *M. Nipper[1], R. S. Carr[2], A. Evans[1], J. Biedenbach[2], P. Gschwend[3] and J. MacFarlane[3](PL)*
[1]Texas A & M University, Corpus Christi, TX, USA ; [2]US Geological Survey, Corpus Christi, TX, USA ; [3] Department of Civil and Environmental Engineering, Massachusetts Institute of Technology, Boston, MA, USA

Hydrophobic organic contaminants (HOCs) in the marine environment accumulate in sediments, which act as a constant source of contaminants to the surrounding environment and associated fauna. Laboratory toxicity tests, however, do not have the HOC concentration "buffering" capacity provided by sediments in the real world. Therefore, HOC toxicity in laboratory experiments tends to be underestimated due to lack of the necessary mass to achieve a critical body residue which would cause adverse effects to the test organisms. A thin polyethylene (PE) film was used as a surrogate for sediments to provide a constant source of HOCs in toxicity tests. PE was exposed to phenanthrene-saturated stock solutions until loaded with the chemical and then added to seawater at a ratio of 1.2 mg PE ml^{-1} seawater. The concentration of phenanthrene was significantly higher in toxicity tests using saturated PE, relative to static systems initiated with a phenanthrene-saturated stock solution, but without saturated PE. The same PE exposure system is being used to mimic pore waters by exposing PE to contaminated sediments and then transferring it to clean seawater in toxicity test systems.This method will also reduce complications from other confounding factors. Results from this ongoing study will be presented and discussed.

Identification of metabolites from phenanthrene and alkyl derivatives in Japanese Medaka. *D. Turcotte[1], P. V. Hodson[1] and R. S. Brown[2](PL)*
[1]Department of Biology, Queen's University, Kingston, ON; [2]Department of Chemistry, Queen's University, Kingston, ON

Fish are often exposed to polycyclic aromatic hydrocarbons (PAHs) and the toxicity and metabolism of these toxicants is not fully understood. Metabolism makes xenobiotics more polar and facilitates their excretion. This mechanism enhances toxicity by the addition of oxygenated substituents by CYP enzymes. In past experiments, metabolites from phenanthrene, anthracene and their alkyl derivatives have been identified in juvenile rainbow trout (*Oncorhynchus mykiss*). Phenanthrenes are metabolised on the alkyl chains whereas anthracenes are metabolised on the rings. A predominance of glucuronides conjugates was found for all compounds. The aim of this study is to determine if this metabolite detection method can be applied to smaller fish like the Japanese medaka (*Oryzias latipes*). After a 17-d toxicity test, fish exposed to phenanthrene and alkyl-phenanthrenes were pooled and metabolites were extracted with methanol in an ultra sound bath. Metabolites were isolated on a C-18 cartridge. A portion of the metabolites was digested with beta-glucuronidase to assess the presence of glucuronide conjugates. The metabolites were separated by reverse phase HPLC and spectral identification was accomplished using a UV-diode array detector. PAH metabolites extracted from medaka embryos have ring and alkyl substituents, similar to what was seen in metabolites from juvenile trout. This suggests similar metabolism at different life stages for these species. However, a minimum of 75 to100 medaka are necessary to achieve a good signal to noise ratio on the UV detector.

Eggs, larvae, and contaminants in aquatic systems: a new technology with great relevance for aquatic toxicology that permits quantifying dispersion, connectivity, sources and sinks in any aquatic system. *B. R. Ruddick[1], C. Taggart[1] and S.M. Bard[1](PL)*

[1] Environmental Programmes, Dalhousie University, Halifax, NS

For decades, aquatic scientists have been frustrated in accurately measuring, across a range of scales, the dispersion of biological propagules, suspended particulates, toxins, natural and manmade tracers, sediments, and pollutants. Of particular concern for aquatic toxicologist is the necessity to establish how exposed a given study site is to the water-borne effluent of interest, whether it be pulp mill and other industrial effluents, municipal sewage, mine acid drainage, offshore oil and gas exploration, etc. Conventional technologies include instrumented drifters, current meters, various dyes and chemical tracers, and a plethora of numerical models. These technologies suffer prohibitive expense, compromised time and space resolution, and the paucity of numerical-model validation. We present concepts, rationale and field-trial results of an inexpensive magnetically-attractive particle and magnetic particle-collector system (patent pending) for measuring dispersion. The system is based on specially designed magnetically-attractive non-toxic particles that incorporate user-designed specific gravity, size and shape (to mimic the study propagules) and markings (for multiple release purposes) used to measure dispersion via the autonomous magnetic particle-collector array. The system has the rare ability to time-integrate particle dispersion at scales of hours to months and metres to thousands of kilometers squared without using power or electronics. Dispersion environments for application range from mixed-phase fluid flows in a lab or industrial setting to sewers, rivers, aquaculture settings, coastal- and open oceans and deep- sea vents, population/species connectivity and each with the added advantage of dispersion-development and/or model validation. NSERC sponsored workshops promoting the use of this technology in aquatic toxicology research and beyond will be held in Moncton, NB Fall, 2006 and in conjunction with ATW07 in Halifax, NS.

Strength in numbers: how Canadian laboratories are joining forces to keep pace with statistics. *L.N. Taylor[1], T.S. Moran[2] and R.P. Scroggins[1](PL)*

[1]Environment Canada, Science and Technology Branch, Ottawa, ON; [2]Pollutech EnviroQuatics Ltd., Port Edward, ON

Laboratories across Canada will soon be required to keep pace with advances in statistical analysis, yet many laboratories lack the software to easily implement these changes. Recognizing that this would be a common problem, representatives from laboratories across Canada met in a workshop forum to explore joint-effort solutions. At this workshop, headed by Environment Canada (Sept 2005, Toronto), participants reviewed current statistical software capabilities and possible software development for Canadian toxicology laboratories, reflecting the recently published EC Statistical Guidance Document (EPS 1/RM/46). Workshop participants outlined the criteria for software selection, including: user friendliness, balance between complex analysis capabilities and minimum statistical procedures, ability to maintain databases of tests and control charts, and suitability for validation to meet accreditation needs (e.g., CAEAL, ISO and GLP). As a plan forward to meet the statistical needs of toxicology laboratories, participants of the workshop were unanimous in their decision to collectively

support: a feasibility study to examine cost-effective approaches (i.e., modification of existing software) and a software improvement project. The Terms of Reference for the Feasibility Study was developed by a project steering committee comprised of members from commercial, Provincial and Federal laboratories. This presentation will provide an update on the Feasibility Study but more importantly, a commercial lab's perspective will be given to engage Canadian Toxicology Laboratories in the Software Improvement Project. Advantages and disadvantages will be highlighted, including a cost analysis. Finally, this will be an opportunity for labs not currently involved to provide feedback, and join the concerted effort.

