UNIVERSITY OF CALGARY
FACULTY OF VETERINARY MEDICINE

‘One Health’ and the Oil & Gas Industry in the West: Animals to Ecosystem

SETAC Prairie Northern Chapter

6th Annual Meeting

June 4th and 5th, 2015

University of Calgary

Table of Contents

SETAC-PNC President's Welcome

Welcome to the 6th annual Prairie Northern Chapter of SETAC annual meeting! Our Calgary hosts have done a wonderful job in organizing this event, and their hard work and efforts are truly appreciated. Well done!

The chapter has grown and developed tremendously since our first gathering in Saskatoon in 2010. We flourished under the direction of Dr. Dave Janz and his excellent team at the Toxicology Centre at the University of Saskatchewan, and this meeting represents the close of my first year as president. The PNC is the largest of SETAC's regional chapters, and comes with many challenges to overcome those geographic hurdles. At the same time, it provides us with a wealth of expertise, issues, and viewpoints from which to draw on and promote strong, sound science. We are all striving to protect the environment in a sustainable manner, and regardless of whether a student or professor emeritus, industry or academic, we do this best when we work together. This has always been the aim of SETAC, and this approach has been a powerful tool in our common goal of a sustainable existence.

As always, if you are looking to help guide the chapter, or have ideas for how we can grow and be more engaged, please do contact myself. The board and I have many ideas about how we can go about this, but we have no doubt you out there have your vision as well. Remember, this is your PNC! Again, many thanks to Drs. Judit Smit and Regina Krohn and their colleagues for all their time and energy, and we look forward to seeing you all next in year in Winnipeg for our 7th annual meeting.

Mark Hanson, Ph.D.

President, PNC

General Information

Emergency Information: In the event of an EMERGENCY dial:

403-220-5333 for Campus Security
or 9-1-1 for Police, Fire or Ambulance

Help Phones are located throughout the campus in most buildings, parking lots, and elevators. There are also pay phones around the campus with a direct link to Campus Security.

Registration fees: Your registration fee covers the costs associated with your entry to all scientific sessions, as well as the following meals, refreshments and receptions:

- Morning coffee break
- Lunch
- Afternoon coffee break
- Poster session reception (cash wine and cheese bar)

Name badges: Please where your name badge during all meeting activities.

Cell phone etiquette: Please turn off or mute your cell phones during scientific sessions and plenaries.

Smoking: Smoking is prohibited in all campus buildings.

Silent auction: Silent auction items can be dropped off at the registration desk. The auction will run during the banquet on Friday evening.

Getting There

Walking between Foothills and Main Campus (20-30 minutes):

Head north along 29th St NW (becomes Uxbridge Drive after 16th Ave NW)

Continue along Uxbridge Drive NW past 16th Ave NW and Ulster Rd NW

Turn right onto Unwin Rd NW

Turn left at the end of Unwin Rd NW onto University Drive NW

Continue to University Main Campus

Buses between Foothills and Main Campus (8 minutes):

Route 20 (Direction: Northmount): Foothills to Main Campus

Route 20 (Direction: Heritage): Main Campus to Foothills

For more information regarding schedules and fares:

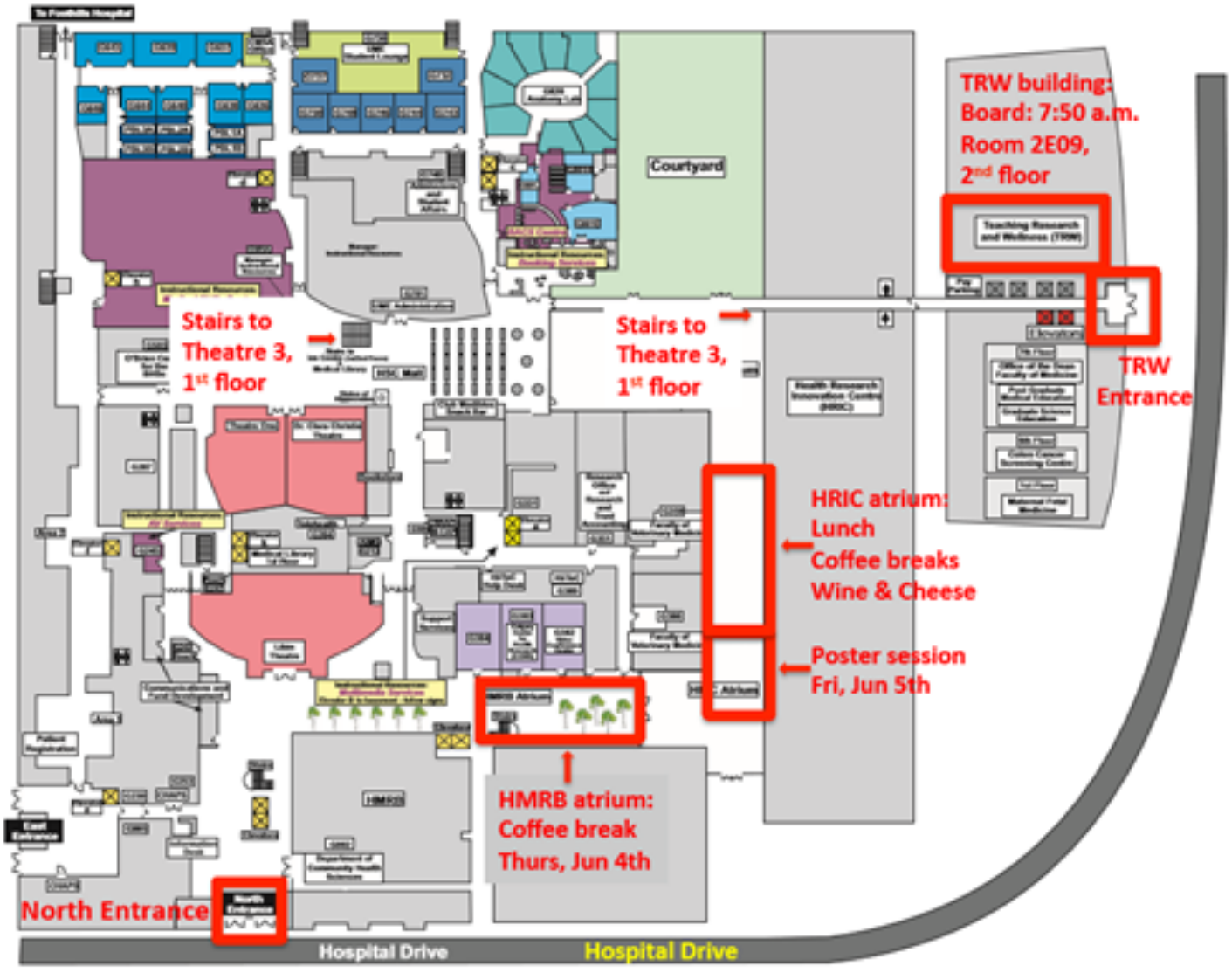
http://www.calgarytransit.com

	Registration: Thursday before workshop or Friday starting at 8 am
8:30 AM	Welcome Message
8:45 AM	Plenary Speaker: **Fred Wrona, AEMERA**. Design and Implementation of Integrated Environmental Monitoring: Challenges and Opportunities.
9:15 AM	**P. Rosa**. Recreating the soundscape: disentangling effects of oil well noise from infrastructure on grassland songbirds.
9:30 AM	**D. Philibert.** A comparison of conventional crude oil and dilbit developmental toxicity to zebrafish.
9:45 AM	**E. Gillio-Meina.** How Surface Water Chemistry Conditions Representative of the Alberta Oil Sands Mining Region Can Shape the Acute Aqueous Toxicity of Vanadium.
10:00 AM	**COFFEE BREAK**
10:30 AM	**J. Doering**. Cross-species comparison of relative potencies and relative sensitivities of fishes to dibenzo-p-dioxins, dibenzofurans, and polychlorinated biphenyls in vitro.
10:45 AM	**E. Folkerts.** Toxicological Profiling of Hydraulic Fracturing Flowback Fluid on Zebrafish and Trout.
11:00 AM	**F. Leal.** Acute metabolic and cardiac effects of benzo-a-pyrene and 5-azacytidine in juvenile rainbow trout (*Oncorrhyncus mykiss*).
11:15 AM	**J. Decker.** Physiological Effects of Selenium and Mercury Mixtures in Two Salmonid Species: Rainbow Trout and Brook Trout.
11:30 AM	**D. Green.** Contamination and multi-decadal decay of reservoir-liberated mercury in a downstream fishery: effects of fish trophic level, size, and age.
11:45 AM	**A. Massé.** Elevated Maternal Dietary Selenium Exposure Produces Developmental Effects in Amphibians.
12:00 PM	**LUNCH BREAK**
1:00 PM	Plenary Speaker: **Karina Thomas, Alberta Health**. Health Risk Assessment: Linking Environmental and Human Health.
1:30 PM	**M. North**. Urban air pollution: In search of predictive biomarkers using wild birds as sentinels.
1:45 PM	**M. Gallant.** Immune system development and benzo[a]pyrene immunotoxicity in the amphibian *Xenopus laevis*.
2:00 PM	**V. Ortega.** Goldfish (*Carassius auratus*) immune responses to intravenously injected polymer-coated TiO2 nanoparticles.
2:15 PM	**S. Hanson.** Reproductive and general health assessment of fathead minnow (Pimephales promelas) populations inhabiting an effluent-dominated stream, Wascana Creek, SK, Canada.
2:30 PM	**COFFE BREAK**
3:00 PM	Plenary Speaker: **Vince Palace, Stantec.** Social License: A new paradigm for environmental monitoring in the oil and gas industry and beyond.
3:30 PM	**L. D'Silva.** Arsenic mobilization from sediments collected from a prairie reservoir, Buffalo Pound Lake, Saskatchewan, Canada.
3:45 PM	**M. Driessnack.** Effects of waterborne copper and nickel, singly and in mixture, on fathead minnow (Pimephales promelas) reproduction.
4:00 PM	**A. Jimmo.** Persistence and Toxicity of Garlon XRT® and Arsenal Powerline® in Soils along Transmission Right-of-Ways in the Yukon Territory..
4:15 PM	**A. Zare.** Microarray applications to investigate the impacts of exposure to environmental contaminants in male fathead minnows.
4:30 PM	**POSTER SOCIAL**
7:00 PM	**BANQUET AT MACEWAN HALL (MAIN CAMPUS)**

Campus Maps

Foothills Campus

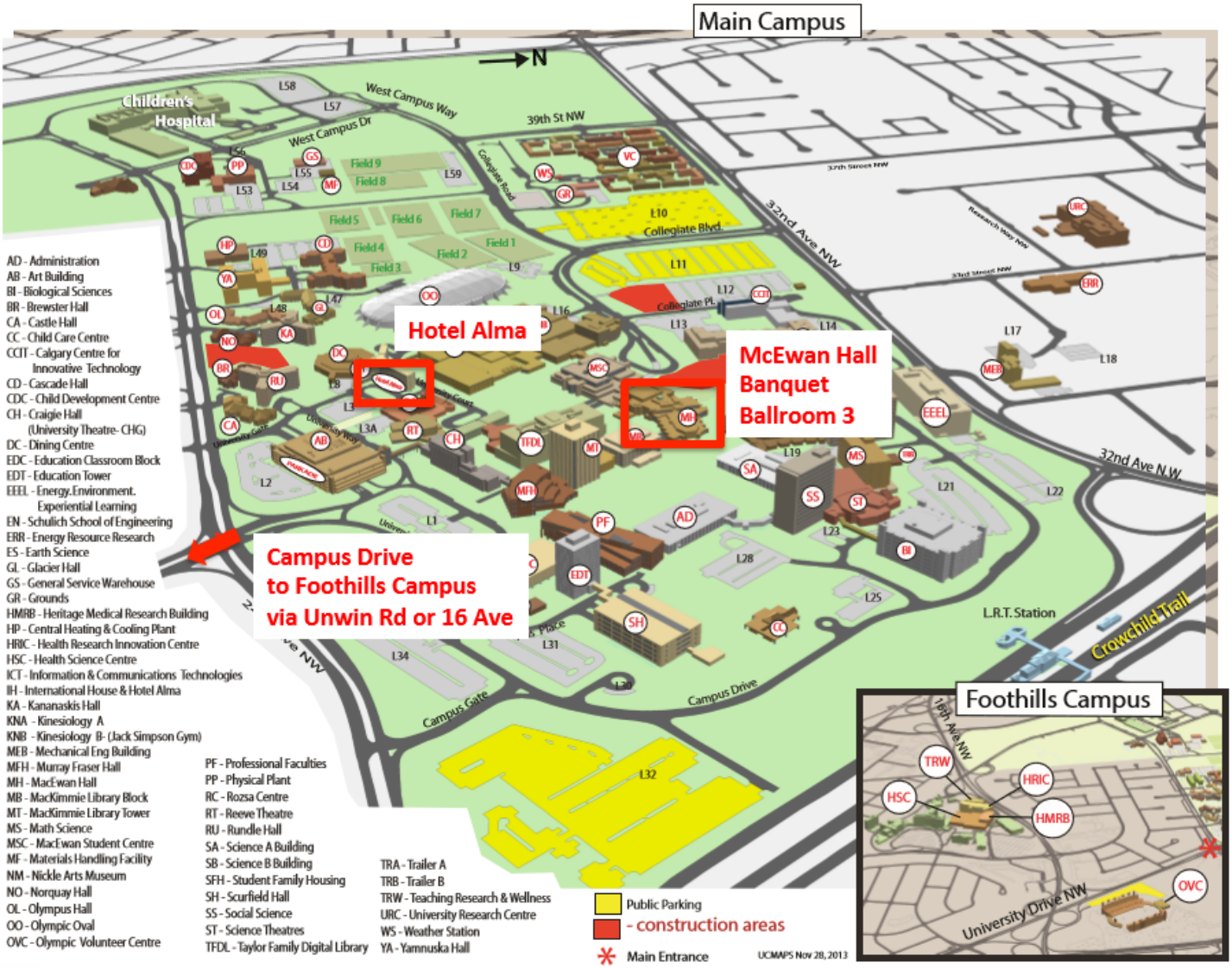
Meeting will take place at the Foothills Campus: 3330 Hospital Drive NW (pay parking available)



Campus Maps

Main Campus

Banquet will take place at Main Campus in the MacEwan Ballroom: 2500 University Drive NW (pay parking available – **lots in yellow**).



