POSTER PRESENTATIONS

1) Impacts of Climate Change on Aquatic Ecosystems

THE IMPACT OF PERMAFROST THAW SLUMP EVENTS ON N AND P, PRIMARY PRODUCTIVITY, AND TRACE METALS, IN UPLAND TUNDRA LAKES EAST OF THE MACKENZIE RIVER DELTA

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In the Inuvik, NT, upland tundra region, shoreline retrogressive thaw slumps currently occur along 8% of lakes often transports large volumes of inorganic material to adjacent lakes. Large reductions in DOC and colour (i.e. clearer lakes), and 2-10 fold increases in major ion concentrations have already been observed in slump-affected lakes. Using a gradient of slump disturbance, measured as the percent of catchment area disturbed (%CD), we observed significantly higher concentrations of several trace metals in the water column, (e.g. uranium, strontium, and lithium), indicative of thawed permafrost soils. Conversely, lower concentrations of several ubiquitous metals, (Fe, Mn, and Al,) suggest removal via sedimentation of incoming slump material. The removal of organics and particulates from the water column to the sediments due to thaw slump events is also the probable driver for lower nutrients, N and P, leading to significantly lower planktonic Chl-*a* concentrations by as much as two thirds when comparing the most disturbed lakes to reference lakes. Both phytoplankton and periphyton measurements indicate the greatest reductions in primary productivity in active slump-affected lakes as opposed to stabilized slump-affected lakes. Additionally, we compared our Chl-*a* and TP results to 10 other studies across Canada, with an emphasis on similar low-Arctic settings, and suggest that slump-affected lakes are hot-zones for ecological change under the context of climate warming. In these already nutrient-poor systems, future climate warming will likely accelerate thaw slumping and further reduce primary productivity in similar tundra systems

HOT FISH: CAN FISH ENERGETICS HELP TO PREDICT THE IMPACTS OF CLIMATE CHANGE ON TROPICAL FRESHWATER FISHES?

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Research has demonstrated that ectotherms living in thermally stable environments tend to be thermal specialists, and that some of them achieve their optimal metabolic performance at temperatures near their upper tolerance limits. Therefore, tropical freshwater fishes may be exceptionally sensitive to even small changes in temperature anticipated from global climate change. Despite that threat, the thermal biology of tropical freshwater fishes has received little attention, albeit they represent an important source of protein and income for many local communities. The ‘Hot Fish’ project is designed to assess whether the thermal sensitivity of fish metabolism and energetics can be used to forecast the vulnerability of key tropical freshwater fishes to climate change. A second part of the mission is to leave more than we take at each location where ‘Hot Fish’ conducts fieldwork. To that end, in addition to delivering fish holding facilities and research equipment, ‘Hot Fish’ provides appropriate training to ensure that research activities continue beyond our collaboration. Experiments are conducted at three locations

(Brazil, Uganda, and Cambodia), where we quantify the metabolic capacities of two species acclimated for three weeks to three water temperature treatments. The project addresses a time sensitive conservation problem, with a goal to contribute to the protection of culturally and socio-economically important fish species in the tropics.

CHANGES IN VEGETATION AND LAKE PRODUCTIVITY IN NORTHWESTERN ONTATION DURING THE MIDEVAL CLIMATE ANOMOLY: AN ANALOGUE FOR THE FUTURE?

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Climate warming is expected to have major effects on boreal ecosystems situated near the prairie-forest boundary in central North America. It is widely expected that the prairie biome will shift eastward and displace the existing forest and that warming will interact with other important drivers of change, including fires, winds, insects and disease. In NW Ontario, little change in prairie expansion has been observed, which is partially related to the low density of study sites in this region. Here we discuss a network of new sites across the boreal region in NW Ontario to determine climate impacts over the Holocene (last ~10,000 years BP) and the development of a new biological proxy to help determine lake productivity. Preliminary results down-core show interesting trends that strongly support their use as paleoenvironmental indicators of changes in production. Overall, results from the pollen records and analyses of Non-Pollen Palynomorphs (NPPs) add further evidence that the climatic and limnological conditions during the mid-Holocene were fundamentally different than the late Holocene. Focus of this study will be on green algae as well as freshwater dinoflagellate cysts and various protozoans.