Ecotoxicological impacts of biotechnological products to freshwater mussels - occurrence of transgenic DNA in mussel tissues. *M. Douville[1], C. André[1], F. Gagné[1], T. Edge[1] and C. Blaise[1](PO)*

[1]Environment Canada, Aquatic Ecosystem Protection Research Division, Montréal, QC

The use of biotechnology for commercial applications is considered an emerging economy. However, concerns have been raised about the increasing release of these products in the aquatic environment. Indeed, biotechnological products might have unknown or pleitrophic effects to the aquatic ecosystems when they are used at large scales. The cry1Ab gene coding for protein δ-endotoxin derived from *Bacillus thuringiensis kurstaki* (Btk) has been successfully used as biopesticides and was recently inserted into corn (Bt-corn). The aims of this study were to examine the occurrence of cry1A genes in freshwater mussels harvested nearby agricultural areas and examine the immunotoxic properties of Btk formulation and other commercial consortia products. First, mussels were harvested at three sites in the Richelieu River (near Chambly area) and in a lake from Ontario differing in agriculture influence. Mussels were allowed to depurate for 24 h at 15^{o}C in clean dechlorinated tap water before health status assessment and gene contamination by fluorescent qPCR methodology in gills, digestive gland and soft tissues. Second, hemolymph samples were collected from 10 mussels (acclimated for one month in aquaria), pooled together and exposed *in vitro* to increasing concentrations of Btk formulation and two other commercial bacterial consortia before evaluating the immune status. The results showed that mussels harvested from a tributary river exposed to intense corn cultivation were more stressed as revealed by increased lipid peroxidation, glutathione S-transferase activity and decreased soft tissues weights. Moreover, they were readily contaminated by cry1 and cry1Ab DNA from Btk and Bt-corn respectively especially in gill tissues. The levels of cry1 were more than 2 orders of magnitude higher than the levels of cr1Ab DNA from Bt-corn. For the *in vitro* experiments, the data revealed that the immune system of mussels reacted to these compounds by enhancing phagocytosis activity and decreasing cell viability. These preliminary studies reveal that mussels are perhaps suitable sentinel species to follow contamination of biotechnology products and might be affected by them as well.

pH maintenance of municipal wastewater effluent by CO2 recycling during trout lethality testing. *G. Elliott[1], N. Kruper[1], W. Antoniolli[1] and R. Beaulieu[1](PO)*
[1]Environment Canada, Science and Technology Branch, Edmonton, AB

The Environment Canada, Trout Acute Lethality Reference Method requires continuous aeration of municipal effluents during trout testing. Aeration during the 96-h test may cause an upward drift in the pH of the effluent sample from the stripping of carbon dioxide (CO_2). The increase in pH causes a shift in ammonia equilibrium to the more toxic un-ionized form, and could make the effluent more toxic to the test fish.
A procedure for maintenance of pH during trout lethality testing was investigated. Carbon dioxide stripped from aeration of municipal wastewater effluent was contained in a closed system and reintroduced (recycled) into the test effluent. The process was referred to as the Recycle Procedure. During three separate trials the pH drifted upwards using the Reference Method for trout testing, with a mean pH increase of 1.0 units. The average increase observed was from pH 7.5, at the start of testing, to pH 8.5 at the end of testing. Concurrent testing using the Recycle Procedure showed that the effluent mean pH increase was only 0.1 units. The Recycle Procedure stabilization of pH, during the 96 hour trout test, was significantly different (a =0.05) than the Reference Method.

Bacterial Source Tracking (BST) capabilities at the Pacific Environmental Science Centre: Using host-specific bacteroides molecular (DNA) markers in PCR-Based assays. *M. Linssen Sauvé[1], H. Osachoff[1] and G. van Aeggelen[1](PO)*
[1]Environment Canada, Science and Technology Branch, North Vancouver, BC

The Environmental Toxicology Section at Environment Canada's Pacific Environmental Science Centre has adopted a genetic technique developed by Dr. Katharine Field at Oregon State University that can identify the organism(s) responsible for fecal pollution in aquatic environments. Using the *Bacteroides*-PCR (Polymerase Chain Reaction) test we are currently able to distinguish between fecal contamination caused by human, ruminant animal (cow, llama, sheep, deer, goat, elk), pig, horse, dog and/or elk feces in samples of water, sediment or shellfish. This BST technique is a presence/undetectable type of assay based on detecting a prevalent intestinal bacterium called *Bacteroides* by amplifying a portion of the 16S rRNA gene using PCR. *Bacteroides* species are host-specific so that the source of a certain *Bacteroides* species identifies the culprit of fecal contamination. Intestinal bacteria are shed in fecal matter which may arise from various sources including human sewage, wild animal and bird populations, or agriculture. Fecal coliforms are commonly used as the indicator organism since they are facultative anaerobes that can be lab-cultured; however, they are less than 5% of an organism's intestinal microflora. Field's technique detects the intestinal bacterium *Bacteroides*, independent of viability because it is based on the DNA of *Bacteroides*. *Bacteroides* species are approximately 30% of intestinal microflora. Future *Bacteroides* primer development is planned for other animals such as cat, gull, duck, bear and marine mammals.

A real time-PCR method for the quantification of the two metallothionein isoforms present in Lake Trout (*Salvelinus namaycush*). *J. Werner[1], V.P. Palace[2], R. Shiu[1]and A. Yarmill[1](PO)*

[1]Department of Zoology, University of Manitoba, Winnipeg, MB ; [2]Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, MB

Metallothionein is a highly conserved protein whose physiological role is the regulation of the essential metals Cu and Zn. This protein also functions in the detoxification of heavy metals and has a role in scavenging free radical species. We have developed primers and Taqman probes to measure the two metallothionein isoforms found in salmonid fish. We assumed a high homology exists between the isoforms and within different groups of salmonids, and used the sequence for MT-I and MT-II from rainbow trout to develop the primers and probes for lake trout. We targeted two sections of each gene in which the two isoforms vary by a few nucleotides. The design of primers and probes was done using the program Primer3. To validate the primer sets we also ran samples using SYBR green. At the end of the run, a melt curve analysis was done to ensure that only one product is amplified. The designed primers produced only one peak per primer set after melt curve analysis. Furthermore, there were differences between mRNA expression between the two isoforms.

The effects of hypoxia on reproductive behaviour and success of fathead minnows. *M. Pollock[1], A.J. Squires[1], L. M. Clarke[1], M.G. Dubé[1] and R. Schryer[2](PO)*
[1]Toxicology Centre, University of Saskatchewan, Saskatoon, SK;[2]Golder Associates Ltd., Saskatoon,SK

Low dissolved oxygen is an increasing threat to aquatic systems. While fluctuating levels of dissolved oxygen can be a natural phenomenon, hypoxia caused by eutrophication and organic pollution is now considered to be amongst the most pressing and critical water pollution problems in the world, particularly in densely populated regions. Studies examining the effects of low dissolved oxygen on aquatic systems are numerous, and given the current and future importance of hypoxia, of utmost importance. Many of these studies concentrate on the effects of hypoxia on fish reproductive behaviour, with a strong bias towards marine systems. Other studies concentrate on the effects of hypoxia as they relate to reproductive success, again with a bias towards marine systems. In our study, we combined and linked endpoints from both reproductive behaviour and success using one of the most common species in North America, the fathead minnow (*Pimephales promeles*). Results indicate a direct link between reproductive behaviour and reproductive success of fathead minnows. Minnows in low oxygen treatments performed significantly fewer breeding behaviours including decreased courtship, egg care and nest preparation. These same fish demonstrated consistently lower breeding attempts, egg production and hatching success. The most likely explanation is that the metabolic expense of reproductive behaviour is too high in hypoxic environments. This study is important as it links reproductive behavior to reproductive success for a sentinel species used as a standard for studies in reproductive toxicology.