Plenary Speakers

Design and Implementation of Integrated Environmental Monitoring: Challenges and Opportunities

Dr. Fred Wrona

AEMERA

Dr. Wrona is the newly appointed Vice-President and Chief Scientist for the Alberta Environmental Monitoring and Evaluation Agency (AEMERA) in Alberta. Over the past 4 years, he was Senior Science Strategist and Advisor with Environment Canada, based out of the University of Victoria, where he is also a Professor in the Department of Geography and the Water and Climate Impacts Research Centre (W-CIRC). He has served as the science advisor to the Arctic Council's Arctic Monitoring and Assessment Program, was Canada's Head Delegate for the UNESCO-International Hydrology Program (IHP), and recently completed his tenure as the Invited Chair of the External Scientific Advisory Committee for the Centre for Environmental and Marine Studies (CESAM) at the University of Aveiro in Portugal. Dr. Wrona has >25 years of experience dealing with the ecology, hydrology and water quality of freshwater systems. He has published >130 peer-reviewed scientific articles, reports and proceedings in these areas and has been the recipient of numerous national and international distinctions and awards. Well acquainted with Alberta, Dr. Wrona served as the Scientific Director of the Northern River Basins Study (1992-96), and as a member of the International Science Advisory Committee of the Alberta Water Research Institute, which is now part of Alberta Innovates – Energy and Environment Solutions. Over the past year, he has also been the co-chair of the Component Advisory Committee (CAC) for Water with the Oil Sands Monitoring (OSM) program.

Plenary Speakers

Health Risk Assessment: Linking Environmental and Human Health

Dr. Karina Thomas

Alberta Health

Dr. Thomas has worked in the Environmental Health field in both government and academia for close to 15 years, focusing on risk assessment and health effects related to air, water, soil and food contamination. Her educational background includes degrees in Chemistry, Environmental Engineering, and Public Health Sciences. Dr. Thomas taught Environmental Epidemiology in the Environmental Health Program at Concordia University College in Edmonton, AB and has guest lectured at the University of Alberta. Her current files address a wide variety of environmental health topics including health concerns related to oil and gas development, drinking water quality, climate change and health, children's environmental health and ambient air quality.

Plenary Speakers

Social License: A new paradigm for environmental monitoring in the oil and gas industry and beyond

Vince Palace

Stantec

Vince is an aquatic toxicologist with over 20 years of experience in determining exposure, evaluating potential impacts and developing mitigative strategies related to chemical (metals, metalloids (arsenic, selenium), flame retardants, and pesticides, as well as non-chemical aquatic stressors. More recently, Vince has led a team to develop an environmental monitoring program establishing baseline conditions prior to construction of a petroleum pipeline. The program will establish environmental quality of the freshwater aquatic environment over a wide geographic region in western Canada. The monitoring program will assess potential impacts arising from construction and operation of the project, but will also establish recovery targets in the event of an oil spill.

Vince has considerable experience with Canada's regulatory framework for Environmental Effects Monitoring (EEM), having served as a member of the Science Advisory Panel for the metal mining and pulp and paper mill programs. Vince has provided expert opinion for numerous national and international clients including Environment Canada, Health Canada, the USEPA, United Nations Environment Program, and World Fisheries Trust.

Platform Schedule

1. **Recreating the soundscape: disentangling effects of oil well noise from infrastructure on grassland songbirds.** Rosa, Patricia[1*], Koper, Nicola[1].
2. **A comparison of conventional crude oil and dilbit developmental toxicity to zebrafish.** Philibert, Danielle, Lewis, Carlie, Tierney, Keith.
3. **How Surface Water Chemistry Conditions Representative of the Alberta Oil Sands Mining Region Can Shape the Acute Aqueous Toxicity of Vanadium.** Gillio-Meina, Esteban[1,2], Liber, Karsten[1].
4. **Cross-species comparison of relative potencies and relative sensitivities of fishes to dibenzo-p-dioxins, dibenzofurans, and polychlorinated biphenyls in vitro.** Doering, Jon[1], Eisner, Bryanna[1], Beitel, Shawn, Wiseman, Steve[1], Raine, Jason[1], and Hecker, Markus[1,2].
5. **Toxicological Profiling of Hydraulic Fracturing Flowback Fluid on Zebrafish and Trout.** Folkerts, Erik He, Yuhe[1], Goss, Greg[1].
6. **Acute metabolic and cardiac effects of benzo-a-pyrene and 5-azacytidine in juvenile rainbow trout (*Oncorrhyncus mykiss*).** Fred, Leal[1,2], Weber, Lynn[1,3].
7. **Physiological Effects of Selenium and Mercury Mixtures in Two Salmonid Species: Rainbow Trout and Brook Trout.** Decker, Jeff [1], Brinkman, Lars [1], Wang, Kang [2], Hontela, Alice [1].
8. **Contamination and multi-decadal decay of reservoir-liberated mercury in a downstream fishery: effects of fish trophic level, size, and age.** Green, D.[1], Duffy, M.[2], Janz, D. [1], McCullum, K.[2], Carriere, G.[3], Jardine, T.[1]
9. **Elevated Maternal Dietary Selenium Exposure Produces Developmental Effects in Amphibians.** Massé, Anita[1], Janz, David[1], Muscatello, Jorgelina[2].
10. **Urban air pollution: In search of predictive biomarkers using wild birds as sentinels.** North, M.A.[1], Bertazzon, S.[2], Kaplan, G.G.[3], Kinniburgh, D.W.[4], Larkin, A.[5], Smits, J.E.G.[1]
11. **Immune system development and benzo[a]pyrene immunotoxicity in the amphibian *Xenopus laevis*.** Gallant, Melanie[1], Hogan, Natacha[1].
12. **Goldfish (*Carassius auratus*) immune responses to intravenously injected polymer-coated TiO2 nanoparticles.** Ortega, Van, Boyle, David[1,3], Stafford, James[1], Goss, Greg[1,2].
13. **Reproductive and general health assessment of fathead minnow (*Pimephales promelas*) populations inhabiting an effluent-dominated stream, Wascana Creek, SK, Canada.** Hanson, Sara[1], Bagatim, Habata[2], Steeves, Kean[1], Wiseman, Steve[1], Hogan, Natacha[1,3], Hontela, Alice[4], Jones, Paul[1,2], Giesy, John[1,5], Hecker, Markus[1,2].
14. **Arsenic mobilization from sediments collected from a prairie reservoir, Buffalo Pound Lake, Saskatchewan, Canada.** D'Silva, Lawrence[1], Liber, Karsten[1,2], Baulch, Helen[2], Doig, Lorne[1].
15. **Effects of waterborne copper and nickel, singly and in mixture, on fathead minnow (*Pimephales promelas*) reproduction.** Driessnack, Melissa K.[1], Jamwal, Ankur[2], Niyogi Som[2].
16. **Persistence and Toxicity of Garlon XRT® and Arsenal Powerline® in Soils along Transmission Right-of-Ways in the Yukon Territory.** Jimmo, Amy[1], Stewart, Katherine[2], Siciliano, Steven[3].
17. **Microarray applications to investigate the impacts of exposure to environmental contaminants in male fathead minnows.** Zare, Ava, Henry, Darren, Chua, Gordon, Habibi, Hamid R.

Recreating the soundscape: disentangling effects of oil well noise from infrastructure on grassland songbirds

Rosa, Patricia[1], Koper, Nicola[1]

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Keywords: grassland songbirds, noise pollution, oil development, playback study

As noise becomes more prominent in many habitats, its impacts on wildlife remain difficult to assess. In western Canada, noise from oil well development may contribute to grassland bird population declines. To date, noise playback studies have failed to accurately reproduce the polluted soundscape, resulting in a limited understanding of its impact. To disentangle effects of noise from confounding factors of oil development (i.e. infrastructure presence, roads, traffic, human activities), we used a solar-powered broadcasting system that reproduces sound with high degree of source fidelity, surveyed bird abundance on transects, and monitored nesting success at pumpjack playback sites, silent playback sites, and control sites without playback infrastructure. We found positive effects of noise for certain species (Chestnut-collared longspurs and horned larks), but for other species, noise reduced abundance (Vesper sparrows). Differences in noise sensitivity were also observed. The presence of infrastructure and not of the noise itself also had varying effects by species due to increased perch availability. Thus, in our system, oil well noise does not have an overall negative or positive costs for residing songbird species. The management implications are not straightforward: simply reducing amplitude of noise without minimizing the footprint of above-ground infrastructure may not aid in conservation of grassland songbirds as a whole; species-specific mitigation must be considered.

A comparison of conventional crude oil and dilbit developmental toxicity to zebrafish

Philibert, Danielle, Lewis, Carlie,Tierney, Keith

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Keywords: oil, zebrafish, development, dilbit

The toxicity of diluted bitumen oil (dilbit) has been largely understudied, despite widespread transport and the potential for accidental environmental release. This study compared the effects of exposure to low and high concentrations of water accommodated fractions (WAFs; 1/1000 and 1/10 oil to water, respectively) of dilbit, a conventional mixed sweet blend crude oil, and a medium sour composite crude using larval zebrafish. Fish were exposed from 30 min to 7 days post-fertilization (dpf) and scored for survival, incidence of pericardial edema, yolk sac edema, abnormal tail curvature and hatch rate. Previous studies have suggested that crude oil WAF exposure inhibits axon path finding, decreases axon number and impairs escape behaviour in larval zebrafish (de Soysa *et al.* 2012). To determine the impact of Alberta conventional crudes and dilbit on the basal activity levels we compared maximum velocity, distance travelled and time spent in zones for 1/10 oil to water WAF exposed fish. Low concentration WAFs had no effects; high concentration WAFs of all three oil types increased pericardial and yolk sac edema, and decreased survival. The survivorship values (7d LC50) indicated that the varieties of conventional crude were more toxic than dilbit, demonstrating that the environmental risks associated with dilbit are less or no different from those of conventional crude.

How Surface Water Chemistry Conditions Representative of the Alberta Oil Sands Mining Region Can Shape the Acute Aqueous Toxicity of Vanadium

Gillio-Meina, Esteban[1,2], Liber, Karsten[1]

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Keywords**:** Vanadium, oil sands, OSPW, water chemistry

Alberta's oil sands industry generates approx. 8.5 million tonnes of coke yearly, which contain up to 5 % of vanadium (V) by weight. Recent investigations have explored the use of coke as a sorbent to reduce concentrations of organic chemicals in oil sands process water (OSPW). Unfortunately, in the process V is released from the coke and can increase in "treated" OSPW to levels up to 7 mg/L of V. Little work has been done to understand how common water quality variables can affect toxicity of V to aquatic organisms. Here the potential for adverse effects of V to aquatic organisms is described by developing relationships that model how different characteristics of representative surface water affect V toxicity to *Daphnia pulex*. Also, V speciation will be modeled using Visual MINTEQ to better understand the effects of key constituents of OSPW on the toxicity of V. Results to date indicate that an increase in pH results in a threshold relationship, where toxicity increases between pH 6 and 7, but then levels off, which could be related to an increase in the proportion of $H_2VO_4^-$ and HVO_4^{-2} species. In addition, when alkalinity increased from 100 to 600 mg/L as $CaCO_3$, the toxicity of V decreased following a saturation model. Also, when sulphate concentrations were raised from 30 to 380 mg/L, the LC_{50} to *D. pulex* rose following a quadratic model. However, changes in water hardness (70 to 140 mg/L $CaCO_3$) and chloride concentration (10 to 120 mg/L) did not have a modifying effect in V toxicity.

Cross-species comparison of relative potencies and relative sensitivities of fishes to dibenzo-*p*-dioxins, dibenzofurans, and polychlorinated biphenyls *in vitro*

Doering, Jon[1], Eisner, Bryanna[1], Beitel, Shawn[1], Wiseman, Steve[1], Raine, Jason[1], Hecker, Markus[1,2]

[1]Toxicology Centre, University of Saskatchewan, Saskatoon, SK, Canada
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Keywords: fish, risk assessment, TEFs, in vitro

Dioxin-like compounds (DLCs) of varying toxicities are found in complex mixtures. In order to enable streamlined risk assessment of DLCs, the toxic equivalency factor (TEF) approach was developed based on the potency of a DLC relative to the potency of the most toxic DLC. One limitation of this approach is uncertainty regarding differences in relative potency (ReP) among different species. RePs among fishes are limited relative to RePs for DLCs among birds and mammals and TEFs for fishes are based entirely on the model test species, rainbow trout. A liver explant assay was utilized to characterize species-specific responses with regard to up-regulation of CYP1A transcript following exposure to DLCs in rainbow trout, white sturgeon, lake sturgeon, and northern pike. Differences in sensitivities were observed among species with rainbow trout having the greatest sensitivity. RePs developed from liver explants of rainbow trout were comparable to RePs developed from embryos. RePs ranged by up to 40-fold among the species tested. To compare RePs among species, concentrations of DLCs in eggs in the Fraser River and Lake Ontario were used to calculate toxic equivalents (TEQs) using TEFs or TCDD equivalents (TCDD-EQs) using RePs. It was demonstrated that TEQs accurately represent TCDD-EQs for rainbow trout. TEQs underestimated TCDD-EQs for white sturgeon, lake sturgeon, and northern pike, indicating uncertainties in the application of current TEFs.