2) Genomic, Proteomic and Transcriptomic Advancements in Aquatic Monitoring, Assessment and Response

APPLICATION OF ENVIRONMENTAL DNA (eDNA) SAMPLING TO DETECT STREAM FISHES OF CONSERVATION CONCERN

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Efficient, reliable and non-invasive monitoring tools are important for fishes of conservation concern that require management at a landscape scale. In recent years, environmental DNA (eDNA) based methods have been developed to detect invasive species and endangered aquatic species from water samples. In this study, we evaluated the performance of eDNA sampling to characterize the distribution of two stream-dwelling fishes: Brook Trout (*Salvelinus fontinalis*) and the endangered Redside Dace (*Clinostomus elongatus*). The distribution of both species in southern Ontario has declined substantially in concert with changes in land-use (*e.g.* increased urbanization). Protection of remaining habitat is dependent on mapping the locations of extant populations. During 2013 and 2014, temporally replicated 1 L water samples were collected

from 72 Lynde Creek sites and 51 sites across four other Greater Toronto Area watersheds (Redside Dace only). Species detection was determined using species-specific primers and quantitative polymerase chain reaction (qPCR). Brook Trout was detected from a third of Lynde Creek sites. Detections were near areas of groundwater recharge, and corresponded with recent backpack electrofishing collections. Alternatively, Redside Dace was only detected at two sites. At other watersheds sampled, there was only a single positive Redside Dace detection. Our results indicate that further declines in Redside Dace distribution have occurred, and/or that the method is not sensitive when species densities are very low.

ENVIRONMENTAL DNA (eDNA) SCREENING OF INVASIVE WATER SOLDIER AND THREATENED NATIVE MUSSELS IN FIELD SURVEYS: PRACTICALITY, VARIABILITY, LIMITATIONS AND POTENTIAL.

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Environmental DNA (eDNA) offers a novel tool for detection of species at low abundances, such as species at risk or newly-established invasive species. Using eDNA detections from water samples, habitat occupancy can be assessed without physically encountering individuals, thereby reducing potential sampling impacts on vulnerable populations and habitats, and potentially detecting organisms that may be too rare to identify visually. Here we report two works in progress that aim to quantify the opportunities and limitations of eDNA detection. One study is focusing on the invasive water soldier plant (*Stratiotes aloides*): there is currently one established population in North America, and we are investigating eDNA as a tool to track its spread. Our second focus is on the detection of threatened native freshwater mussels (Unionidae). To date we have developed species-specific PCR primers for water soldier (using cpDNA) and four unionid species (using mtDNA). Our results have confirmed that target eDNA extracted from water samples can be amplified using the primers that we have developed. Ongoing work will assess the influence of biomass, tissue type, time since introduction or removal of source tissue, and source viability (live/ dead) on detections. Results to date suggest that eDNA can provide a sensitive tool for targeted species detection, provided the appropriate ecological, spatial, and temporal factors are considered. When used appropriately, eDNA analyses can complement and enhance traditional sampling, which may otherwise fail to detect newly established invasive species and remnant populations of endangered species.

RAPID EVOLUTION IN AN INTRODUCED ATLANTIC SALMON (*SALMO SALAR)* POPULATION: GENOMIC AND EXPERIMENTAL EVIDENCE OF ADAPTATION IN ROCKY RIVER, NEWFOUNDLAND