Accumulation of PAHs in the blackworm (*Lumbriculus variegatus*) and PDMS membranes. *S. Mok[1], A. Farwell[1], Z. Qin[1], D. Siladi[1], J. Pawliszyn[1] and D. G. Dixon[1] (PO)*

[1] Department of Biology, University of Waterloo, Waterloo, ON

Determining exposure of aquatic organisms to polycyclic aromatic hydrocarbons (PAHs) by measuring PAHs in the water, sediment and/or aquatic organisms is laborious and costly but important for environmental effects monitoring and risk assessment. The polydimethylsiloxane (PDMS) membrane is a technological advance that has provided a feasible way of measuring bioavailability in aquatic environments. The use of this device is advantageous in reducing the labour involved in the extraction process. However, the correlation between PAH accumulation by PDMS membrane and aquatic organisms is not well established. The purpose of this study is to compare PAH accumulation by PDMS membranes and the blackworm, *Lumbriculus variegatus. L. variegatus* is a small freshwater oligochaete (2-5cm) that minimally metabolizes PAHs. Several parent PAHs are used in this study, such as fluoranthene (K_{ow} 4.90), pyrene (K_{ow} 4.88), fluorene (K_{ow} 4.18), and anthracene (K_{ow} 4.5). Bioaccumulation studies will be conducted at concentrations ranging from the PAHs' solubility to >0.0008 $\mu g \cdot L^{-1}$ (Provincial Water Quality Objective, Ontario, Canada). PAHs concentrations in blackworms and PDMS membranes are compared at various time-points for accumulation over a 15-d exposure.

Assessing cumulative ecological effects of agriculture stressors on stream benthic ecosystems. *E.A. Luiker[1], J. Culp[1], A. Alexander[2] and K. Heard[2](PO)*

[1]Environment Canada, National Water Research Institue, Fredericton, NB; [2]Department of Biology and The Canadian Rivers Institute, University of New Brunswick, Fredericton, NB

Field run off in areas of agricultural activity can carry nutrients and pesticides to adjacent streams. The fate of these stressors on the benthic aquatic environment is various and effects potentially cumulative. Determining cause and effect relationships from multiple agricultural stressors requires an approach that can identify the effects of individual stressors on their own and in combination. To aid in the investigation of cause of these stressors on the aquatic benthic community, we propose using a weight of evidence approach combining the sediment quality triad (proposed by Chapman 1990, which includes "chemistry to measure contamination, bioassay to measure toxicity, and *in situ* biological assessment"), and the novel nutrient enrichment triad (which includes chemistry to measure nutrient concentrations, periphyton chlorophyll *a* measurements to estimate productivity, and nutrient limitation studies to determine nutrient limitation). Effects of both pesticide exposure and nutrient enrichment will be evaluated using an integrated differential triad response method. Black and Dead Brook (New Brunswick, Canada) are second order streams in an area of intensive agriculture activity, with emphasis on potato production. Data from these two subwatersheds was collected to support the sediment quality and nutrient enrichment triad assessment approach.

Global Pollutants: Top Predators at Risk/Pollutant Global: Prédateur Supérieur à Risque

Session Co-chairs/Présidents: Peter Ross and Jennie Christenson

Factors affecting the accumulation of mercury through food webs that support lake trout. . *K.A. Kidd[1], M.S. Evans[2], D.M. Whittle[3] and D.C.G. Muir[4](PL)*

[1]Department of Biology and The Canadian Rivers Institute, University of New Brunswick, Saint John, NB; [2]Environment Canada, National Water Research Institute, Saskatoon, SK; [3]Fisheries and Oceans Canada, Bayfield Institute, Burlington, ON; [4]Environment Canada, National Water Research Institute, Burlington, ON

Concentrations of mercury in the top predator lake trout vary considerably across lakes and this has been attributed to food chain length and trophic status of the systems as well as to fish population characteristics. In this study we examined whether the trophic transfer of mercury to top predators was similar in food webs of lakes that differ in size, species composition, and physical and chemical characteristics. Seventeen lake trout lakes in Ontario, Saskatchewan, Alberta and New York State were sampled in 1999 through 2002 for fish, plankton and littoral invertebrates, and water quality. Fish muscle and whole invertebrates were analyzed for total or methyl mercury as well as stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios to understand energy flow and food web positioning of the organisms, respectively. Mean mercury concentrations in lake trout muscle ranged from 0.13 to 1.3 $\mu g \cdot g^{-1}$,wet weight, and were significantly different among lakes even after adjusting for size differences. In each lake, concentrations of mercury were significantly and positively related to the trophic position (using $\delta^{15}N$) of the biota. The slopes of the log-transformed mercury-$\delta^{15}N$ relationships were not significantly different across systems, within the range of what has been observed for other lakes, and not related to any physical or chemical characteristics we examined. Results from this study indicate that the rate of biomagnification through food webs is not influencing the variable concentrations of mercury in lake trout across systems.

A food web bioaccumulation model for PCBs in the Strait of Georgia. *C.D. Condon[1] and F. A. Gobas[1](PL)*

[1]School of Resource and Environmental Management, Simon Fraser University, Burnaby, BC

The Strait of Georgia (SoG), located on the southwest coast of British Columbia, is home to a rich marine ecosystem which is under increasing environmental stress due to population and development pressures. One of the stressors is the presence of persistent organic pollutants (POPs). PCBs and PBDEs, for instance, have been detected at unexpectedly high levels in marine mammals and birds. We have developed a mechanistic bioaccumulation model which converts measured PCB concentrations in SoG sediments to predicted PCB concentrations in a range of SoG organisms including harbour seals, double-crested cormorants, and great blue herons. We use the model to assess health risks to these top predators, recommend sediment quality targets for their protection and estimate the relative contribution of Strait vs. non-Strait PCB sources to their PCB loads. The model may potentially be adapted to include other organisms (i.e., Orcas) and other POPs (i.e., PBDEs) in the same or similar systems.