Toxicological Profiling of Hydraulic Fracturing Flowback Fluid on Zebrafish and Trout

Folkerts, EriK[1], He, Yuhe[1], Goss, Greg[1]

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Keywords: Toxicology, Hydraulic Fracturing, Trout, Zebrafish

Hydraulic fracturing and horizontal drilling practices are becoming a growing component of the Alberta and British Columbia energy sectors. A by-product formed from these practices is a surface returned fracturing proppant mixture called flowback fluid. To date, significant knowledge gaps exist not only on the chemical identity and characteristics of this secondarily formed fracturing flowback fluid, but also on the handling, disposal, and potential hazards posed to the aquatic environment. Profiling the toxigenicity of this fluid on fresh water aquatic vertebrate species (*Oncorhynchus mykiss* and *Danio rerio*), we have found this fluid to have significant toxicological effects at several life stages, affecting survival, development, and specific toxin induced gene expression changes. Future acute and chronic exposure assays will further help to outline potential protocols for remediation efforts should spills or leaks occur. This study is the first in Canada to investigate the effects hydraulic fracturing fluid has on indicator species.

Acute metabolic and cardiac effects of benzo-a-pyrene and 5-azacytidine in juvenile rainbow trout (*Oncorrhyncus mykiss*)

Leal, Fred.[1,2], Weber, Lynn[1,3]

[1]Toxicology Graduate Program, [2]CREATE HERA Program, [3]Veterinary Biomedical Sciences, University of Saskatchewan, Saskatoon SK

Keywords: epigenetics, cardiovascular, metabolism, benzo-a-pyrene

Benzo-a-pyrene (BaP), an ubiquitous contaminant, exerts acute cardiotoxicity in fish and induces persistent effects via epigenetic modifications. 5-Azacytidine (5AZA) inhibits DNA methylation and was used to determine if DNA methylation plays any role in acute BaP cardiac toxicity. Juvenile rainbow trout were injected twice with control vehicle or BaP (0.1, 1mg/kg) with/without 5AZA (2mg/kg) in a 2x3 factorial study design, then cardiac ultrasound performed and fish euthanized on days 4 and 7 (n=10 fish/group/time). Heart, red muscle and liver were removed for analysis of triglycerides and glycogen content, as well as activity of ethoxyresorufin-o-deethylase, 3-hydroxyacyl coenzyme A dehydrogenase, citrate synthase, and lipoprotein lipase. 5AZA alone increased heart rate and decreased duration of blood flow through the atrioventricular and ventriculobulbar valves and caudal aorta at Day 4. Blood flow velocity through atrioventricular valve during atrial diastole decreased with high-BaP alone. Triglycerides stores increased in muscle at both doses of BaP+5AZA compared to 5AZA alone; in heart by high-BaP and high-BaP+5AZA compared to control as well as with 5AZA alone. Furthermore, triglycerides increased in liver with high-BaP+5AZA compared to 5AZA alone. All cardiac function and triglycerides values returned to control levels at Day 7. Although cardiac and metabolic effects were observed, we found no evidence of persistence or potentiation of effects due to epigenetic mechanisms playing a role in acute cardiotoxicity or impairment of metabolism.

Physiological Effects of Selenium and Mercury Mixtures in Two Salmonid Species: Rainbow Trout and Brook Trout

Decker, Jeff [1], Brinkman, Lars [1], Wang, Kang [2], Hontela, Alice [1]

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Selenium (Se) is an essential element; however, at slightly above homeostatic concentrations Se becomes toxic. Recent studies suggest that Se has antagonistic interactions with mercury (Hg), a non-essential element that biomagnifies in the food chain and accumulates in fish. Our study investigated the effects of mixtures of Se and Hg on brook trout and rainbow trout under controlled laboratory conditions. Fish were exposed to Se (Se-methionine) through diet for 28 days. After 14 days of Se exposure, fish were injected with a single controlled dose of Hg ($HgCl_2$). Tissue concentrations of Se and Hg, liver GSH and LPO, and plasma T3 and T4 were measured on Day 28. Se and Hg accumulated in the muscle and liver of both species and exposure to high concentrations Se in the diet increased Hg accumulation in the muscle of rainbow trout, suggesting a Se-Hg interaction. Also, Hg caused adverse effects such as oxidative stress, decreased plasma thyroid hormone concentration and lower growth and condition. Interestingly, evidence of Se antagonism was reported only in brook trout liver GSH concentration and plasma T4 concentration, endpoints which both rely on Se for normal function.

CONTAMINATION AND MULTI-DECADAL DECAY OF RESERVOIR-LIBERATED MERCURY IN A DOWNSTREAM FISHERY: EFFECTS OF FISH TROPHIC LEVEL, SIZE, AND AGE

Green, D.[1], Duffy, M.[2], Janz, D. [1], McCullum, K.[2], Carriere, G.[3], Jardine, T.[1]

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Keywords: Industrialization, mercury, bioaccumulation, fisheries.

Aquatic mercury (Hg) can be biomethylated into a potent neurotoxin, MeHg. Hydroelectric reservoir construction is frequently responsible for bioaccumulation of MeHg within endemic biota. [Hg] in fish impounded in artificial reservoirs and affected downstream sites can exceed this limit and take decades to decay below the 0.5 mg/kg consumption guideline. The present study examines the characteristics of fish affecting mercury decay from a hydroelectric reservoir created in 1963 and an affected downstream fishery in the Saskatchewan River Delta. Rates of decay in Tobin Lake (reservoir) and Cumberland Lake (delta) were analyzed using exponential regression. Northern pike (*Esox lucius*), sauger (*Sander canadensis*), goldeye (*Hiodon alosoides*), and walleye (*Sander vitreus*) all showed significant decay rates between the 1970s and present (Tobin: $p < 0.05$ for all regressions; Cumberland: $p < 0.01$ for all regressions). In *S. vitreus*, contemporary tissue [Hg] was strongly correlated with length, age and reservoir proximity. Stable nitrogen isotopes were used to assess correlations between Hg and trophic levels, but explained little additional variation beyond that accounted by length and age. Our results suggest that contemporary fish [Hg] have decayed below consumption guidelines.

Elevated Maternal Dietary Selenium Exposure Produces Developmental Effects in Amphibians

Massé, Anita[1], Janz, David[1], Muscatello, Jorgelina[2]

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Keywords : selenium, amphibian, development

Selenium (Se) is a contaminant of potential concern in aquatic systems due to its bioaccumulation at higher trophic levels within the food web and its role as a developmental toxicant in oviparous vertebrates. The objective of this study was to determine early life stage Se toxicity tissue thresholds in amphibians. Following a 68 day dietary exposure to food augmented with L-selenomethionine at measured concentrations of 0.7 (control), 10.9, 30.4, and 94.2 µg Se/g d.m., adult female *X. laevis* were bred with untreated males and the resultant embryos were evaluated for endpoints related to mortality, maturation and malformation. There were no biologically significant differences among the treatment groups in relation to fertilization success, hatchability or mortality of tadpoles within the first 5 dpf. The measured Se concentration in eggs showed mean values of 1.6 (control), 10.8, 28.1 and 81.7 µg Se/g d.m., respectively. Both the frequency and severity of total abnormalities were significantly increased in the 5 dpf tadpoles from the 81.7 µg Se/g egg d.m. group when compared to the control (p<0.001) with an EC_{10} value for egg based tissue threshold pertaining to teratogenic abnormalities for *X. laevis* estimated at 44.86 µg Se/g d.m.. Time to metamorphosis and mortality in the later stages of tadpole development showed no significant differences among treatment groups.

Urban air pollution: In search of predictive biomarkers using wild birds as sentinels

North, M.A.[1], Bertazzon, S.[2], Kaplan, G.G.[3], Kinniburgh, D.W.[4], Larkin, A.[5], Smits, J.E.G.[1]

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Keywords: Urban air-pollution, sentinels, wild birds, biomarkers

Increasingly sensitive equipment has substantially improved detection and measurement of air pollutants. Burgeoning human population and increased transport and power requirements mean that many cities suffer from heavy pollution burdens. Epidemiological studies demonstrate associations between disease (e.g., asthma and cardiovascular disease), and air pollution, but proof of causality is elusive. Establishing reliable biomarkers in free-living sentinel species would permit monitoring of exposure and toxicity which may serve as early-warning systems relevant to human health. Nest boxes are located in areas of relatively higher and lower air pollution in Calgary to attract wild birds. Biological responses including growth and development, survival, immune function, detoxification and oxidative stress are measured in nestling European starlings for evaluation as potential biomarkers of exposure to urban air pollution. Additionally, a combined approach to air pollution is investigated, including the novel use of personal membrane-type passive air monitors to provide local exposure data. This is a novel, integrative approach to investigating the biological effects of chronic exposure to air pollution under natural conditions.

Immune system development and benzo[a]pyrene immunotoxicity in the amphibian *Xenopus laevis*

Gallant, Melanie[1], Hogan, Natacha[1]

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Keywords: Immunotoxicology, *Xenopus laevis*, cytokines, development.

The recent large-scale disease outbreaks in certain amphibian populations have highlighted the need to better understand contaminant-induced immunotoxicity. Cytokines are soluble proteins that allow communication between immune organs when mounting an inflammatory immune response and the analysis of mRNA levels has been used as a marker of immunomodulation. In this study, expression of the cytokines interleukins-1β (IL-1β) and tumor necrosis factor α (TNF- α) were characterized across development to determine basal expression. Results indicate that their expression is transient over development and raise the question of differential sensitivity to immunomodulation across stages. We then exposed *Xenopus laevis* tadpoles at various stages of development to benzo[a]pyrene, a model polycyclic aromatic hydrocarbon and known immunotoxicant in mammals and fish. In three separate exposures, tadpoles were reared to a specific stage of development (representing embryo-larval, pre-metamorphosis and pro-metamorphosis) and exposed to sub-lethal concentrations of benzo[a]pyrene. Individuals were examined for morphological abnormalities, lengthed, weighed and collected for gene expression analysis of the pro-inflammatory cytokines. Results indicate that the immunotoxic impacts of benzo[a]pyrene are stage dependent. This research will help us understand mechanisms underlying developmental stage-specific immunomodulatory effects of B[a]P. Reducing the efficiency of immune defense mechanisms could increase the susceptibility to infectious agents and contribute to various detrimental health effects in amphibians.

Goldfish (*Carassius auratus*) immune responses to intravenously injected polymer-coated TiO_2 nanoparticles

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Evidence of nanoparticle (NP) effects on immune cell function has been demonstrated using *in vitro* models in previous studies that report both the over-activation of pro-inflammatory responses, and suppression of others. Our group has also demonstrated modified immune effects for both cell lines and isolated primary goldfish neutrophils when exposed *in vitro* to polymer-coated metal-oxide NPs. However, the translation of these effects to *in vivo* models has not yet been explored. Despite a lack of information of *in vivo* immune effects, it has been shown that when NPs enter circulation in fish, the vast majority is deposited into kidney tissues, which in fish are the major hematopoietic organ and where many innate immune cells reside. Thus, there is an increased opportunity for neutrophils and macrophages in the kidneys to interact and be affected by tissue-accumulated NPs. In this study we have isolated kidney neutrophils and macrophages at 0, 1, 7 and 14 days from mature goldfish (C*arassius auratus*) injected on day 0 with either polymer-coated TiO_2 (1 µg/g) or to Cortland's saline (control). At each time point, kidney, spleen, blood, kidney neutrophils and macrophages were extracted for measurement of tissue metal distribution, expression of various immune and apoptotic-related genes and neutrophil degranulation and respiratory burst. Peripheral blood and tissue prints were also collected for analysis of white blood cell proportions. Preliminary results show increased neutrophil degranulation and respiratory burst relative to control. Gene expression, tissue metal distribution and blood proportional results will be presented.

Reproductive and general health assessment of fathead minnow (*Pimephales promelas)* populations inhabiting an effluent-dominated stream, Wascana Creek, SK, Canada.

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Keywords: Endocrine disruption, Municipal wastewater, Wascana Creek, Fathead minnow

Waterbodies in the southern Canadian Prairies may be at an elevated risk to the exposure with contaminants released from municipal waste-water effluents (MWWEs), particularly endocrine disrupting compounds (EDCs), due to the uniqueness of prairie surface water systems. During low flow periods, Wascana Creek, a small stream in southern Saskatchewan can consist of up to 100% treated effluent originating from the City of Regina's outdated lagoon based treatment facility. The aim of this study was to characterize the potential endocrine disrupting effects of municipal waste-water effluents on wild fathead minnow (*Pimephales promelas*; FHM) populations in an effluent dominated stream, Wascana Creek, SK. Field studies were conducted during the spawning season (August 2014) to assess responses in terms of overall health (condition factor, somatic indices), reproduction (secondary sexual characteristics, gonadal morphology and histology, gene expression), and sex ratios. FHMs downstream of the effluent fallout had lower gonadosomatic indices and significantly greater hepatosomatic indices compared to upstream populations. Additionally, there was significant disruption of regulation of key genes associated with reproductive processes. Exposed male Fathead Minnows displayed lower scores of secondary sexual characteristics. Preliminary data supports the hypothesis that MWWEs might be adversely impacting populations of FHMs inhabiting receiving waters around Regina, thus, warranting further research.

Arsenic mobilization from sediments collected from a prairie reservoir, Buffalo Pound Lake, Saskatchewan, Canada.

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Keywords: Arsenic, Sediments, Anoxia, Internal Loading

Buffalo Pound Lake, Saskatchewan, is a eutrophic reservoir that provides potable water to nearby cities. The development of annual summer algal blooms creates water treatment challenges. Lake sediments are potentially releasing nutrients into the overlying water and driving these annual blooms, while simultaneously releasing associated arsenic (As). Using sediment core incubations, this study investigated the effects of oxygen status and temperature on metalloid and nutrient mobilization from Buffalo Pound Lake sediments.