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The capacity of populations to evolve quickly is central to population-scale responses to climatic change and anthropogenic stress. Here, we characterize the presence and magnitude of recent adaptive divergence in a population of Atlantic salmon (*Salmo salar*) introduced from Little Salmonier River into Rocky River, Newfoundland, in the 1980s. Adaptive divergence was quantified by analyzing a genome-wide single nucleotide polymorphism (SNP) array (n=5568), as well as common garden and reciprocal transplant experiments. Bayesian outlier analysis identified ~90 loci potentially under selection, despite only 4-5 generations since introduction. Multivariate analysis (PCoA) indicated more variation among Rocky River than Little Salmonier individuals. Bayesian clustering analysis revealed similar trends with two groups identified, one present at both locations and a second only at Rocky River, supporting hypotheses of heterogeneity in the Rocky River population. Reciprocal transplants of fry from controlled lab crosses were conducted to compare growth and survivorship of introduced and parent populations in the two rivers. Prior to release, fry were reared in a common lab environment, allowing us to evaluate developmental differences. Preliminary results from the initial rearing indicate higher variance in size at hatching among the Rocky population, but convergence towards a similar size distribution as that among Little Salmonier fish at first feed and release time points. Genetic and morphological analysis of recaptured individuals are currently underway. Preliminary genomic and developmental results support hypotheses of rapid evolution of salmon in Rocky River and the potential for rapid responses to environmental change in Atlantic salmon populations.

3) Stable Isotope and Diet Analyses in Aquatic Food Webs

VALIDATION OF NON-LETHAL SAMPLING METHODS TO TRACK CHANGES IN $\delta^{15}N$ AND BODY CONDITION/GROWTH RATE OF YELLOW PERCH (*PERCA FLAVESCENS*) CAUSED BY A DIET SHIFT TO CANNIBALISM

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Stable isotope analysis (SIA) is an important tool used in ecological studies examining food web structure and tracing organic matter sources in aquatic ecosystems. Stable isotopes of nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) are most commonly analyzed, with $\delta^{15}N$ providing information about trophic position and $\delta^{13}C$ about dietary organic sources. SIA in fish usually involves sacrificing the animal to sample muscle or liver, however, progress has recently been made in developing species-specific non-lethal sampling techniques. In this study, we validated the use of caudal fin tissue as a non-lethal alternative to muscle and liver tissue sampling for analysis of $\delta^{15}N$ and $\delta^{13}C$ isotopes in young-of-the-year (YOY) yellow perch (*Perca flavescens*) held in aquaria with a controlled diet. Caudal fin tissue was highly correlated with both $\delta^{15}N$ and $\delta^{13}C$ in liver, a fast turnover organ which can reflect recent dietary uptake, but only correlated with $\delta^{13}C$ in muscle tissue, a slow turnover tissue reflecting a longer record of diet. These results indicate that caudal fin can be used as a reliable alternative to lethal sampling methods in yellow perch, with some limitations. We are using this validation technique to track changes in trophic level position

(using $\delta^{15}N$) and body condition/growth rate in YOY yellow perch being used in a long-term behavioural study (~6 months), where non-lethal sampling methods are necessary. We expect that individual yellow perch with higher growth rates and with increasing relative body condition will have a greater change in $\delta^{15}N$ content over the course of the study because of a hypothesized switch to cannibalism, a natural phenomenon for *P. flavescens*. The results presented will indicate how species-specific non-invasive sampling methods could be developed for SIA to provide intra-individual information on how the trophic ecology of a study system can change over time

DOES ATLANTIC COD FEEDING REFLECT SPATIAL AND TEMPORAL PREY DYNAMICS IN NEWFOUNDLAND WATERS?

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The Northwest Atlantic ecosystem underwent substantial changes in the early 1990s marked by the collapse of the Atlantic cod (*Gadus morhua*) stocks in northeast Newfoundland and Labrador. Parallel and subsequent changes occurred in numerous other fished and non-fished species that are less well documented. Diets of generalist feeders such as Atlantic cod provide a means of assessing prey abundance, hence we hypothesize that the frequency of occurrence (FO) and percent weight (%W) of prey in cod stomachs would track changes in prey abundance at decadal scales. Through a combination of historical data from 1947 to the mid-1990s (91,750 stomachs) and original data from 1997 to 2011 (18,299 stomachs) from NAFO subdivisions 2J, 3KL, and 3Ps, we investigated whether cod stomach contents mirrored the documented abundance trends in three key prey species: shrimp (*Pandalus* sp.), capelin (*Mallotus villosus)* and crab (particularly snow crab, *Chionocetes opilio*). Shrimp FOC and % W directly reflected abundance. On the other hand, capelin did not decline in the cod diet in proportion to abundance, suggesting a preference. Crab comprised a minor portion of the stomach contents irrespective of the abundance. We conclude that cod are not solely generalist feeders but will preferentially consume certain kinds of prey presumably with the intention of maximizing energy intake. The changing ecosystem of the North Atlantic has had ecosystem-wide impacts on prey assemblages and species interactions. Stomach content data allow assessment these impacts and help our understanding and managing of fish stocks from an ecosystem-based perspective.