Divergent feeding ecologies and hibernation events drive persistent organic pollutant (POP) patterns in British Columbia grizzly bears. *J.R. Christensen[1], M. MacDuffee[2], M. Yunker[3] and P.S. Ross[3](PL)*

[1] Department of Earth and Ocean Sciences, Univeristy Of Victoria, Victoria, BC; [2]Raincoast Conservation Society, Victoria, BC; [3]Fisheries and Oceans Canada, Institute of Oceans Sciences, Sydney, BC

Grizzly bears (*Ursus arctos horribilis*) in British Columbia have a diet dominated either by salmon or by vegetation. Each winter they hibernate, during which time they fast. In 23 grizzly bears sampled in both fall and spring, we characterized feeding ecology using carbon and nitrogen stable isotopes in hair samples, and contaminant exposure using fat for polychlorinated biphenyls (PCBs), organochlorine (OC) pesticides and polybrominated diphenyl ethers (PBDEs). We calculated that salmon preferentially delivered the majority of POPs to grizzly bears, especially those within a window of optimal food web bioaccumulation (i.e. log K_{ow} 6 - 7.5). Conversely, non-salmon-eating grizzlies had POP profiles that were dominated by more volatile contaminants and the higher-brominated PBDEs. Following hibernation, some POP concentrations increased as a result of lipid metabolism (e.g. PCBs) in both bear feeding groups. However, others declined, indicating metabolic removal during hibernation (e.g. DDT). While fall grizzly bear POP patterns diverged according to the presence or absence of salmon in their diet, all spring bears were characterized by similar POP profiles, independent of their previous fall diet. Our results indicate that dietary factors dictate patterns during a feeding phase, while metabolism dictates patterns during a fasting phase. Since grizzly bear cubs are born and nurse during the hibernation period, we suggest that the developing cubs may experience elevated risk of endocrine disruption associated with both parent compounds, as well as reactive metabolites, that are transferred during the perinatal period.

Prolonged risk of persistent organic pollutant (POP)-related health effects in British Columbia's killer whales. *P.S. Ross[1], J. K. Ford[2], B. Hickie[3], R. W. Macdonald[1] and S. J. Jeffries[4](PL)*

[1]Fisheries and Oceans Canada, Institute of Ocean Sciences, Sydney, BC; [2]Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC; [3] Canadian Environmental Modelling Centre, Trent University, Peterborough, ON; [4]Washington Department of Fish and Wildlife, Olympia, WA, USA

The southern resident killer whales (*Orcinus orca*) of British Columbia (BC) are heavily contaminated with polychlorinated biphenyls (PCBs), are intensely watched by the ecotourism sector, and face a dwindling supply of their primary prey (salmon). As part of efforts to recover this "endangered" population under the terms of the Species at Risk Act (SARA), we have been characterizing 1) the source, transport and fate of persistent contaminants (PCBs, dioxins, furans, and PBDEs) in killer whale habitat, and 2) the risk of contaminant-related health effects. Biopsies have provided samples that establish these long-lived animals as among the most contaminated marine mammals in the world. Given the logistical, ethical and legal constraints associated with obtaining the samples from killer whales that would be suitable for measuring health impacts, we have: 1) compared tissue residue concentrations against published toxicity "thresholds" in other marine mammals, and 2) studied the harbour seal as a "surrogate species"

where additional samples such as blood can be readily obtained. Our research indicates that BC's killer whales face a prolonged risk of contaminant-associated effects on the immune and endocrine systems, which may contribute to population level impacts including reproductive impairment, increased incidence of disease and mortality, and abnormal development. An integrated "weight of evidence" approach, which considers other conservation threats, provides perhaps the best scientific basis for the protection and recovery of long-lived, high trophic level wildlife species.

Science and Law/Science et Loi

Session Chair/Président: Deib Birkholz

Science and Law Workshop. ***S. McRory[1], A. Fradsham[2], D. Birkholz[3] and J. Stefaniuk[4](PL)***

[1]Alberta Justice, Edmonton, AB; [2]Provincial Court of Alberta, Edmonton, AB; [3]ALS Laboratory Group, Edmonton, AB; [4]Thompson Dorfman Sweatman LLP, Winnipeg, MB

Judge Allan Fradsham, Susan McRory, John Stafaniuk, and Deib Birkholz provided their various perspectives on the issue of environmental science and law in an open forum.

Metals/Métaux

Poster Session Chair/Président: Jenny Ferone

Can *Chironomus tentans* develop tolerance to uranium exposure over several generations? *C. Burnett[1] and K. Liber[1](PO)*

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The uranium mining and milling industry is continually growing in northern Saskatchewan, Canada. Effluent discharges from these operations result in the possibility that the aquatic receiving environment could be adversely impacted. However, the possibility also exists that some aquatic organisms could develop some level of tolerance to uranium after long-term, multi-generational, sublethal exposure. Using the benthic macroinvertebrate *Chironomus tentans* as a model, this study investigated the potential of uranium tolerance development over four generations at sublethal uranium ("acclimation") concentrations of 0.02 and 0.08 $mg \cdot L^{-1}$. Larvae were exposed throughout their entire aqueous life-cycle. During each generation, some larvae (10-d post-hatch) from each acclimation concentration were used in a separate 10-d uranium toxicity ("tolerance") test. Overall, the average median lethal concentration (10-d LC_{50}) for *C. tentans* larvae over four generations and three acclimation scenarios (control and two uranium concentrations) was 6.4 ± 2.5 mg $U \cdot L^{-1}$. Larvae from the acclimation control and two sublethal uranium acclimation treatments displayed similar and consistent tolerance to uranium. This response suggests that development of increased tolerance to uranium did not occur over four *C. tentans* generations at the chosen acclimation exposure concentrations. The significance of findings from this study has implications for the development of water quality guidelines for uranium.

Mercury in walleye, *Stizostedion vitreum*, from Lake Erie. *J. Mecca[1], G. Smietana[2], J. Telecky[3], B. Schepart[2] and P. Dehn[1](PO)*
[1]Department of Biology, Canisius College, Buffalo, NY, USA; [2]WasteStream Technology, Inc, Buffalo, NY, USA; [3]New York State Department of Environmental Conservation, Bufflao, NY, USA

Methyl mercury bioaccumulates within trophic levels of a food web and poses a potential hazard to human health through the consumption of contaminated food. Previous studies have analyzed the concentration of mercury (Hg) in top trophic level sport fish in Lake Erie, however, walleye have not been examined. The purpose of this study was to determine the concentration of Hg in walleye from the western end of the Lake Erie basin. Two classes of walleye samples were caught in the summer of 2004 and obtained from the NYSDEC: yearlings (n=11) and adults (n=6). Skin-off fillets were prepared, extracted and analyzed for Hg using EPA Methods 200.7, 7074, and 245.6. Mercury concentrations were expressed as $mg \cdot kg^{-1}$ dry weight. The average Hg concentrations for the yearlings was 0.15 ± 0.05 $mg \cdot kg^{-1}$, and 0.60 ± 0.14 $mg \cdot kg^{-1}$ for the adults, which represented a statistically significant difference (P=<0.001, Mann-Whitney Rank Sum Test). The Hg concentrations were adjusted to reflect EPA's suggested meal size of 0.227 kg and expressed as $mg \cdot kg^{-1}$ wet weight. The average Hg concentrations were 0.28 ± 0.08 $mg \cdot kg^{-1}$ for the yearlings and 1.04 ± 0.26 $mg \cdot kg^{-1}$for the adults. These values were above EPA recommended fish consumption limits for methyl mercury (0.12-0.23 $mg \cdot kg^{-1}$) based on four meals per month, which have been shown to be realistic consumption rates for fishers from the Great Lakes; indicating fish consumption advisories may need to be re-examined for Lake Erie walleye, particularly in light of the potential risk to sport and subsistence fishers.