Sediment cores from sites were incubated (cores collected June, 2014) in either oxic or anoxic conditions 35 days at 20°C, simulating summer conditions. Overlying water was analyzed for dissolved As, iron, manganese, and phosphorus fractions. A second core incubation (cores collected October, 2014) simulating winter conditions was conducted using a similar design with core incubation for 105 days at 4°C.

Arsenic release was similar under both oxic (0.61±0.27 mg/m^2/day, n=12) and anoxic (0.73±0.30 mg/m^2/day, n=12) conditions during the summer incubation.

Arsenic remobilization under anoxic conditions was likely due to dissolution of sediment oxyhydroxides, and release of associated As into overlying water. Arsenic remobilization under oxic conditions was likely due to the formation of anoxic conditions below a thin oxic sediment-water interface, and the inability of the thin oxic layer to scavenge As diffusing upward.

The winter incubation is completed and samples are currently being analyzed. Once finished, As release under summer and winter conditions will be compared.

Effects of waterborne copper and nickel, singly and in mixture, on fathead minnow (*Pimephales promelas*) reproduction

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Keywords: copper, nickel, fathead minnow, reproduction

We examined the reproductive effects of single and combined waterborne copper (Cu) and nickel (Ni) exposure in fathead minnow (FHM; *Pimephales promelas*) using a 21-day bioassay. Trios of FHM (1 male: 2 female; n=5) were exposed to: (i) control (no added metals), (ii) Cu (30 µg/L; ~15% of 96h LC_{50}), (iii) Ni (250µg/L; ~15% of 96h LC_{50}), and (iv) Cu (30 µg/L) plus Ni (250 µg/L). Over the 21-day exposure, cumulative egg production and spawning events were found to be significantly reduced by Cu and Ni, both singly and in mixture, however the mixture of Cu and Ni did not elicit any additive effects. Tissue-specific (gill, liver and gonad) accumulation of Cu and Ni increased in the respective single metals and metal mixture exposures, although no interaction between Cu and Ni accumulation was observed. The alterations in hepatic expression of key female reproductive genes [vitellogenin (Vtg), estrogen receptors (ER-α and ER-β)] were generally more pronounced in Cu-only, and Cu and Ni mixture treatments. In particular, Vtg expression was found to be significantly downregulated in both of these treatments relative to the control and Ni-only treatments. Overall, our results indicate that both Cu and Ni can impair fish reproduction during chronic exposure, albeit via different physiological mechanisms.

Persistence and Toxicity of Garlon XRT® and Arsenal Powerline® in Soils along Transmission Right-of-Ways in the Yukon Territory.

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Keywords: Yukon, Herbicide Use, Soil, Invertebrates

Vegetation management along transmission right-of-ways (ROWs) in the Yukon consists of mechanical methods such as mowing and brushing. When mowed, fast growing woody species that dominate these ecosystems need to be controlled frequently. Thus other vegetation control measures, such as herbicide application, that can reduce management costs, improve long-term effectiveness and reduce environmental risks are being examined. This research aims to determine the persistence and toxicity of Garlon XRT® (triclopyr) and Arsenal Powerline® (imazapyr) in soils along Yukon ROWs.

Soil samples from field application (foliar spray, cut stump and point injection) are currently being analyzed, however, it is hypothesized that the herbicides will persist longer in northern soils when compared to average half lives reported for temperate soils. This can be attributed to the length of time the soil is frozen, reducing attenuation rates through both microbial and chemical degradation. Invertebrate toxicity assays will be utilized to determine the ecological risk associated with application on five Yukon ROWs. It is hypothesized that less than 25% of the soil invertebrate population will be affected when applied at maximum application rates.

Microarray applications to investigate the impacts of exposure to environmental contaminants in male fathead minnows

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Keywords: Gene expression, Biomarker, endocrine disruption, Microarray

Chronic or acute exposure to environmental contaminants may result in impairment of reproduction, metabolism and development in wild life and humans. Efficient, specific, and robust biomarkers will be needed to develop effective screening tools. Our main objective was to use microarray approach to investigate the mechanisms that may be involved in the adverse effects of a number of chemicals present in Alberta Rivers [Nonylphenol, BPA, DEHP and mixture of the three chemicals]. IPA core and toxicity analysis, and gene ontology revealed distinct modes of action for the individual chemicals and their mixture in the liver of male fathead minnows. A number of canonical pathways were significantly affected by these contaminants, including cell cycle & proliferation, inflammatory, innate immune response, stress response, and drug metabolism. In the present study, we identified a number of genes as potential biomarkers for monitoring all contaminants as well as the individual chemicals. In general the results of this study provide novel information on mechanisms by which contaminants disrupt normal health based on pathway analysis, and identified a number of specific new biomarkers that can be used for screening the presence of contaminants in the aquatic environment.

Study was funded by NSERC grants.

Poster Session

1. **Predicting the Acute Toxicity of Oil Sands Process Affected Water to embryos of Fathead minnow (*Pimephales promelas*).** Morandi, Garrett[1*], Zhang, Kun[2], Wiseman, Steve[1], Pereira, Alberto[2], Martin, Jonathan[2], Giesy, John[1,3,4,5,6,7,8,9].
2. **The effects of water hardness on the swimming performance and metabolic status in fathead minnows (*Pimephales promelas*).** Manek, Aditya[1], Dillman, Brett[1], Weber, Lynn[2], Meays, Cindy[3], Pyle, Gregory[1].
3. **Exploring right hand coiled coil (RHCC) proteins as a matrix for a new aquatic passive sampling device for PAHs.** Leslie, Jennifer[1], Stetefeld, Jorg[2], McDougall, Matthew[3], Hanson, Mark[4], Palace, Vince[5].
4. **Pathways to Petroleum: Developing an Exhaustive One-Pot Reduction Method for Naphthenic Acids.** Hynes, Tristan,[1] Withey, Jonathan[1], Ross, Matthew S.[1]
5. **Effects of Multiple Stressors (Diltiazem, Temperature, and Hypoxia) on the Behavioural and Physiological Performance of Rainbow Trout (*Oncorhynchus mykiss*).** Keller, A. G.[1], Manek, A.[1], Brooks, B.[2], Pyle, G.[1], Hontela, A.[1]
6. **The role of thermodynamics and metal exposure on mammalian bioavailability of polycyclic aromatic hydrocarbons (PAHs).** James, Kyle[2], Siciliano, Steven[1,3].
7. **Ecological risk assessment of pesticides in Manitoba waters: 1995-2014.** Moore, Dana[1,2], Wong, Charles[2], and Hanson, Mark[1].
8. **Sublethal effects of polymer-coated titanium dioxide nanoparticles and ultraviolet light coexposure in developing zebrafish (*Danio rerio*).** Felix, Lindsey[1], Oliveira, Taiane[1], Goss, Greg[1,2].
9. **Assessing biological effects of municipal wastewater effluent using the fathead minnow reproductive bioassay.** Steeves, Kean[1], Hanson, Sara[1], Bagatim, Tabata[2], Wiseman, Steve[1], Jones, Paul[1], Giesy, John[1,4], Hontela, Alice[3], Hogan, Natacha[1], and Hecker, Markus[1,2]
10. **Inhibition of multi-xenobiotic resistance (MXR/MDR) efflux activity as a potential mechanism of toxicity of oil sands process affected water.** Alharbi, Hattan, Saunders, Giesy, JWiseman, Steve.
11. **Investigating the potential effects of polycyclic aromatic hydrocarbons on rainbow trout (*Oncorhynchus mykiss*) gastrointestinal microbiome composition.** Moate, Ashley[1], Jardine, Tim[1,2], Wiseman, Steve[1], Van Kessel, Andrew[3], Hecker, Markus[1,2].
12. **Standard vs. regionally-relevant test species: Determining the toxicity of vanadium to aquatic organisms representative of the Athabasca Oil Sands region.** Schiffer, Stephanie[1,2], Doig, Lorne[2], Liber, Karsten[2].
13. **Canada's new Centre for Oil and Gas Research and Development (COGRaD) at University of Manitoba.** Tomy, Gregg T.[1], Stetefeld, Jorg[1], Halldorson, Thor[1]; Bestvater, Lianna[1], Palace, Vince[2].
14. **Inputs of Chemical Contaminants Along the Lower Red River.** Joudan, Shira[1], Cuscito, Leah D.[1], Voloshina, Maria[1], Henderson, Anna R. P.[1], Bestvater, Lianna[2], Luong, Kim[1], Knapp, Charles W.[3], Hanson, Mark L.[4], Wong, Charles S.[1,4].
15. **Is the Recovery of the Soil Nitrifying Community after Metal Toxicity determined by Metal Type, Energy or Soil Properties?** Awuah, Fred, Siciliano, Steven.
16. **Development of a novel assessment approach to track changes in the toxicity of specific chemicals of concern in oil sands process water.** White, Kevin[1*], Liber, Karsten[1].
17. **Developing the brook stickleback (*Culaea inconstans*) as a bioindicator of exposure to endocrine disrupting compounds in aquatic environments.** Muldoon, Breda, Hogan, Natacha.
18. **An Investigation into Occurrence of Wastewater Contaminants in Norway House Cree Nation.** Luong, Kim[1], Challis, Jonathon[2], Lobson, Chelsea[3], Knapp, Charles[4], Wong, Charles[1,2], Hanson, Mark[3]

Poster Session

19. **Naphthenic Acid Biodegradation by Photosynthetic and Non-photosynthetic Microbial Communities in Oil Sands Process-Affected Water.** Clothier, Lindsay N[1], Quesnel, Dean M.,[1] Chua, Gordon,[1] Gieg, Lisa M.[1]
20. **Assessing the occurrence of wastewater contaminants in Cambridge Bay.** Chaves-Barquero, Luis,[1,3], Hanson, Mark[1], Wong, Charles[1,2], Knapp, Charles[4], Luong, Kim[2], Mundy, C.J.
21. **Is Oxidative Stress the Main Driver of Selenium Toxicity in Juvenile White Sturgeon (*Acipenser transmontanus*)?** Zee, Jenna[1], Patterson, Sarah[2], Wiseman, Steve[2], Tang, Song[2], Hecker, Markus[1,2].
22. **Stability and Rat Liver Microsome Oxidative Metabolism of Secoisolariciresinol (SECO) Analogues.** McGurn, Leah[1], Krol, Ed[2].
23. **The Use of the Chitinolytic Enzyme Chitobiase as an Indicator of Aquatic Ecosystem Health.** Randell, Matthew, Hanson, Mark.
24. **Bioassay-directed characterization of endocrine-disrupting potencies of municipal effluents in Canada.** Bagatim, Tabata[1], Hanson, Sara[2], Yuan, Hongda[2], Steeves, Kean[2], Wiseman, Steve[2], Hogan, Natacha[2,3], Hontela, Alice[4], Jones, Paul[1,2], Giesy, John[2,5], Bragg, Leslie[6], Dhiyebi, Hadi[6], Servos, Mark[6], Gauthier, Charles[7], Gagné, François[8], Hecker, Markus[1,2].
25. **Sub-lethal Behavioral Effects of Oil Sands Process-affected Water Exposure in Zebrafish.** Ingraham, Erica[1], Morrill, Adam[1], Johnson, Adrian[1], Hamilton, Trevor J.[1], Ross, Matthew S.[2]
26. **The impact of venlafaxine on neurogenesis in Zebrafish.** Thompson, Andrew, Best, Carol, Kurrasch, Deborah, Vijayan, Mathalikath.
27. **The developmental, cellular and genetic responses of the model plant, *Arabidopsis*, after exposure to oil sands process affected water and naphthenic acids.** Olsen, Steven, Alberts, Mitchell, Widdup, Ellen, Muench, Doug[1].
28. **Assessing the health impact of the acid extractable organic fraction of oil sands process affected water on embryonic zebrafish (*Danio rerio*).** Toth, Cameron G. A., Chua, Gordon, Habibi, Hamid R.
29. **Determination of Acute and Sub-Chronic Toxicity of Emerging Contaminants in Early Life Stages of Northern Pike (*Esox lucius*).** Schultz, D.[1*,] Beitel, S.[1], Sarauer, B.[1], Tang, S.[1], Hanson, S.[1], Hecker, M.[1], Janz, D.[1], Wiseman, S.B.[1], Jones, P.D.[1], Giesy, J.P.[1]
30. **Assessing biochars made from Albertan industrial wastes for utilization as tailings ponds reclamation caps.** Frankel, Mathew[1,2], Veksha, Andrei[3], Turner, Raymond[1], Hill, Josephine[3], Helleur, Robert[4].
31. **A novel passive sampler for the measurement of polar organic contaminants in aquatic systems.** Challis, Jonathan K.[1], Hanson, Mark L.[2], Wong, Charles S.[1,3]
32. **The role of sediment characteristics in the adsorption and bioavailability of uranium(VI) in freshwater sediments**. Crawford, Sarah[1,2], Emmons, Sydney[2], and Liber, Karsten[2, 3].
33. **Sulfamethoxazole transformation products in wastewater effluent dominated streams pose little risk of toxicity to aquatic organisms.** Lobson, Chelsea[1], Hanson, Mark.
34. **Characterizing the Cumulative Action of Neonicotinoid Insecticide Mixtures on a Sensitive Aquatic Insect Species**. Maloney, E.,[1,2], Morrissey, C.,[3,4], Headley, J.,[5], Peru, K.,[5], Liber, K.[1,4]
35. **The effect of thiamethoxam on aquatic invertebrates and fate in shallow model wetlands**. Vanderpont, Adam[1], Lobson, Chelsea[1], Lu, Zhe[2], Luong, Kim[2], Arentsen, Marie-Claire[2], Vera, Trisha[2], Moore, Dana[2], White, Michael[3], Wong, Charles[2] and Hanson, Mark[1].

Predicting the Acute Toxicity of Oil Sands Process Affected Water to embryos of Fathead minnow (*Pimephales promelas*).