DIETARY CHARACTERISTICS OF SYMPATRIC ARCTIC COD AND CAPELIN IN THE CANADIAN ARCTIC

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Reduction of sea ice combined with encroachment of habitats as Arctic marine conditions ameliorate due to climate change, is expected to affect the abundance of Arctic Cod *Boreogadus saida* (Lepechin, 1774) and perhaps also the relationships of these intermediate-level trophic

taxa, particularly in more southerly fringing seas in the Arctic. Arctic Cod and Capelin, *Mallotus villosus* (Müller, 1776) are pelagic, planktivorous forage fishes, which occupy similar dietary niches. Co-occurring individuals of both species were collected in the Darnley Bay, NT during summer marine sampling from the F/V *Frosti* in August of 2013. Standard length used as a proxy suggests that observed Arctic Cod (71.07 $\pm$ 10.33 mm) were predominantly aged 1+ age and Capelin (96.17 $\pm$ 13.42 mm) were mostly age 2+. Stomach-content analyses indicate that both species feed extensively on calanoid copepods (*Calanus hyperboreus, C. glacialis, Metridia longa)* and amphipods (*Themisto libellula).* There was high dietary overlap (i.e. >0.6) between Capelin and Arctic Cod, evidenced by Schoener's index (0.797). Additionally feeding characteristics differed among size classes in both Capelin (70.49 – 132.04 mm) and Arctic Cod (42.08 – 114.42 mm). This study describes the feeding characteristics of these sympatric forage fishes in an Arctic ecosystem and contributes to better understanding of feeding preferences, the potential for competition between these species, and the possible consequences of climate change to mid-level components of the ecosystem.

4) Aquaculture and Its Impacts on Aquatic Environments

OUT-CROSSING WITH WILD STOCKS IN COMMERCIAL AQUACULTURE OF CHINOOK SALMON TO OPTIMIZE EARLY GROWTH AND SURVIVAL

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Capture fisheries alone are unable to sustain demand for seafood, and aquaculture is a growing source for that demand. Salmon farming is one of Canada's growing industries and is extremely valuable. Farmed Chinook salmon are a valuable niche market with substantial growth potential, coupled with lower perceived environmental concerns (being a native species in BC); however, their performance has not been systematically assessed. We are currently attempting to develop a performance-enhanced hybrid Chinook salmon stock with higher survival and growth. In order to accomplish this goal we crossed our inbred aquaculture stock line with milt from seven wild populations to test whether an infusion of new genes could increase the fitness of the offspring (i.e. hybrid vigour) and ultimately the size and quality of salmon. We reared the resulting offspring in a common environment and tested for stock effects on growth and survival (hatching success and early juvenile survival). In addition to examining the impact of infusing new genes into an aquaculture setting, this research will also address important questions in the conservation of salmonids, specifically the genetic rescue hypothesis.

POSTER PRESENTATIONS

BITE ME: FEEDING PREFERENCES OF JUVENILE CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) RAISED IN CAPTIVE AND NATURAL SETTINGS