Uranium uptake and accumulation via dietary and aqueous exposure routes in freshwater midge (*Chironomous tentans*) larvae. *J. Hunt[1] and K. Liber[1](PO)*
[1]Toxicology Center, University of Saskatchewan, Saskatoon, SK

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 to freshwater invertebrates has, until recently, largely been overlooked. Some researchers have assumed aqueous exposure to be the major route of uptake, others have suggested that the dietary route can be a significant contributor to total bioaccumulation of metals in benthic invertebrates. The mining and milling of uranium (U) 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 fed Nutrafin fish food prepared to contain 100 and 1500 mg U kg^{-1} dry weight. The experiment was a 10-d test, with complete water and substrate renewal every 48 h, to keep the aqueous concentration of U at minimum levels. Test endpoints included larval growth 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 $\mu g \cdot L^{-1}$). Dietary U bioaccumulation resulted in growth inhibition in animals fed 1500 mg $U \cdot kg^{-1}$. No growth effects were observed from aqueous exposure to 2 and 20 μg $U \cdot L^{-1}$. The dietary U contribution was

calculated from the total bioaccumulation in the dietary study minus the aqueous contribution.

The effect of seasons, size and proximity to finfish aquaculture on metal concentrations in clams. *N.R.H. Eyding[1], A. M. deBruyn[1] and A. Mazumder[1](PO)*

[1] Department of Biology, University of Victoria, Victoria, BC

Marine foods are important for sustenance and livelihood among coastal First Nations groups. Research indicates that some metals are elevated in invertebrates living in close proximity to finfish aquaculture, creating uncertainty among First Nations about the impact of fish farms on traditional foods harvested further a field. To investigate these concerns, Manila clams (*Venerupis philippinarum*) were collected from sites on the west coast of Vancouver Island, including three sites within one km of fish farms and three sites hydrologically isolated from farms. Metal concentrations in edible tissues were compared among clams collected in four seasons, from six size classes, and from near-farm and reference sites. Preliminary results suggest distinct patterns of metal accumulation based on clam size and site.

General Submissions/Soumissions Générales

Poster Session Chair/Président: Jenny Ferone

Investigation of *de novo* cholesterol biosynthetic capacity in the gonads of goldfish (*Carassius auratus*) exposed to β-sitosterol. *R. L. Sharpe[1], M. Drolet[1] and D. L. MacLatchy[1](PO)*

[1]Department of Biology and The Canadian Rivers Institute, University of New Brunswick, Saint John, NB

Total and intra-mitochondrial gonadal cholesterol concentrations are decreased in fish exposed to the phytoestrogen β-sitosterol (β-sit). The present study examined the potential for β-sit to disrupt *de novo* cholesterol synthesis in the gonads of goldfish exposed to 200 $\mu g \cdot g^{-1}$ β-sit and 10 $\mu g \cdot g^{-1}$ 17β-estradiol (E2; estrogenic control) by intra-peritoneal Silastic® implants for 21 days. The *de novo* cholesterol synthetic capacity was estimated by incubating gonadal tissue with ^{14}C-acetate for a period of 18 hours, followed by chloroform/methanol lipid extraction. Lipids were separated using thin layer chromatography (TLC) and total radioactivity in each lipid class was determined. Plasma testosterone (T) and gonadosomatic index (GSI) were also measured. Plasma T was significantly reduced in male β-sit-treated fish compared to control and E2-treated fish ($p=0.005$). These results indicate gonadal *de novo* cholesterol biosynthetic capacity is not disrupted by β-sit or E2 treatment in early recrudescing male or female goldfish. The research was funded by the Natural Sciences and Engineering Research Council (NSERC) Discovery Grant program (D.L. MacLatchy).

Characterization and toxicity testing of seafood processing plant effluent in the Atlantic Region. *B. Lalonde[1](PO)*

[1]Environment Canada, Environmental Protection Branch, Dartmouth, NS

Fish and seafood processing is of national importance, with over 1400 processing plants nationwide. Historically, the characterisation of the effluent from seafood processing has focused mainly on a few conventional characteristics. To enable a better understanding of seafood processing and its potential impacts on the environment we conducted an enhanced wastewater characterization study of 18 seafood processing plant effluents. Final composite effluent samples from the seafood processing plants were collected for acute and chronic toxicity testing and physico-chemical analyses. Based upon all of the individual toxicity tests performed in this study and according to the toxicity classification scheme by Sandhu (1979), 17% wastewater samples were classified as highly toxic (LC_{50}<10%), 34% were moderately toxic (LC_{50} 10-50%), 19% were considered as having low toxicity (LC_{50} 50-100%) while 30% had non-detectable toxicity (LC_{50}>100%). Statistically significant negative relationships between toxicity test results and oil and grease or BOD were detected for most toxicity tests. However the statistically significant relationships did not account for all of the variability in the dataset (R^2 varied from 31 to 71%) which lead us to hypothesize that there were other factors which influence the toxicity values. Other predictors of toxicity that are being assessed include cleaning, disinfecting and sanitizing chemicals, type of processing procedures and species processed. In the last year of sampling, characterisations of the receiving environment (sediments) have been added to the study.

Expression of P-glycoprotein in killifish (*Fundulus heteroclitus*) from the Sydney tar ponds, Nova Scotia, Canada. *S. Paetzold[1], S.M. Bard[1] and M. Jones[2] (PO)*

[1] Environmental Programmes, Dalhousie University, Halifax, NS; [2] Department of Biology, Cape Breton University, Sydney, NS

P-glycoproteins (P-gp) are transmembrane efflux transporters that prevent the cellular accumulation of moderately hydrophobic compounds and are responsible for certain multidrug resistance phenotypes in tumor cell lines and human patients. We investigated whether P-gps could be involved in a contaminant-resistant phenotype observed in a population of fish exposed over generations to high levels of polycyclic aromatic hydrocarbons (PAHs). Hepatic and intestinal P-gp expression was evaluated in killifish (*Fundulus heteroclitus*) from the Sydney Tar Ponds, Nova Scotia, Canada, a site highly contaminated with PAHs for over 100 years and from Conrad Beach, a relatively unpolluted site. Chemical analysis demonstrated that sediment and fish samples from the Sydney Tar Ponds have high levels of PAHs compared to the Conrad Beach reference site. To investigate the half-life of P-gp inducers, killifish from either site were depurated in clean water for up to 3 months. To investigate the contribution of P-gps in concert with phase I and II metabolizing enzymes to the contaminant resistance phenotype, differential gene expression of cytochrome P4501A1, aryl hydrocarbon receptor, multidrug resistance associated protein 2 and glutathione-S-transferase was undertaken in liver and intestine.