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Keywords: Oils Sands process affected water, Target lipid model, Effect-directed analysis

Oil sands process-affected water (OSPW) produced during the extraction of bitumen in the surface-mining oil sands industry in Alberta, Canada, is acutely and chronicly toxic to aquatic organisms. The dissolved organic fraction of OSPW is responsible for toxic effects, but knowledge of the specific chemicals that cause toxicity is limited. Using a top-down approach, a predictive aquatic toxicity model has been developed to predict the acute toxicity of the organic fraction of OSPW to early-life stages of fathead minnow, a ecologically relevant species in the Athabasca region. Mixture composition and the concentration of individual mass fractions is characterized by use of Orbitrap ultra-high resolution mass spectrometry. Bioaccumulation estimates were made by use of polydimethylsiloxane (PDMS)-coated stir bar sorptive extraction or solid supported lipid membranes (SSLM). A narcosis mode of action was assumed and the target-lipid model of Di Toro *et al.*, 2000 was applied for toxicity predictions of mass fractions. The 96 hr LC50 was predicted assuming strict additivity of hazard and compared to in-lab embryo lethality assays. Predictions compared well with observed acute lethality and highlight the accuracy of this spreadsheet model for predicting the acute toxicity of the organic fraction of OSPW. In addition, the contribution of chemical classes identified by use of a effect-directed analysis of the dissolved organics are investigated and highlight chemical classes of concern.

The effects of water hardness on the swimming performance and metabolic status in fathead minnows (*Pimephales promelas*).

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Keywords: hardness, U_{crit}, triglycerides, glycogen.

Industrial activities can be associated with the release effluents to freshwater systems. Some effluents can substantially increase water hardness (calcium and magnesium ions). Water hardness is known to have ameliorative effects against metal toxicity in aquatic organisms. Little is known about the effects of changing water hardness by itself on the swimming performance and metabolic status in freshwater fish species. Swimming performance can be used as a surrogate to suggest hardness-induced effects related to ionoregulation, gas exchange, and metabolism in a fish. The main goal of this study was to assess if exposure to soft (50 mg/L as $CaCO_3$) and hard water (600 mg/L as $CaCO_3$) at a constant calcium:magnesium ratio affects endurance swimming performance (U_{crit}) and metabolic status (triglycerides and glycogen) in liver and muscle from adult fathead minnows. Fathead minnows were exposed to the aforementioned hardness concentrations in a modified swim tunnel to evaluate U_{crit}. Post exhaustion, liver and muscle samples were collected from exposed fish for triglyceride and glycogen measurements. Findings of our preliminary study suggest that water hardness does not significantly affect swimming performance. Ongoing triglyceride and glycogen analysis will shed light on the metabolic status of these fish.

Exploring right hand coiled coil (RHCC) proteins as a matrix for a new aquatic passive sampling device for PAHs

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Keywords: Passive Sampler, Right Hand Coiled Coil (RHCC), Protein, Poly-Aromatic Hydrocarbons

Passive Sampling Devices (PSDs) are increasingly used to determine the bioavailability of contaminants in aquatic systems. PSDs accumulate contaminants similarly to the biota they are intended to model and are constructed from various adsorptive materials. They are retrieved easily, extracted inexpensively, and provide certainty of contaminant occurrence in the area of interest. Current PSDs have relatively long times associated with reaching equilibrium which becomes problematic when volatiles are present. Right Hand Coiled Coil (RHCC) is a protein isolated from bacteria that reside in deep sea hydrothermal vents. The protein is thermally stable, resistant to a wide range of salinity, pH and sulfide concentrations and can be custom synthesizedin the laboratory in a variety of polymeric forms. The binding of 16 priority PAHs to the RHCC protein was examined in a series of benchtop experiments. X-ray crystallography was used to demonstrate binding of each PAH in the internal cavity of the protein. These studies demonstrate the potential for RHCC proteins to be used as a new matrix for PSDs for modeling the bioavailability of PAHs.

Pathways to Petroleum: Developing an Exhaustive One-Pot Reduction Method for Naphthenic Acids

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Keywords: Oil Sands, Naphthenic Acids, Organosilane Reduction, Gas Chromatography

Oil sands process-affected water (OSPW) contains a heterogeneous and largely uncharacterized complex mixture of petroleum-derived organic acids, commonly termed naphthenic acids (NAs). NAs are acutely and chronically toxic to aquatic organisms, and have demonstrated chronic toxicity to mammals. In order to further our understanding of the toxic action of NAs, a greater understanding of the structures of individual NAs is of the utmost importance. Due their complexity, NAs cannot be resolved into their constituent individual compounds by traditional chromatographic techniques (e.g.-GC and LC), hindering identification of individual acids. Advanced chromatographic techniques, such as GCxGC, have been successfully applied to the identification of individual NAs, but these techniques have not yet found widespread adoption within the field. The goal of this project is to develop a simple and efficient method to reduce NAs to hydrocarbons, creating a product that is amenable to analysis by gas chromatography and enabling greater characterization of the hydrocarbon backbones. Presently, we are evaluating a "one-pot" organosilane reduction using triethyl silane (TES) in the presence of the Lewis acid catalyst tris(pentaflurophenyl)borane ($B(C_6F_5)_3$). Using this method, a range of aliphatic and aromatic model NAs were efficiently reduced to hydrocarbons. This method will be further applied to commercial NA mixtures and NAs extracted from OSPW.

Effects of Multiple Stressors (Diltiazem, Temperature, and Hypoxia) on the Behavioural and Physiological Performance of Rainbow Trout *(Oncorhynchus mykiss)*

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Keywords: diltiazem, hypoxia, rainbow trout, multiple stressors

The aquatic environment is affected by anthropogenic threats such as the disposal of pharmaceuticals and their metabolites in surface waters, as well as the global warming effect, hypoxia of surface waters, and other stressors in the aquatic environment. Little is still known about the impacts of multiple stressors, concomitantly, in the aquatic environment. Diltiazem is a calcium channel blocker commonly prescribed in the treatment of hypertension, angina pectoris, and some types of arrhythmia in humans. It reduces the heart rate and causes systemic and peripheral vasodilation. Even though it has been recently detected in waste water effluents at relatively high concentrations and the LC50 has been determined for a few invertebrates (e.g. *Daphnia magna*) and fish species such as the Japanese medaka (*Oryzias latipes*), limited information is available on the effects of diltiazem in the environment and aquatic species. Moreover, the effects of diltiazem under hypoxic conditions and warm temperature in fish have not been studied. The current study will investigate the effects of diltiazem in rainbow trout (*Oncorhynchus mykiss*) under controlled laboratory temperatures and oxygen saturation to determine how hypoxia and temperature modulate the effects of diltiazem in fish. (Funded by Alberta Innovates – Energy and Environment Solutions – AI-EES)

The role of thermodynamics and metal exposure on mammalian bioavailability of polycyclic aromatic hydrocarbons (PAHs)

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Keywords: PAHs, Metals, Bioavailability, Soil

Polycyclic aromatic hydrocarbons (PAHs) are a group of hydrophobic organic chemicals which are commonly found in soil and are known to be carcinogenic. Approximately 25 PAH contaminated soils have been collected from around the world and the bioavailability of various PAHs has been determined using the *in vivo* juvenile swine model. The soils have a wide range of properties, including organic carbon content, metal concentrations, and PAH concentrations. Due to the organic nature of PAHs, thermodynamics is suspected to play a significant role in PAH bioavailability and the organic carbon is predominately responsible for governing the thermodynamic response. Soils are primarily composed of metals, therefore they will contain many different metals at varying concentrations. Both heavy metals and trace metals have the potential to interact with cellular biochemical mechanisms associated with PAHs, including metabolism and transportation. In this study, the role of thermodynamics and metal exposure is examined to further understand the bioavailability of PAHs in soil.

Ecological risk assessment of pesticides in Manitoba waters: 1995-2014

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Keywords: Risk Assessment, Pesticides, Lake Winnipeg

Since 1995, the Province of Manitoba's Pesticide Monitoring Program has amassed data for >80 compounds from >200 unique sampling sites. Many of these pesticides can have significant ecological effects on fish populations – both directly (e.g., insecticides through mortality) and indirectly (e.g., herbicides through changes in primary productivity) – and include those of public and regulatory concern, such as the neonicotinoid insecticides and the herbicide atrazine. Working together with Manitoba Conservation, this study provides a probabilistic ecological risk assessment for pesticides based on this provincial data cache – in combination with available literature and data from other monitoring programs (i.e., Environment Canada). Using probabilistic techniques, the assessment aims to predict the likelihood of observing a pesticide through space and time, as well as the likelihood of exceeding water quality guidelines. Recently initiated, this assessment will help to identify the location of pesticide hotspots; predict future pesticide levels based on application rate increases or decreases; characterize trends between pesticide application rates or sites and the subsequent environmental concentrations; and make recommendations for a renewed monitoring initiative in the province. This approach has been adopted globally, but has yet to be employed in Manitoba.

Sublethal effects of polymer-coated titanium dioxide nanoparticles and ultraviolet light coexposure in developing zebrafish (*Danio rerio*)

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Keywords: Nanoparticles, ultraviolet light, zebrafish, phototoxic

Nanoparticles (NPs) are used in many agricultural applications, from micronutrients for crops to carriers for pesticides. Most studies examine NP toxicity under fluorescent lamps that emit no ultraviolet (UV) light, yet certain NPs such as titanium dioxide (TiO_2) absorb photons and generate electron-hole pairs that react with water and oxygen to produce reactive oxygen species. We tested aqueous polymer-coated TiO_2 NPs, uncoated TiO_2 NPs, as well as the polymer coating alone. Zebrafish (*Danio rerio*) embryos were exposed to 0.1, 1 or 10 mg/L of each NP type and subsequently irradiated with UV light similar to the intensity and spectrum of natural light. We assessed sublethal endpoints including total glutathione levels and superoxide dismutase activity after seven days and we tested the potential for NPs to interfere with these biochemical assays. While coexposure of polymer-coated TiO_2 NPs and UV light had no effect, uncoated TiO_2 NPs significantly increased total glutathione levels at all concentrations tested. These uncoated TiO_2 NPs, however, have been shown to absorb at wavelengths monitored in the presented assays, which can lead to false positive results. To validate these findings, we plan to examine the differential expression of *glutathione peroxidase 1a* and *superoxide dismutase 2* genes. Further research is needed to determine if these NPs are phototoxic and development of new and more accurate endpoints for NP toxicity testing is essential.

Assessing biological effects of municipal wastewater effluent using the fathead minnow reproductive bioassay.

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Keywords: Municipal wastewater; endocrine disruption; fathead minnows

Municipal wastewater effluents (MWWEs) contain anthropogenic substances that can exhibit endocrine disrupting activity. In the Prairie Provinces, increasing urban populations and industrial activities has meant greater water demand and therefore greater MWWE released into the aquatic environment. The objectives of this study were to (1) determine the biological effects of MWWEs on fathead minnow (*Pimephales promelas*) using the US EPA short-term fish reproductive bioassay assay and (2) compare responses to effluents collected from both the Regina and Saskatoon wastewater treatment systems. The endocrine disrupting effects were assessed using various reproductive measurements (number of eggs, fertilization success), as well as morphological, histopathological, and molecular/biochemical indicators in both male and female fish. Exposure of fathead minnows to Regina MWWE caused a significant decrease in fecundity at all concentrations compared to non-exposed minnows. Regina MWWE exposure also caused a trend of decreasing GSI in male fathead minnows. While no changes in fecundity were observed after Saskatoon MWWE exposure, a trend of increasing LSI was observed for female minnows exposed to Saskatoon MWWE, while a decreasing LSI was observed in the exposed males. Fertilization rate remained consistent regardless of treatment, demonstrating a lack of effect. This study confirmed the reproductive impacts of MWWE discharged into Saskatchewan aquatic systems and will provide critical information regarding the particular toxicological risks associated with ineffective removal of EDCs from MWWEs. *(Funded by CWN)*

Inhibition of multi-xenobiotic resistance (MXR/MDR) efflux activity as a potential mechanism of toxicity of oil sands process affected water.

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Keywords: OSPW, ABC protiens, naphthenic acids

The mechanism of toxicity of oil sands process-affected water (OSPW) has not been elucidated. Many organic chemicals dissolved in OSPW, including naphthenic acids (NAs), are surfactants. Disruption of membrane bound transporter proteins, in particular carrier-mediated efflux proteins such as ATP binding cassette transporter proteins (ABC proteins), is one mechanism by which surfactants exert toxic effects. Therefore, it was hypothesised that organic chemicals dissolved is OPSW might exert adverse effects on aquatic organisms by inhibition of ABC proteins. To investigate this hypothesis the effects of dissolved organic chemicals in OSPW on the activity of ABC proteins was investigated in the fry life-stage of Japanese medaka. Dissolved organic chemicals in OSPW were fractionated into acidic, basic, and neutral fractions. Equal volumes of each fraction were pooled as a surrogate for the dissolved organic phase of OSPW. The lipophilic dye Calcien-AM was used to monitor activity of these proteins.In fry exposed to neutral, basic, or acidic fractions of OSPW, accumulation of Calcien-AM was 2.2, 1.3, and 0.9-fold greater than in fry exposed only to Calcien-AM. This result suggests that chemicals in the neutral fraction had the greatest effects on activity of MRP.The results suggest that elimination of metabolites from cells of organisms exposed to OSPW might be inhibited.