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Hatchery fish readily adapt to commercial pelleted feed, but it is less clear if they lose instinctual feeding behaviour on natural insect prey. We sampled pre-smolt offspring from six stocks of hatchery-raised Chinook salmon at Yellow Island Aquaculture Ltd (YIAL), British Columbia, to examine the effects of domestication on juvenile foraging behaviours. The stocks used were distinguished by their relative growth rates from alevin to pre-smolts (fast vs. slow) and their rearing environments (hatchery vs. stream channel).We investigated whether semi-domesticated (wild sire) and domesticated (brood stock parents) salmon recognize and respond to a more natural prey item (a fisherman's fly) and how this reaction compares to a familiar yet artificial prey item (pellets). We sampled 60 individuals from each treatment; fish were placed individually in a small aquarium, allowed to acclimate, and presented first with a fishing fly followed by pelleted feed. We recorded feeding, orientation, aversion, and freezing responses. We predict that faster growing semi-domesticated stocks will feed on pellets preferentially, but still chase flies. We expect the slower growing populations to show moderate interest in the pellets and almost no interest in the flies. The domesticated population will likely only feed on pellets, having lost natural prey item recognition. The stream channel population will respond to flies more readily than any other group, since they experience similar prey items regularly. Our results will address the need for natural food supplements in hatchery settings so that juvenile fish maintain natural feeding behaviour when raised for stock enhancement or restoration.

LINKS BETWEEN DIURNAL CORTISOL VARIATION AND GROWTH RATE IN OUTBRED POPULATIONS OF HATCHERY-RAISED CHINOOK SALMON

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As global demand for sustainable protein grows, optimization of aquacultural practices becomes progressively critical. Native to the Pacific coast, Chinook salmon (Oncorhynchus tshawytscha) offer a high valued fish protein coupled with a lower perceived environmental impact. Optimizing fish growth at little operator cost is a driving practice in aquaculture, making the physiological mechanisms linking growth rates to optimal feeding regimes key. As part of a federally-funded Strategic Project Grant we are characterizing the diurnal variation in physiological traits (baseline cortisol, IgF-1, growth hormone) expected to impact variation in relative growth rates of different outcrossed hatchery-stock Chinook salmon at Yellow Island Aquaculture Ltd (YIAL), British Columbia. Ten males each from eight wild B.C. stocks were crossed with females from YIAL's domesticated population and offspring were reared in captivity in 2014. Bi-weekly weights were taken on a subset of juveniles (n = 10) from each family, 20 weeks post hatching until 31 weeks to obtain stock-level growth rates. At the final

sampling time, blood was collected from 36 fish per population at 4-hour intervals over a 3-day period and plasma was assayed to obtain baseline diurnal cortisol levels. Since variation in baseline cortisol has been linked to individual differences in locomotory and foraging behaviors, we will examine relationships between plasma cortisol variation and growth rates to determine whether there is a key window in the 24-hour cycle where cortisol influences growth. These findings can assist in determining optimal feeding times during the pre-smolting period, predicting growth rates at later saltwater stages, and helping predict eventual flesh quality at harvest.

STABILITY AND FLEXIBILITY IN INDIVIDUAL BEHAVIOUR: CONSEQUENCES FOR ATLANTIC SALMON (*SALMO SALAR*) REINTRODUCTION.

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Hatchery rearing and stocking programs designed to supplement wild populations can produce intentional and unintentional selection of behavioural phenotypes contributing to the poor performance of released fish. There has been a growing effort to restore native Atlantic salmon (*Salmo salar*) to Lake Ontario; these fish are produced by artificial propagation in hatcheries and stocked into multiple tributaries at different life history stages, albeit with limited success. A postulated reason for high mortality of captive-raised Atlantic salmon after release is poorly developed behaviour, such as an inability to adapt to novel conditions, to learn to forage on natural prey, or avoid predators. Using two multi-generation, captive-reared stocks of Atlantic salmon originally sourced from the LaHave (NS, Canada) and Sebago (Maine, USA) populations, we investigated individual variation in behavioural responses of 288 juveniles from 12 families to multiple tests (open exploration, novel object, and mirror) designed to assess the fish's acclimation, exploratory, neophilic, and aggression behaviours. We hypothesize hatchery-born salmon have been selected for behaviours that no longer confer adaptive benefits to conditions generally experienced by fish in the wild. Our expected results will reveal whether there exist stock-level differences in behavioural variation; if individuals display flexible behavioural responses; and whether there are behavioural phenotypes better suited to restoration than others. Insight into behavioural flexibility and intrinsic individual differences of juvenile salmon is critical for enhancing the success of reintroduction programs to our Great Lakes.