Sediment Profile Imaging and Micro-Sampling System (SPIMS) . *M. Nipper[1] and R. S. Carr[2](PO)*

[1]Texas A & M University, Corpus Christi, TX, USA ; [2]US Geological Survey, Corpus, Christi, TX, USA

Sediment quality assessments have traditionally relied on the transfer of field collected samples to the laboratory for testing and analyses. Such removal of sediments from their natural environment introduces a series of artifacts that may modify the actual condition of the sediment, and consequently affect the results of further laboratory analyses and ultimate understanding of sediment condition. In order to minimize these artifacts and provide the capability to assess sediment quality *in situ*, a Sediment Profile Imaging and Micro-sampling System (SPIMS) has been designed and is being constructed by Deep Ocean Exploration Research (DOER) of Alameda, California. The instrument will use real time digital imagery and rams with feedback control to guide the positioning of the micro-measurements and sampling of precise depths and features in the sediment profile. The SPIMS includes (1) the use of digital imagery with LED illumination for real time visualization through a fiber optic connection as well as high resolution images, of the benthic biota, their burrows and tubes, (2) a series of robotic microsensors for measuring *in situ* dissolved oxygen, pH, redox, sulfide, various metals and other parameters which can be measured with an electrode, (3) a planar optode system for observing DO and pH concentrations over the complete two dimensional profile image in conjunction with the visible image and, (4) a robotic sampling system which would allow sediment and pore water to be sampled at discrete locations within the visible sediment profile. The instrument will provide a unique tool that can be applied simultaneously to the study of numerous scientific aspects of bedded sediments including benthic ecology, ecotoxicology, geochemistry and environmental chemistry.

Validation of Environment Canada's biological test method for assessing contaminated soils: Collembolan toxicity tests. *S. Hendry[1], J. Princz[1] and R.P. Scroggins[1](PO)*

[1]Environment Canada, Science and Technology Branch, Ottawa, ON

Environment Canada is finalizing a standardized soil test method for measuring soil contamination using three species of Collembola: *Folsomia candida*, *Folsomia fimetaria* and *Orthonychiurus folsomi*. This method will complement two other Biological Test Methods for the assessment of contaminated soils using standardized plant and earthworm toxicity tests. Finalization of the method requires test method validation, and as a result, Environment Canada initiated a series of collembolan inter-laboratory round robin tests involving nine laboratories across Canada. The tests were designed to assess the accuracy and precision of the collembolan toxicity tests, in three phases, using *Folsomia candida* as a test species. The first phase (Phase 1) consisted of a 14-d reference toxicity test using a formulated artificial soil amended with boric acid, and measuring adult survival as an endpoint. The second phase (Phase 2) involved a 28-d reproduction test using a formulated artificial soil amended with boric acid, and measuring adult survival and juvenile production as endpoints. Phase three of the series will consist of a 28-d reproduction test, but with the assessment of a field-contaminated soil, and using the same endpoints as for Phase 2. As part of this study, Environment Canada also compared between two processing techniques: traditional water floatation,

and newly derived heat extraction procedures. The mean 14-d LC50 for adult survival for Phase 1 was 1,149 mg $H_3BO_3 \cdot kg^{-1}$ soil dry wt, with a co-efficient of variation of 27%, indicative of good inter-laboratory precision. The results obtained from each phase will be summarized and discussed, and the efficiency of test processing procedures compared.

Escapement success of rainbow trout (*Oncorhynchus mykiss*) fry from artificial redds with different fine sediment loadings. *T. Fudge[1], G. Sterling[2], K. Wautier[3] and V.P. Palace[3](PO)*

[1]Department of Biological Sciences, University of Manitoba, Winnipeg, MB; [2]Alberta Sustainable Resource Development, Edson, AB; [3]Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, MB

Ground and surface water flow over salmon redds can be impaired by increased sedimentation, affecting embryonic development. An artificial stream system with discrete redds was used to examine the effects of fine sediments on the escapement success of rainbow trout (*Oncorhynchus mykiss*) fry. Twenty redd chambers, each containing 5.0L of river rock (0.5-6cm diameter), received one of four different fine sediment additions (Fine Sediments (FS) ~61% 2mm<x<1cm & 39% x<2mm) (Control-no fines, Low-FS = 0.68L, Med-FS = 1.35L and High-FS = 2.03L). Eighty (80) eyed rainbow trout eggs (197.4 degree days) were seeded, at 8cm of depth, into each redd chamber. Chambers received dechlorinated water (9.4 ± 0.3^0C), delivered at ~0.675L min^{-1} from a lower supply chamber, within the flume, in order to mimic upwelling ground water. Water was also delivered over the surface of the egg chamber at a speed of ~4-6 m s^{-1}. Measurement endpoints included total emergence, residual yolk sac scoring, condition factor, and oxygen saturation in the chambersediments. Fry began to emerge 507.6 degree days post-fertilization with overall emergence of >70% in all treatments. Emergence rates were binodal in all treatments except for redds with high sediment loads, where emergence was initially higher and where a slower more continuous emergence occured. Peak emergence occurred later in the high sediment redds compared with all other treatments. Additionally, early emerging fry from the high sediment treatment chambers contained the greatest proportion of residual yolk. The altered emergence pattern of fry from the high sediment treatment may have been due to the formation of a sediment cap on the surface of the redds.

Canadian Environmental Quality Guidelines for DIPA (di-isopropanolamine). *K. Potter[1], S.L. Roe[1], M. Tindal[2] and J.R. Hill[3](PO)*

[1]Environment Canada, National Guidelines and Standards Office, Gatineau, QC; [2]Axiom Environmental Inc., Calgary, AB; [3]Environment Canada, Science and Technology Branch, Ottawa, ON

DIPA (di-isopropanolamine), has a variety of commercial, industrial and household applications including natural gas processing (removal of acid gases from a natural gas stream), detergents, metalworking fluids, cosmetics and personal care products. It has been commercially available for over 40 years. DIPA is a secondary alkanolamine which is a hygroscopic polar solvent that is completely miscible in water. DIPA has been

reported in groundwater, surface water, soil and vegetation in the vicinity of facilities where it is being used. DIPA is known to raise the pH of water with a low buffering capacity which may preclude the survival of certain aquatic organisms. Interim Canadian water quality guidelines for DIPA were calculated to be 1.6 $mg \cdot L^{-1}$ for the protection of freshwater aquatic life and 2 $mg \cdot L^{-1}$ for the protection of water used for irrigation of all crop species. A source guidance value for groundwater, for the protection of potable water, was set at 4 $mg \cdot L^{-1}$. The overall recommended soil quality guideline for DIPA was calculated to be 180 $mg \cdot kg^{-1}$ based on the groundwater check for aquatic life. A pH check, a novel approach developed specifically for the DIPA guidelines, was calculated due to the potential for DIPA to increase the pH of soil porewater. The CCME Water and Soil Task Groups and the National Guidelines and Standards Office of Environment Canada worked with the Canadian Association of Petroleum Producers (CAPP) to derive these guidelines.