Investigating the potential effects of polycyclic aromatic hydrocarbons on rainbow trout (*Oncorhynchus mykiss*) gastrointestinal microbiome composition

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Keywords: gastrointestinal microbiome, next generation sequencing, 16S rRNA gene

The gastrointestinal microbiome influences metabolic processes, plays a role in host nutrition, and contributes to intestinal and immune system development in vertebrates, including fish. Many factors can affect the composition of the intestinal microbiome in fish including diet and host phylogeny, but little is known about the effects of contaminants. Studies have shown that microorganisms are sensitive to low concentrations of pollutants and that some bacterial taxa are found only in fish, indicating their potential to be used as bioindicators of pollutant exposure. Any changes in gut microbiome composition have the potential to negatively influence fish health, and due to the essential role of bacteria in the gut, research is needed in this area. One potential class of chemicals, polycyclic aromatic hydrocarbons (PAHs), are ubiquitous environmental contaminants that elicit a variety of deleterious effects on a wide range of organisms, including bacteria. Current research will investigate the effects of PAHs on the gastrointestinal microbiome composition in rainbow trout through next generation sequencing of the 16S rRNA gene. Information generated from this study may be used in identification of bioindicator taxa, and development of biomonitoring strategies around known PAH sources. This research could also provide insight into novel aspects of PAH toxicity and metabolism in fish, and further our understanding of the important role played by gut flora in host well-being and adaptation to changing environmental conditions.

Standard vs. regionally-relevant test species: Determining the toxicity of vanadium to aquatic organisms representative of the Athabasca Oil Sands region

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Keywords: vanadium, oil sands, toxicity, regionally-relevant species

Bitumen from the Athabasca Oil Sands (AOS) region of Alberta, Canada, contains elevated concentrations of the metal vanadium (V). During bitumen upgrading, V is removed and concentrated into the by-product coke, which is produced in vast volumes and stored on-site of major oil sands operators. Previous studies have shown that coke can leach ecotoxicologically relevant levels of V into water under wet conditions. This research suggests that leachates from coke could potentially expose aquatic ecosystems of northern Alberta to elevated concentrations of V, depending on future plans for storage and remediation of coke. Therefore, this study aimed to develop new data on V toxicity to various freshwater organisms that are either (i) commonly-used laboratory species, or (ii) species more regionally representative of northern Alberta, and to develop acute and chronic species sensitivity distributions (SSDs) using these and existing, published data. From these SSDs, hazardous concentrations for 5% of the species tested (HC_5 values) were calculated. Toxicity tests were performed using various freshwater algae, invertebrates and fish species. Acute and chronic toxicity endpoints for V included lethality, growth, inhibition of reproduction, and emergence of insects. Acute toxicity (LC50s) for species tested ranged from 0.60 to 64.6 mg V/L for *Ceriodaphnia quadrangular* and *Chironomus riparius*, respectively. Chronic toxicity values (EC50) ranged from 0.15 to 33.9 mg V/L for *Daphnia dentifera* reproduction and *Chironomus dilutus* emergence, respectively. Generated SSDs show that similar sensitivities are observed between standard and comparable field-relevant species. This research provides the data needed for future development of an appropriate site-specific water quality guideline for V in the AOS region.

Canada's new Centre for Oil and Gas Research and Development (COGRaD) at University of Manitoba

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Keywords: Environmental monitoring, remediation, passive sampling, fingerprinting analyses

The newly announced Centre for Oil and Gas Research and Development (COGRaD) at the Department of Chemistry, University of Manitoba, will be an internationally accredited laboratory to meet and advance the analytical science required to meet the R&D needs of both the O&G industry and the Federal and provincial governments in Western Canada. To achieve this, the *Centre* will conduct research collaboratively with private research laboratories in Western Canada conducting similar research resulting in the transfer of new technologies to industry creating both increased industry technological capacities and business investments in the region. There will be two primary activities of COGRaD including: (*i*) an environmental monitoring component and (*ii*) an R&D component. COGRaD will provide an internationally accredited analytical facility committed to advancing and supporting industry and/or government mandated environmental monitoring obligations through the development of faster and cheaper analytical monitoring techniques, tools designed to delineate sources of crude oil exposures and forensic studies leading to new areas of analytical research. The second component of the Centre is to provide R&D on O&G issues mutually beneficial to both industry and COGRaD's principal investigators including: (*i*) designing innovative strategies to remediate and monitor crude oil components in the environment; (*ii*) determining the fate of oil spills; (*iii*) understanding the toxicological impacts of crude oil components on aquatic organisms and; (*iv*) developing analytical methods based on recently acquired instrumentation to accurately measure carcinogenic crude oil components.

Inputs of Chemical Contaminants Along the Lower Red River

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Keywords: Red River, Lake Winnipeg, Contaminants

The Red River, which originates from the U.S. and drains into Lake Winnipeg, carries various contaminants including pesticides, polyfluorinated chemicals, human and veterinary use pharmaceuticals, and personal care products from its drainage basin. This study assesses the input rates of these contaminants from the U.S. and from southern Manitoba and the city of Winnipeg. Atrazine, a corn herbicide, was found at levels over 0.5 μg/L near the border and decreased towards Lake Winnipeg, indicating that the U.S. was the predominant source. However, neonicotinoid insecticides had fairly constant concentrations along the river, indicating input from both the U.S. and Canada.

Is the Recovery of the Soil Nitrifying Community after Metal Toxicity determined by Metal Type, Energy or Soil Properties?

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Keywords: Ammonia oxidizing bacteria, risk assessment, recovery

Extending our current knowledge of ecosystem restoration and risk assessment to include the predictability of soil microbial activity recovery after metal toxicity is essential. Microbial conversions determine the bioavailability of nutrients to plants. However, metal stressors decrease the conversion activity of soil microbes. Furthermore, the ability of metal contaminated sites to recover after stress is largely dependent on the recovery of ammonia oxidizing bacteria (AOB) and other microbes.

This study seeks to identify the factors that determine the variation in recovery of AOB activity in relation to metal properties, soil properties or amount of energy supplied. First, the differences in recovery of AOB activity will be determined for As, Ba, B, Cd, Cr, Co, Cu, Pb, Hg, Mo, Ni, Se, Tl, Sn, V, and Zn, through a multivariate model that will include ionic and covalent binding indices, ionic radii etc. This will be followed by selecting 4 metal ions with varying AOB recovery time and tested for the effect of energy (NH_4^+-N) supplied on recovery time. The third experiment will ascertain soil properties that stimulate AOB recovery in 65 Canadian soils with varying characteristics.

The expectation at the end of the project is to identify the main drivers of AOB recovery and this knowledge can be employed to improve the management of contaminated sites and risk assessments.

Development of a novel assessment approach to track changes in the toxicity of specific chemicals of concern in oil sands process water.

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Keywords: OSPW, Base Mine Lake, naphthenic acids, salinity

Syncrude's recently created Base Mine Lake (BML) is an end-pit artificial lake located within the Athabasca oil sands area containing a mixture of fluid fine tailings and oil sands process-affected water (OSPW). End-pit technology has been proposed as a method for long-term reclamation of oil sands activity, however OSPW is a complex mixture of naphthenic acids, metals, polycyclic aromatic compounds, and salts, and is known to cause adverse effects on aquatic organisms.

In order to properly understand the environmental risks and sustainability of end-pit lakes, it is necessary to be able to associate changes in the concentrations of specific chemicals of concern with changes in the toxicity of BML surface water. Conventional aquatic toxicity testing procedures used for regulatory compliance are inadequate in assessing such complex mixtures, however, and are further confounded by the elevated salinity found within BML. Preliminary tests have shown that while BML OSPW is not acutely toxic to *Chironomus dilutus*, exposure to its salinity does cause significant reductions in growth.

The purpose of our research is therefore to create a toxicity testing protocol specific to BML by evaluating aquatic test species that are tolerant of high salinity and which respond uniquely to the key chemicals of concern within OSPW.

Developing the brook stickleback (*Culaea inconstans*) as a bioindicator of exposure to endocrine disrupting compounds in aquatic environments

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Keywords: stickleback, endocrine disruption, spiggin, vitellogenin

Brook stickleback (*Culaea inconstans*) are a local freshwater fish that possess two unique, quantifiable responses for exposure to both androgens (spiggin) and estrogens (vitellogenin). We developed a qPCR assay to measure tissue-specific expression of spiggin and vitellogenin and to evaluate their responsiveness to (anti-)androgenic and estrogenic compound exposures. Stickleback were exposed to methyltestosterone (MT) or ethinylestradiol (EE2) at 1, 10 and 100 ng/L in a semi-static renewal system with samples collected at 7 and 21 days. In addition, female brook stickleback were co-exposed to MT at 500 ng/L and to flutamide at 25, 150 or 250 µg/L in order to induce spiggin production in females and then knock-it down with exposure to an anti-androgen. Exposure to MT and EE2 resulted in an induction of spiggin and vitellogenin mRNA transcripts in female kidneys and male livers, respectively. In female brook stickleback MT exposure induced spiggin transcript levels while exposure to flutamide resulted in a dose dependent reduction of spiggin levels. In all exposures, transcript induction typically occurred at lower concentrations and at an earlier time point than changes in other endpoints (e.g. somatic indices and kidney epithelium cell height). Given the sensitivity of the biomarker responses assessed here the brook stickleback could be an effective bioindicator species for EDCs in the aquatic environment.

An Investigation into Occurrence of Wastewater Contaminants in Norway House Cree Nation

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Keywords: Wastewater lagoons, filtration, pharmaceuticals

The presence of wastewater contaminants at various stages of Norway House Cree Nation's wastewater facility was characterized. Water was collected from the primary lagoon to discharge into Little Playgreen Lake, as well as at an upstream site (control site) that is the community's drinking water source. Basic water quality parameters (e.g., pH, temperature, conductivity and dissolved oxygen), nutrients (nitrogen and phosphorus) and emerging contaminants (human-use pharmaceuticals and antibiotic resistance genes) were measured.

Polar Organic Chemical Integrative Samplers (POCIS) were deployed for 21 days, where seven pharmaceuticals were detected from a suite of 42 analytes: atenolol, carbamazepine, sulfamethoxazole, sulfapyridine, gemfibrozil, metoprolol and trimethoprim. Pharmaceutical concentrations at upstream and downstream sites were below detection limits, indicating no exposure via drinking and recreational waters. Reduction of most compounds from lagoon to final effluent was limited. Atrazine was found at all sampling sites, with the greatest concentrations found at upstream and downstream sites (ranging from 16-18 ng/L).

Both nutrients and water quality parameters improved from lagoon to final effluent. However, little improvement in water quality or reduction in nutrients was observed within the primary, secondary, and tertiary lagoons. We recommend that lagoon operation needs to be more optimized to improve treatment prior to entering the treatment facility.

Naphthenic Acid Biodegradation by Photosynthetic and Non-photosynthetic Microbial Communities in Oil Sands Process-Affected Water

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Keywords: Naphthenic Acids, Oil Sands Process Water, Bioremediation, Microorganisms

Naphthenic acids (NAs) are naturally occurring complex cyclic carboxylic acids found in Alberta's oil sands. The surfactant properties of NAs contribute to the separation of bitumen from sand during surface bitumen extraction. The remaining water, bitumen, NAs and solid wastes from bitumen extraction are stored in large settling basins known as tailings ponds. The oil sands process water (OSPW) in tailings ponds are held on site because some components, such as NAs, can be toxic to aquatic organisms and must be removed for reclamation efforts.
The objective of this research was to determine if stimulation of the indigenous OSPW microorganisms (photosynthetic and non-photosynthetic) using light and phosphate would result in NA biodegradation and toxicity reduction. The OSPW samples were stimulated with or without light and/or phosphate and analyzed for changes in NA composition, toxicity, and microbial community composition. The findings from this study indicated that the loss of low molecular weight NAs in OSPW incubations stimulated with light and phosphate resulted in a significant decrease in acute toxicity of the OSPW. The microbial community analysis suggests that a relationship between algae (*Scenedesmus, Chlorella*) and bacteria *(Porphyrobacter, Planctomyces*) may contribute to the reduction of NAs and toxicity. This method could prove to be a feasible biotreatment option for partial remediation of the large volumes of OSPW.

Assessing the occurrence of wastewater contaminants in Cambridge Bay

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Keywords: wastewater lagoons, pharmaceuticals, arctic

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The treatment of municipal wastewater in the Canadian Arctic is challenging due to a variety of financial, operational, climatic and technical reasons. To better understand the efficacy of wastewater treatment under these conditions, we assessed the occurrence of wastewater contaminants attenuation and release (i.e. pharmaceuticals, antibiotic resistance, nutrients) from a facility in Cambridge Bay in Nunavut, Canada. Wastewater treatment in this community is performed by the use of a lagoon-tundra wetland system that is discharged into the bay.

Samples were collected before and during lagoon discharge from two locations in the main lagoon, one location downstream from the lagoon effluent and three locations offshore. Grab samples were collected to measure nutrients (e.g. total nitrogen and phosphorus) and Polar Organic Chemical Integrative Samplers (POCIS) were deployed to passively collect organic contaminants in all locations. A total of eight pharmaceuticals were detected from a screen of 28 analytes: atenolol, carbamazepine, clarithromycin, metoprolol, propranolol, sulfamethoxazole, trimethoprim and sulfapyridine. The greatest nutrient and pharmaceutical concentrations were found upstream in sampling spots within or near the treatment lagoon. Locations downstream and offshore showed drastic reductions in concentrations for both nutrients and pharmaceuticals, which suggests that attenuation mechanisms are in place along the wastewater path.

Is Oxidative Stress the Main Driver of Selenium Toxicity in Juvenile White Sturgeon (*Acipenser transmontanus*)?

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Keywords: selenomethionine, oxidative stress, RNA sequencing, white sturgeon

It has been shown that selenium (Se) released to the aquatic environment can have devastating effects on local wildlife. Sturgeon have a particularly susceptible life history and their protection is of interest as they are culturally and economically important and many populations are already classified as endangered. During a 72 day dietary study multiple signs of decreased health and Se lethality were seen. Juvenile white sturgeon (*Acipenser transmontanus*) were given diets containing 1, 5, 25 or 100 ug Se (dm) per g food in the form of selenomethionine. Se accumulated in tissues in a dose dependent manner. Lethal effects rates of 54% and 22% occurred in high and medium doses respectively. Edema developed within 10, 23 and 52 days in the high, medium and low doses respectively. Food avoidance and decreased growth was observed in the high dose. Full transcriptome analysis using Illumina technology showed that approximately 11,000 genes remained unchanged, 4000 were down regulated, and 200 were up regulated.