THE USE OF BENTHIC INVERTEBRATES TO DETERMINE NET EFFECTS OF FRESHWATER CAGE AQUACULTURE

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Cage aquaculture results in the release of organic matter to the lake with the greatest deposition under the cages. Organic matter deposition can lead to alterations of the benthic invertebrate populations exposed. Total abundance, richness and biomass are classical proxies for benthic

community succession during exposure to organic matter enrichment (Pearson & Rosenberg 1978). Measures of total abundance, richness and biomass of benthos from three commercial freshwater finfish aquaculture farms in Lake Huron were presented spatially to measure the net effect of aquaculture waste. In 2009 and 2012, sediment cores were collected from under the cages to 110 m distance away, as well as at six distant reference sites. Our data showed that total abundance, richness and biomass of benthos were suppressed under and in close proximity to the farm, while further afield invertebrate abundance and biomass of some taxa was elevated above reference values. We quantified the total biomass per m^2 and initial results found that total biomass was comparable amongst all three farms. However, reference sites are the determinant for calculating the net gain or loss of benthic invertebrates at a farm and net biomass results differed between farms. Net biomass is a simplistic metric and does not completely present the dynamic change in diversity or functional groups by benthic invertebrates. Rather, net biomass represents the recycling of energy from aquaculture farm waste into invertebrates and potentially to higher trophic levels like wild fish.

5) Conservation and Rehabilitation of Natural Habitats and Biodiversity

WILL HYBRIDIZATION HINDER THE REINTRODUCTION EFFORT OF ATLANTIC SALMON (*SALMO SALAR*) IN LAKE ONTARIO: A LOOK AT THE JUVENILE LIFE-STAGE OF HYBRID ATLANTIC SALMON

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Within-species hybridization is becoming increasingly common as a result of introductions of allopatric fish populations to common environments. The fitness of resulting hybrid offspring can vary compared to offspring from pure parental combinations, sometimes resulting in hybrid vigour (superior fitness relative to pure strains) or hybrid breakdown (inferior fitness relative to pure strains). Atlantic salmon (*Salmo salar*) are distributed across eastern North America with many populations of varying sizes and local adaptations. Lake Ontario once had an indigenous population of *S. salar* until the early 20th century when they were extirpated as a result of anthropogenic activities. Despite the massive stocking of the species, there is currently no self-sustaining population in Lake Ontario. Currently, two distinct populations are being used for stocking, a strain from the LaHave River in Nova-Scotia and another from Lake Sebago in Maine. These populations have evolved separately as a result of thousands of years of separation, and their eventual hybridization will cause unknown fitness outcomes for their offspring. This study examines whether the crossing of these populations will result in the expression of hybrid breakdown or hybrid vigour in F1 juveniles when raised in a common garden environment by examining traits associated with fitness (e.g. survival, growth rate and body morphology) between hybrid and pure strains. The results show no significant difference between the measured fitness characteristics of the hybrids and pure strains. In conclusion, the crossing of the Sebago and LaHave populations does not result in hybrid breakdown or hybrid vigour in F1 juveniles.

POSTER PRESENTATIONS

HABITAT AND FISH POPULATION REHABILITATION IN SALMON COVE RIVER, NEWFOUNDLAND TO OFFSET LOSSES DUE TO TAILINGS IMPOUNDMENT IN LONG HARBOUR

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Vale Newfoundland and Labrador (Vale) is currently operating a nickel processing plant in Long Harbour, Newfoundland and Labrador. The hydrometallurgical processing technology is used to process nickel concentrate from the Voisey's Bay Mine and Concentrator in Labrador. Vale has undertaken multiple offsetting programs to compensate for any loss of fish habitat due to the construction and operation of the nickel processing plant. Fish species recorded on the processing plant site include brook trout (*Salvelinus fontinalis*), rainbow smelt (*Osmerus mordax*) and American eel (*Anguilla rostrata*). As part of the offset requirements under the Canadian Fisheries Act, a local river outside Vale's project area was identified for habitat restoration, to improve access to an historical Atlantic salmon (*Salmo salar*) run. This paper overviews the data and methods used for rehabilitation and the results to date. Historic data and surveys assisted in identifying the rehabilitation potential and focusing rehabilitation efforts. The first three years of post-rehabilitation monitoring indicate a re-establishment of the anadromous salmon runs to a large portion of their historic habitat. Spawning habitat enhancements have also increased juvenile salmon densities from 0-0.05/m^2 to over 1.1/m^2. Anadromous brown trout (*Salmo trutta*) have also shown a six-fold increase in juvenile densities.