Canadian Environmental Quality Guidelines for sulfolane. *S.L. Roe[1], K. Potter[1], M. Tindal[2] and J.R. Hill[3](PO)*

[1]Environment Canada, National Guidelines and Standards Office, Gatineau, QC; [2]Axiom Environmental Inc., Calgary, AB; [3]Environment Canada, Science and Technology Branch, Ottawa, ON

Sulfolane has been traditionally used in the extraction of aromatics and in the removal of acid gases from a natural gas stream. More recently, sulfolane has been used as a distillation solvent, a plasticizer, and in electrical applications. Sulfolane has been reported in groundwater, surface water, soil and vegetation in the vicinity of facilities where it is being used. Sulfolane is a colourless, highly polar compound with good chemical and thermal stability. Interim Canadian water quality guidelines for sulfolane were calculated to be 50 $mg \cdot L^{-1}$ for the protection of freshwater aquatic life and 0.5 $mg \cdot L^{-1}$ for the protection of water used for irrigation of all crop species. A source guidance value for groundwater, for the protection of potable water, was set at 0.09 $mg \cdot L^{-1}$. The overall recommended Canadian soil quality guideline for sulfolane was calculated to be 0.8 $mg \cdot kg^{-1}$ based on the groundwater check for potable water. The CCME Water and Soil Task Groups and the National Guidelines and Standards Office of Environment Canada worked with the Canadian Association of Petroleum Producers (CAPP) to derive these guidelines.

Refined risk assessment for aquatic biota exposed to Aldicarb. *D.R.J. Moore[1], R. P. Thompson[1], S.I. Purbrick[1], D. Fischer[2] and T. Ramanarayanan[2](PO)*

[1]Cantox Environmental, Inc., Ottawa, ON; [2]Bayer Crop Science, Triangle Park, NC, USA

This poster presents the results of a risk assessment for aquatic biota exposed to aldicarb applied to agricultural fields. It builds upon the methods used in an ecological fate and ecological effects (EFED) risk assessment that was prepared by the U.S. Environmental Protection Agency. Aldicarb is a systemic insecticide that is applied directly to the soil to control mites, nematodes, and aphids on a variety of crops (e.g., cotton, potatoes, peanuts). Tier 2 PRZM/EXAMS (Predicted Root Zone Model (PRZM) and Exposure Analysis Modeling System (EXAMS)) modeling were conducted to

estimate summed peak and 21-d average concentrations of aldicarb and the carbamate metabolites in surface waters of a standard pond (10,000 m^2, 2 m deep) resulting from each of 17 risk scenarios. For each scenario, PRZM used 30 years (1961-90) of site-specific climate data to generate exposure results. Results derived using PRZM were used as input into EXAMS. Acute effects were assessed using a species sensitivity distribution (SSD) approach to estimate risks to groups of aquatic species (e.g., freshwater fish, freshwater invertebrates). No observed adverse effects concentrations (NOAEC) were collected for each receptor group to assess the potential for chronic effects. Risks to aquatic biota from exposure to aldicarb were characterized using risk curves for acute risk scenarios, risk quotients for chronic risk scenarios, incident reports, and by comparing monitoring data to effects thresholds. The monitoring data line of evidence does not provide conclusive evidence about the level of risk. The risk curves and incident reports indicated low acute risk for aquatic biota exposed to aldicarb following granular application to agricultural fields. The risk quotients for chronic risk indicated that freshwater fish and invertebrates and saltwater fish are not at risk for any of the scenarios considered. However, saltwater invertebrates are potentially at risk for banded applications of aldicarb to cotton, peanuts, and pecans.

Investigation of fish kills in Quebradas Ayash and Pichiu in the Peruvian Andes.

G.P. Tello[1], J. Troll[1], D. Farara[2] and D.G. Fitzgerald[2](PO)

[1]Compania Minera Antamina, Lima, Peru; [2]EcoMetrix Incorporated, Brampton, ON

On September 22, 2005 Compañía Minera Antamina (Antamina), located in the Peruvian Andes, received a report that there was a number of dead fish observed in Qda Ayash, downstream of the tailings impoundment. The dead fish were found just downstream of Ayash Village in an area known as Chocopampa. Antamina environmental staff immediately started an investigation into the incident. On October 15, 2005 there was an additional report of approximately 140 dead fish in the stream. This fish kill was located 2 km downstream of Pichiu Village and just upstream of the confluence with Qda Shiloui. There were some reports that estimated the number of dead fish to be more than 400. After an in-depth investigation into the fish kills that occurred in Qda Ayash near Chocopampa around September 22, and upstream of the confluence of Qda Shiloui around October 15, it is concluded that the fish kills were caused by the ingestion of large numbers of the red fire ants. The stomachs of dead fish that were collected from the fish kill areas were often filled with the winged form of fire ants. Similar fish kills caused by fish ingesting fire ants have been reported throughout the Southeastern United States. An investigation into all other potential causes including chemicals (e.g., metals, ammonia, pesticides), disease (e.g., bacterial gill disease) and natural physical factors (e.g., temperature, dissolved oxygen) indicated that there was nothing that would have led to the fish kill.

Assessment of metal speciation and toxicity in Upper Columbia River and the tributaries along the U.S. - Canadian border using the Biotic Ligand Model and VMINTEQ. *C. Bollinger[1] and R. Harper[1](PO)*

[1] Department of Environmental Science, Western Washington University, Bellingham, WA

The leaching and atmospheric deposition of heavy metals from mining and smelting activities into freshwater ecosystems is of on-going concern. This research project focused on an intensively mined area of the Upper Columbia River Basin and included six tributaries around Trail, British Columbia (BC), Canada, two tributaries in northeastern Washington state and one trans-border tributary. Although extensive environmental studies have been conducted in the Columbia River Basin, most of them have focused only on the respective surface waters on either side of the Canadian – U.S. border. This research was designed to assess the effects of metal speciation on the potential toxicity contributed by the nine tributaries to the Columbia River on both the Canadian and U.S. sides of the border. Surface water samples were collected at medium flow conditions and low flow conditions in 2006 from the nine tributaries and at six sites in the upper Columbia River. Acute toxicity studies and chemical analysis were conducted on the water samples. The chemical data will be used as input for the Biotic Ligand Model (BLM) to predict toxicity, and those results will then be compared to actual toxicity data. The VMINTEQ geochemical model will be used to further refine the BLM predictions. This research is intended to contribute to the growing body of knowledge on metal speciation and resultant toxicity in aquatic environments.

Identification of endocrine disrupting substances in municipal wastewater treatment plant effluent using an effects-based approach. *L.M. Hollis[1], B.L. Crago[1], D.A. Birkholz[2] and S.E. Goudey[1](PO)*

[1]HydroQual Laboratories Ltd., Calgary, AB; [2]ALS Laboratories, Edmonton, AB

We used an effects-based fractionation procedure to identify the chemical group(s) eliciting endocrine disrupting effects in a municipal wastewater treatment plant effluent. *In vivo* fish bioassays (short-term exposures of breeding fathead minnows, *Pimephales promelas*) were performed to determine bioactivity. Of the endpoints measured, including fish survival, growth, plasma vitellogenin (VTG) induction, total plasma protein, and gonadosomatic index, plasma VTG was the most sensitive bioindicator of endocrine disruption due to effluent exposure. The estrogenic and androgenic potency of the isolated compounds from the effluent were quantified with *in vitro* bioassays using genetically modified yeast cells, *Saccharomyces cercisiae*. With further chemical analysis of effluent fractions, specific causative compounds were isolated and identified (Funded in part by Alberta Ingenuity Fund).