Stability and Rat Liver Microsome Oxidative Metabolism of Secoisolariciresinol (SECO) Analogues

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Keywords: Lignans, xenobiotic metabolism, LC-MS

Several analogues of secoisolariciresinol (SECO), a lignan from flax seed with potential pharmaceutical properties, were synthesized. These were used to probe the effect of structure on SECO metabolism. The stability of SECO analogues in a 50 mM Na_2HPO_4 buffer at pH 6.0 and 7.4 were quantified using high performance liquid chromatography. All SECO analogues were stable at pH 6.0. SECO-1,3 and 4 are unstable at pH 7.4 with $t_{1/2}$ of 25.95, 3.21 and 3.51 h respectively. Microsomal oxidation was performed in a 100 mM Na_2HPO_4 buffer at pH 7.4 with and without GSH to trap reactive intermediates. Mass spectroscopy and LC-MS analysis was used to identify the products. Two reaction pathways for the oxidative metabolism of SECO analogues are proposed.

The Use of the Chitinolytic Enzyme Chitobiase as an Indicator of Aquatic Ecosystem Health

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Keywords: chitobiase, arthropods, environmental effects monitoring

A common approach for assessing ecosystem health for possible impacts by contaminants is the assessment of benthic arthropod community structure. There are multiple drawbacks to this approach including the costs associated with sampling and taxonomic expertise, sensitivity of results to the time and location of sampling, and that impacts are generally not detected until after the change has occurred. One approach to deal with some of these issues would be to measure secondary production as it relates to water quality and link these to environmental effects in the field.

An enzymatic technique to assess and monitor arthropod community status and hence, aquatic ecosystem health, holds potential for effects monitoring. We propose employing the measurement of the rate of chitobiase production, an arthropod moutling enzyme, as a surrogate for secondary production in freshwater monitoring. Chitobiase can be easily measured in water using fluorescence spectroscopy, rapidly and cheaply. Chitobiase levels present in the aquatic ecosystem should be directly correlated to the status of arthropod populations, reflecting factors such as number of organisms, growth/development rate and size of the organisms. Measuring for chitobiase can be performed frequently, increasing detection of effects to aquatic systems. This should allow it to be used as an indicator of disturbances, such as toxicants, in aquatic systems.

This poster will discuss the origin and function of chitobiase, the method by chitobiase is detected in water, and the putative relationship between chitobiase and the status of arthropod communities. As well as, we will critique the potential for its use in environmental effects monitoring.

Bioassay-directed characterization of endocrine-disrupting potencies of municipal effluents in Canada

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Keywords: Emerging contaminants, Wastewater, *in vitro*, monitoring

There is increasing concern regarding municipal wastewater effluents (MWWEs) as a major source of endocrine disrupting chemicals (EDCs) in surface waters. EDCs have the potential to adversely affect the endocrine system of humans and wildlife, and conventional wastewater treatment technologies are frequently inefficient at removing these compounds. Our understanding of the contribution of effluents from wastewater treatment plants (WWTPs) to environmental endocrine disruption in Canadian surface waters is incomplete. Therefore, the aim of this project was to investigate the effectiveness of six WWTPs across Canada to remove EDCs from wastewater. Specifically, samples of influents and effluents were collected during all four seasons in 2014 and 2015 to evaluate the influence of climatic conditions, population size and treatment level on EDC removal efficiency. Endocrine potentials of wastewater were analyzed using three *in vitro* bioassays: MVLN ((anti-)estrogenicity), MDAkb2 ((anti-)androgenicity), and H295R Steroidogenesis Assay (steroidogenesis disruption). Preliminary results indicated that all influent samples collected in spring 2014 had a significant increase in androgenicity relative to solvent controls (4- to 5-fold), while effluent samples were less potent and showed variability in response, suggesting different efficiency of treatment processes. This project will provide insight into the most effective approach for monitoring MWWEs, and will inform development of advanced wastewater treatment technologies for improved EDC removal.

Sub-lethal Behavioral Effects of Oil Sands Process-affected Water Exposure in Zebrafish

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Keywords: oil sands, anxiety, zebrafish, toxicity

The extraction of bitumen from surface mined oilsands in Northern Alberta produces large volumes of oil sands process-affected water (OSPW), which is stored onsite until it may be returned to the environment. OSPW contains a variety of potentially toxic chemical compounds, including polyaromatic hydrocarbons (PAHs), metals, and naphthenic acids (NAs). The exposure of terrestrial and aquatic organisms to OSPW has demonstrable sub-lethal toxicity, particularly when reproductive or immunological endpoints are investigated. However, alternative measures of sub-lethal toxicity, such as alterations in behavior, have not yet been fully investigated. In the present study, we exposed zebrafish (*Danio rerio*) to dilute OSPW (1%, 10%, or 50% OSPW) for 10 days. Following exposure, zebrafish were tested for both light/dark preference and their tendency to approach a novel object; two measures which have been shown to be reliable indicators of anxiety-like behaviours in fish. Results from this study may have potential implications on sub-lethal toxicity levels of OSPW on fish.

The impact of venlafaxine on neurogenesis in Zebrafish

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Keywords: Venlafaxine, municipal wastewater effluent, neurogenesis, pharmaceuticals

Venlafaxine is a serotonin and norepinephrine reuptake inhibitor (SNRI) and is one of the most prescribed pharmaceuticals, commonly used to treat conditions such as depression, anxiety, and panic disorder. Human consumption has resulted in elevated concentrations of venlafaxine in municipal wastewater effluents at levels close to 1µg/L. We tested the hypothesis that environmental levels of venlafaxine affects neurogenesis in zebrafish (*Danio rerio*). Newly fertilized embryos were exposed to either 0 (control), 0.2 or 1.0µg/L venlafaxine, or 5µM serotonin for 5 days. At 24hpf embryos were pulsed with EdU (5-ethynl-2'-deoxyuridine), which incorporates into cellular DNA during DNA replication, allowing us to visualize the birth of new neurons. At 5dpf, fish were fixed, stained, and embedded in OCT (optimal cutting temperature) medium and sectioned using a cryostat. We examined neurogenesis in the hypothalamus, tuberculum, and thalamus, and the new cells were normalized to the total number of neurons in each section. There was a significant difference in new neuronal cells between the control and serotonin exposed samples, with serotonin exposure resulting in a 20% increase in new neurons. Venlafaxine exposure produced a 10% increase in new neurons compared to controls. The results demonstrate that serotonin increases neurogenesis in developing zebrafish embryos. Overall, drugs that alter serotonin content in the brain, including SNRI's, may affect brain development leading to developmental dysfunction in fish.

The developmental, cellular and genetic responses of the model plant, Arabidopsis, after exposure to oil sands process affected water and naphthenic acids

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Keywords: phytoremediation, biotechnology, naphthenic acids, tailings ponds

The Alberta oil sands are a major driving force in the Canadian economy, however, a negative environmental effect associated with bitumen mining from the oil sands are the large volumes of tailings produced and stored in ponds at mine sites. Naphthenic acids (NAs) are stable compounds that are a by-product of the bitumen extraction process and are concentrated in tailings pond water. NAs are known to have toxic effects on a number of organisms, including bacteria, fish, plants and mammals. NAs are difficult to degrade through industrial or organismal methods and they have the potential to contaminate nearby water systems.

In order to prevent environmental contamination it is important to identify approaches that will assist in the degradation of NAs. We have been investigating the developmental and cellular response of plants exposed to NAs using the model plant species, *Arabidopsis thaliana*, in order to determine which tissues and processes are affected by these contaminants. We have also performed a microarray experiment to identify genes that are regulated in response to NA exposure. Information from these studies will allow us to pinpoint specific genes that could be involved in the sequestration or degradation of NAs by plants. This research uses molecular, biochemical, and cellular tools to develop specific bioremediation strategies that will assist in the decontamination and reclamation of contaminated sites.

Assessing the health impact of the acid extractable organic fraction of oil sands process affected water on embryonic zebrafish (*Danio rerio*)

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Keywords: Oil sands, *Danio rerio*, Acid Extractable Organics, Acute Toxicity

Large volumes of oil sands process affected water (OSPW) are currently being produced by surface mining operations in Northern Alberta oil sands. Studies have shown that OSPW is both acutely and chronically toxic and can be lethal at higher concentrations to aquatic organisms. However, little is known about the mechanisms of toxicity and adverse health impact caused by sub-lethal concentrations of OSPW and specific fractions of OSPW. The objective of the present study was to identify and validate robust biomarkers to estimate the no observed effect concentration (NOEC) of the acid extractable organic fraction (AEO) in zebrafish (*Danio rerio*) embryos. Measurements include the number of living embryos, mRNA transcript abundance, and the abundance of yolk sac edema, pericardial edema, hemorrhage, spinal malformations, and abnormal swim bladder development. Exposure to 10mg/L dissolved AEO lead to a 2.1-fold decrease in embryo survival compare to control and exposure to 15mg/L lead to no survivors by the end of treatment (120hpf). In addition, exposure to AEO showed significant increases in the transcript abundance and developmental abnormalities. The results suggest that exposure to the AEO fraction of OSPW can lead to a series of developmental abnormalities in embryonic zebrafish, which provides a framework for better understanding of the mechanisms of OSPW toxicity.

Determination of Acute and Sub-Chronic Toxicity of Emerging Contaminants in Early Life Stages of Northern Pike (*Esox lucius*)

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Keywords: Emerging Contaminants, Malformations, Fish

In recent years, emerging contaminants have gained notoriety due to their ubiquity in the aquatic environment as well as the lack of data available regarding low-dose, chronic toxicity, especially in northern fish species. Chemicals such as hexabromocyclododecane (HBCD), silver (Ag) nanoparticles, short-chain chlorinated paraffins (SCCP), 17α-ethynylestradiol (EE2) and Prozac™ (FLX) generally enter the aquatic environment as mixtures in municipal wastewater effluent (MWWE). MWWE may be released from wastewater treatment plants into receiving waters with little to no treatment, which is not uncommon, especially in rural Canada. From there, they may sequester to sediments or expose biota through the water column. In this study, *E. lucius* gametes were collected from Lake Diefenbaker, Saskatchewan and fertilized in exposure solutions of EE2, FLX, MWWE, and Ag nanoparticles of varying concentrations with the lowest being environmentally relevant. For the sediment-based exposures, HBCD and SCCP, eggs were fertilized in facility water and immediately transfered to exposure sediment. Fish were reared, and after each endpoint (hatch, swim-up, sexual differentiation), a sub-portion of the population was sampled and assessed for morphological and histological defects, as well as endpoint specific rates of development. We hypothesize that chronic exposures to early life stages of *E. lucius* will have different toxic effects than acute exposures, from which most chemical characterizations are derived.

Assessing biochars made from Albertan industrial wastes for utilization as tailings ponds reclamation caps

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Keywords: Tailings ponds, reclamation cap, biochar, industrial waste

Open-pit oil sands operations in Alberta are transitioning to their end of life, thus, it is in the interest of operators to find economical ways to effectively reclaim tailings ponds. Wastewater treatment technologies have been using adsorption for the removal of contaminants, and some enhance treatment by utilizing microbial metabolic processes for immobilization and/or degradation. While activated carbon (AC) has long been used as a proven adsorbent, its cost is restrictive to widespread use. Biochars, on the other hand, can provide comparable adsorption as ACs for a fraction of the price. Here, we tested the ability of multispecies cultures, from an oil sands wastewater inoculum, to attach and proliferate on biochar using industrial waste products. We found microbial attachment on all support materials. Differences were seen in which materials facilitate growth, with biochars showing significant proliferation of biomass. Our assays demonstrated that microbes utilized carbon substrates provided by our media, as opposed to the carbon from our support materials, for growth and reproduction. This suggests that Alberta oil sands operators can utilize wastes from local industries (i.e. sawmills, pulp mills) to enhance their reclamation activities, such as for pond capping, contaminant adsorption, and support microbial growth for biosorption and/or degradation. This would be an economic and environmental benefit to oil sands development, and help the province of Alberta to meet sustainability and GHG goals.

A novel passive sampler for the measurement of polar organic contaminants in aquatic systems

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Keywords: passive sampling, pharmaceuticals and pesticides, surface waters

Current passive sampling designs for polar organic contaminants in water lack the ability to easily adjust uptake rates for differing environmental conditions (e.g., flow rate). This issue significantly reduces the overall applicability of current polar passive samplers. The diffusive gradients in thin films (DGT) sampler, popular for measuring metals, is largely insensitive to effects of flow on sampling rates due to the inclusion of a rate-limiting diffusive gel. In this study, we calibrated 34 polar organic contaminants (pharmaceuticals and pesticides) using the analogous organic-DGT or o-DGT. To obtain sampling rates of the analytes into o-DGT, diffusion coefficients through 0.8 mm diffusive gels were determined using a diffusion cell and ranged from 10^{-7}-10^{-6} cm^2/s. Calibration of o-DGT was achieved by spinning the samplers at a flow of 1-2 cm/s through a 40L tank containing spiked lab water (2 ng/mL, renewed every 24-48 hr). The diffusive boundary layer thickness was approximated and uptake rates into the o-DGT sampler were deemed to be largely independent of flow rate. These results illustrate the promise of o-DGT to potentially eliminate the need for *in-situ* calibrations, and provide a universal passive sampler with increased ease of use, reliability, and reproducibility, for polar organics in aquatic environments.