Ecological categorization of the domestic substances list: Results and next steps.
P. Costa[1], Y. Couillard[1], N. Davidson[1], M. Eggleton[1], J. Gauthier[1], M. Lin[1], D. MacDonald[1], A. Okonski[1], P. Robinson[1], S. Schnabel[1], A. Séné[1] and S. Reid[1](PO)
[1]Environment Canada, Science and Technology Branch, Gatineau, QC

The Existing Substances Program identifies, prioritizes, and assesses the risks resulting from exposure to substances existing in Canada. These activities are conducted jointly by Environment Canada and Health Canada.
Environment Canada and Health Canada are responsible for identifying and categorizing (by September 14, 2006) the approximately 23,000 substances on the Domestic Substances List (DSL) that present for individuals in Canada the greatest potential for exposure or that are persistent or bioaccumulative and inherently toxic. Categorization is a prioritization process and involves the systematic identification of substances on the DSL that should be subject to screening assessments (Section 74, CEPA 1999). To facilitate categorization, substances were grouped into different classes such as organics, inorganics, organometals, polymers, and UVCBs (Unknown or Variable Composition, Complex Reaction Products, or Biological Materials). In June 2004, the government of Canada launched an 18-month voluntary challenge to stakeholders to submit experimental studies or other information that could help refine categorization decisions. Over 20 larger data submissions and approximately 375 individual studies were received and considered.
Canada's categorization work is precedent setting in addressing the legacy of existing substances.

Assessment of indicators of stress in fish from St. John's Rivers. *A. Mathieu[1], K. Clarke[2], J. Guiney[1], L.L. Fancey[2] and J.F. Payne[2](PO)*
[1]Oceans Limited, St. John's NL; [2] Fisheries and Oceans Canada, Science Branch, St. John's NL

Bioindicator studies are presently being used in Europe in the CITY FISH program to assess health effects in fish in urban rivers. Also, a pilot study carried out earlier by DFO in Newfoundland indicated that the water quality in two St. John's rivers was impaired as assessed by two bioindicators of contaminant stress, mixed-function oxygenase (MFO) enzyme induction and acetylcholinesterase (AChE) inhibition. This pilot study led to the following investigation which included analysis of fish from a larger number of rivers in order to identify priority areas of potential concern in relation to present and future developments. Brown trout were collected from six rivers, two rural and four urban. A relatively high level of MFO induction was observed in both male and female fish in city rivers. AChE was also shown to be inhibited in muscle tissues of fish from city rivers. Interestingly, inhibition was observed more often in females, suggesting that females may be at greater risk to AChE inhibiting substances. Fish, liver and gonad weight as assessed by ANCOVA displayed differing degrees of inter-site variability. However, it is of interest that there was a pattern towards lower liver and gonad weights in female fish from city rivers. One of the other interesting observations was the presence of relatively large immature fish in all the city rivers but not in the putatively less contaminated rural rivers. Overall, the results of the bioindicator studies support the hypothesis that water quality in St. John's rivers poses a risk to fish health. (Supported by Environment Canada ACAP program and DFO).

Assessment of the effects of the oil-well drilling waste barite on fish health. *C.D. Andrews[1], J. Guiney[2], L..L. Fancey[1], J.F. Payne[1] and K. Lee[3](PO)*

[1]Fisheries and Oceans Canada, Science Branch, St. John's, NL; [2]Oceans Ltd., St. John's, NL; Fisheries and Oceans Canada, Centre for Offshore Oil and Gas Environmental research, Bedford Institute of Oceanography, Dartmouth, NS

Laboratory based long-term chronic toxicity studies along with field monitoring programs employing early warning bioindicators, provides a robust approach for assessing any ecological and fisheries risks from drilling discharges. Barite is a major waste in drilling fluids and is often the primary waste of concern associated with exploratory drilling. An earlier review of drilling discharges by the National Academy of Science noted the dearth of information on barite toxicity. We have carried out a long-term chronic toxicity study on the effects of barite on fish health. Cunners (*Tautogolabrus adspersus*) were exposed on a weekly basis for 40 weeks to 200g "clouds" of barite in a 1,800 liter tank. Fish survival was unaffected. Also, fish health, as assessed by fish and organ condition as well as detailed histopathological studies on liver, gill and kidney, did not differ between control and experimental groups. Given the prolonged and high level exposure, results support the hypothesis that barite poses little or no risk to fish health in association with exploratory drilling (supported by PERD and ESRF).

Gulf Region's Community Aquatic Monitoring Program (CAMP) *A.Turcotte[1], S.C. Courtenay[2,3] and J. Weldon[3](PO).*

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The Community Aquatic Monitoring Program (CAMP) began in 2003 as a partnership between community environmental groups and the Department of Fisheries and Oceans to quantify faunal assemblages in estuaries and bays of the southern Gulf of St. Lawrence. In addition to raising awareness of estuarine ecology, the objective was to test the hypothesis that the numbers and types of animals present reflect marine environmental quality. From four pilot sites sampled in 2003, the program expanded to 24 sites throughout New Brunswick, Nova Scotia and Prince Edward Island in 2004. In each site, six stations are beach-seined once per month between May and September. Juvenile and adult fish, shrimp and crabs are enumerated by species or genus and released live at the point of capture. Data are also collected on water temperature, salinity and oxygen content, as well as plant coverage and the grain size and organic content of sediments. Preliminary analyses of 2004 data revealed significant temporal and spatial variance in community structure. Sites sampled in New Brunswick during August showed more juvenile Atlantic silversides (*Menidia menidia*) and fewer crustaceans than more easterly sites sampled in Nova Scotia and Prince Edward Island. The generality of these patterns across months and years, and their relationship to environmental quality is the subject of ongoing data collection and analysis.

New sediments quality criteria for prevention, disposal and cleanup goals, for the Quebec region., *C. Bélanger[1], L. Boudreau[2], C. Gagnon[2], I. Guay[2], L. Martel[3], P. Michon[4], M. Pelletier[1] and S. Thibodeau[1](PO)*

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Environment Canada and the Quebec *Ministère du Développement durable, de l'Environnement et des Parcs* reviewed the sediment quality criteria adopted for the province of Quebec in 1992. This process lead to the adoption of a new approach based on the Canadian Council of Ministers of the Environment (CCME) procedure, and of new sediment quality criteria.

To protect aquatic life, the CCME has determined two reference values for thirty substances in freshwater and marine sediments: a threshold effect level (TEL) and a probable effect level (PEL). The task group recommended that the TEL and PEL be adopted for the Quebec sediment quality criteria, but judged that these two reference levels did not adequately allow defining all of the intervention levels needed for sediment management in Quebec. Three other levels were therefore defined using the CCME database and a calculation method similar to the one used to determine the TEL and PEL. They are: (1) the rare effect level (REL), (2) the occasional effect level (OEL) and (3) the frequent effect level (FEL).

This set of criteria is a screening tool for assessing sediment contamination levels. Employed in conjunction with background levels, they are used to prevent the contamination of sites that are sensitive to anthropogenic pollution. Used with other assessment tools, such as toxicity tests and biological field studies, the criteria facilitate the determination of appropriate disposal methods for dredged material. They also serve as indicators of the remedial measures required at contaminated sites and define clean-up goals.

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