The role of sediment characteristics in the adsorption and bioavailability of uranium(VI) in freshwater sediments

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Keywords: sorption, metals, sediment, bioavailability

Uranium (U) can enter the environment from mining and milling of U, often accumulating in sediments to concentrations that have the potential to adversely affect benthic organisms. Thus, predicting the sorption, mobility, and fate of U in the environment is important for our understanding and assessment of U-contaminated sites. Physicochemical properties of sediment, such as particle size and total organic carbon (TOC) content, have been shown to modify bioavailability and toxicity of U in freshwater environments. Sorption of U is strongly influenced by pH, but few studies have investigated this effect in conjunction with role of physicochemical properties of sediment. The goal of this research was to quantify the role different sediment physicochemical characteristics have on altering U sorption in field sediment under varying pH conditions. Sorption of U was quantified using OECD equilibrium batch experiment guidelines. Test solutions were reconstituted to mimic water quality characteristics commonly found downstream of Canadian U mines. Field sediments consisted of 9 uncontaminated sediments with a wide range of physicochemical characteristics (i.e., TOC, CEC, particle size). U concentrations were environmentally relevant (0.023 to 2.3 mg U/L). The degree of adsorption to each sediment was strongly pH-dependent, increasing sharply around pH 7, and then decreasingly significantly towards pH 8. There were significant differences in the pH-dependent sorption among different sediment physicochemical characteristics, with greatest adsorption occurring in sediments with approximately 37% fine fraction (clay + silt) and 12% TOC content. This trend coincides with maximum reduction in U accumulation in *Chironomus dilutus* larvae from previous U-spiked sediment bioaccumulation studies.

Sulfamethoxazole transformation products in wastewater effluent dominated streams pose little risk of toxicity to aquatic organisms

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Keywords: Risk assessment, Transformation products, Sulfamethoxazole

Antibiotics are released into aquatic ecosystems with municipal wastewater effluent as a result of human-use applications. Sulfamethoxazole is one such antibiotic commonly released into the environment. Along with the parent compounds, transformation products (TPs) formed through various biotic and abiotic processes are also released; however our understanding of their occurrence, fate, and ecological risk is much less certain. The goal of this ecological risk assessment was to characterize which sulfamethoxazole TPs may have direct toxicological effects at concentrations currently found in the environment. We used measured concentrations of sulfamethoxazole in the environment and assumed a 1:1 TP to parent compound production ratio. Relevant TPs, formed by photolysis, hydrolysis and biological degradation, were determined by the literature and University of Minnesota's Biodegradation Database Pathway Prediction System and ECOSAR was used to model toxicity for a variety of acute and chronic endpoints. Exposure distributions were constructed for average and maximum effluent concentrations and for effluent concentrations after varying levels of wastewater treatment globally. The greatest measured environmental concentration was 8.71 µg/L. Some ECOSAR endpoints had hazard quotients above one. However, the greatest probability of exceedence was 0.26% for a chronic endpoint (daphnid) exposed to analine, and only two endpoints had probability of exceedences above 0.001%, suggesting there is little to no risk of direct toxicity associated with these TPs at current environmental concentrations. Overall, we recommend using this ecological risk assessment approach to identify data gaps for TPs, specifically for targeted toxicity testing.

Characterizing the Cumulative Action of Neonicotinoid Insecticide Mixtures on a Sensitive Aquatic Insect Species

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Keywords: neonicotinoid insecticides, aquatic invertebrates, mixture toxicity

Neonicotinoids are a class of broad-spectrum insecticides, used in agriculture to protect crops against biting-sucking insects. Although highly efficacious as seed- and foliar-treatments, these compounds have come under international scrutiny due to their toxicity to non-target invertebrate species. Following application, neonicotinoids (i.e. imidacloprid, clothianidin, and thiamethoxam) are likely to move into nearby water bodies, presenting a risk to local aquatic invertebrate communities. Due to multi-season persistence and application within the same watershed, these compounds are frequently detected in waterbodies as binary or tertiary mixtures. However, the toxicity of neonicotinoid mixtures is poorly understood, especially for sensitive aquatic insects. This research aims to fill that knowledge gap by characterizing the toxicity of binary and tertiary mixtures of imidacloprid, clothianidin, and thiamethoxam under acute and chronic exposure scenarios, using the aquatic invertebrate *Chironomus dilutus* as a test species. Preliminary work has included completing static, 96-hour toxicity tests for each compound, using larval *C. dilutus*, and survival as an endpoint. Imidacloprid and clothianidin displayed similar toxicity threshold values (LC50) of 4.63 and 5.93 µg/L, respectively. Thiamethoxam displayed lower acute toxicity, with an LC50 of 55.34 µg/L. These values will be used to develop parametric models, which will be statistically compared to the acute toxicity of binary and tertiary mixtures, observed in 96-hour laboratory studies, using the MIXTOX approach. These methods will be similarly applied in chronic (28-day) exposure scenarios. Results obtained will allow for an assessment of whether neonicotinoid mixtures display concentration additive toxicity and what risk mixtures pose to aquatic environments.

The effect of thiamethoxam on aquatic invertebrates and fate in shallow model wetlands

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Keywords: Neonicotinoids, Wetlands, Invertebrates, Mesocosms

The neonicotinoid insecticide thiamethoxam is used extensively, especially on the Canadian Prairies. In this study, the effects of thiamethoxam on emergent benthic insects and zooplankton were examined using model shallow prairie wetlands (3500 L outdoor mesocosms). A pulse input, e.g., via thiamethoxam-coated seeds at treatment levels based on industry-recommended seeding rates (1x, 10x, and 100x the canola seeding rate; equivalent to 9.2, 92.0, and 920 µg/L total thiamethoxam, respectively) were conducted and compared to controls. Water quality was monitored frequently, i.e., 27 days pre-exposure and 70 days post exposure. Emergent benthic insects were collected bi-weekly and were sampled prior to exposure, and throughout the 70-day post exposure duration using emergence traps. Pelagic zooplankton was collected prior to exposure and throughout the 70-day post exposure using passive zooplankton traps. Water quality parameters were not significantly affected by thiamethoxam. Statistical analyses (repeated measures ANOVAs, post-hoc Dunnett's testing) determined that current levels of thiamethoxam observed in Canadian wetlands are unlikely to have significant effects on emergent benthic insects and zooplankton. Multivariate analyses, partial canonical correspondence analysis (pCCA) and non-metric multidimensional scaling (NMDS) will also be presented.

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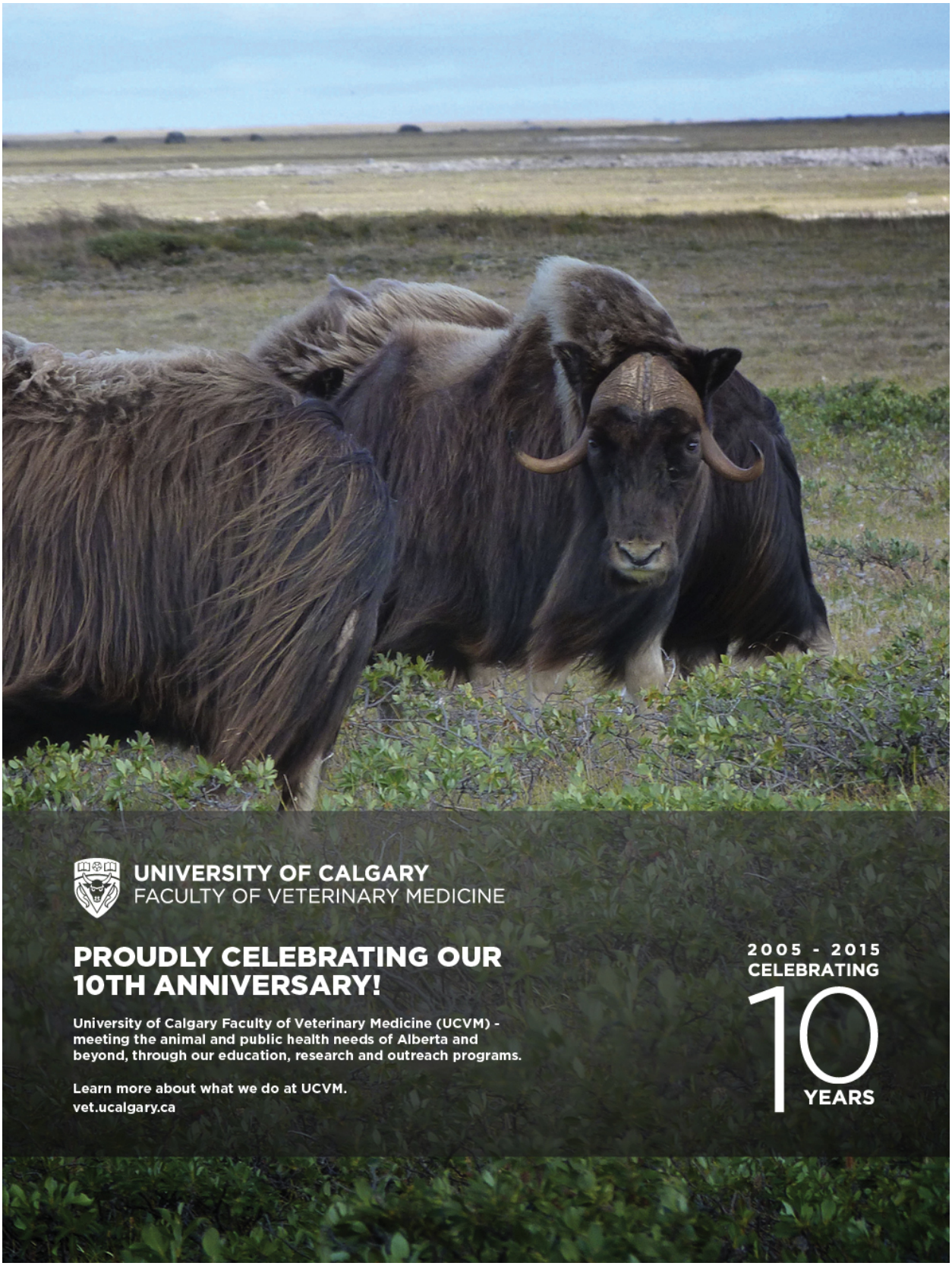

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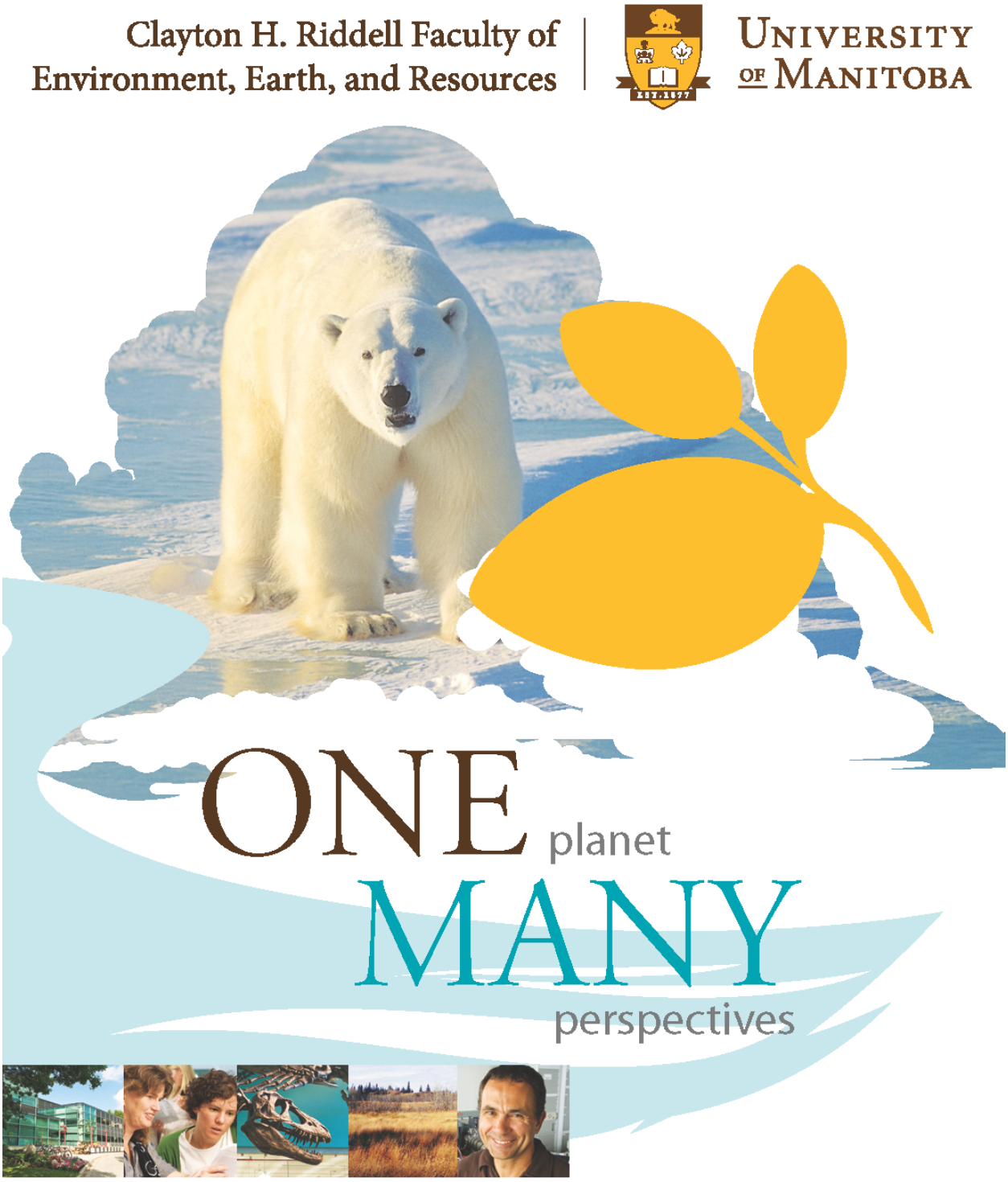

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