PREDICTING COASTAL WETLAND RESTORATION OUTCOMES USING STATE-AND-TRANSITION SIMULATION MODELS

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Many Great Lakes coastal wetlands have undergone landscape-scale changes in vegetation due to the expansion of cattails and more recent invasion by *Phragmites* which in turn, impact biodiversity, wildlife habitats and wetland functions. Given the limited resources available for restoration, modeling is one method that can be used to determine which actions on the ground are most effective in the long-term, and which actions will be resilient over time, before initiating any work. In this study, we developed state-and-transition simulation models (STSM) for *Typha* and *Phragmites* dynamics in coastal wetlands, to predict changes in vegetation over time in response to natural disturbances and management. Calibrated using a ~50-year dataset from Point Pelee National Park, and management effectiveness data from the literature, we compared the outcomes and costs of various management scenarios, including do-nothing, mechanical, chemical and hydrological control methods. Results indicate that management

strategies that control the *Phragmites*, with the longer term goal of re-creating openings by reducing the dominance of cattails in the wetland, would be optimal to increase diversity and restore wetland ecosystem condition.

ECOLOGY OF GRASS PICKEREL (*ESOX AMERICANUS VERMICULATUS* LESUEUR) IN ONTARIO STREAMS

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The Grass Pickerel is a little known member of the Pike family that is a species of Special Concern under the Species at Risk Act in Canada. Its habitat has been reasonably well described, but its distribution in Ontario is disjunct and sporadic suggesting we still have much to learn about the ecology of Grass Pickerel in the province. The specific objectives of this study are i) to improve our understanding of the current distribution of Grass Pickerel, ii) to assess the health of individual populations and iii) to determine the habitat features that influence the distribution of this species in Ontario. Grass Pickerel was targeted in three watersheds in southern, central and eastern Ontario using a seine net. Sampling locations were chosen based on historical records of the species, and in the case of the eastern Ontario population, were sites sampled by Dr. E.J. Crossman during his pioneering study on the species in 1962. Grass Pickerel made up 0.1-1% of the total catch suggesting declines in relative abundance in certain populations. In addition, a large, multi-year data set from a population in Fort Erie, Ontario will be used as a case study to evaluate the habitat features that influence the distribution of Grass Pickerel within a given watershed.

RESTORATION OF LAKE STURGEON (*ACIPENSER FULVESCENS*) IN THE DETROIT RIVER AND THE IMPORTANCE OF MILT QUALITY

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The lake sturgeon (*Acipenser fulvescens*) population in the Detroit River was nearly extirpated during the 20th century due to habitat destruction and human interference. Recent efforts have been made to restore the natural spawning habitat through the use of artificial spawning reefs to enhance reproductive success in the wild. This population of lake sturgeon has a relatively low number of spawning adults (~ 1% of historical size) and appears to receive little gene flow from surrounding populations. As such, it is possible that this population could have reduced gamete quality due to increased risk of mating between relatives. In the current study we took milt samples from males in the Detroit River as well as from a more abundant and relatively less isolated Lake Huron population. The goal of this study was to answer two questions, 1) how

lake sturgeon sperm morphology relates to velocity and longevity metrics in general, and 2) does sperm quality differ between these two populations? In order to answer these questions, we investigated sperm morphometry characteristics (including head shape and tail length) as well as sperm motility parameters related to reproductive success (i.e. velocity, longevity, and path straightness) for each of the populations. Most variables did not differ between the populations, but sperm from the Detroit river population were significantly faster at 5 and 10s post-activation. Data from this study are crucial for the design of future lake sturgeon population management strategies related to enhancing natural reproduction and ultimately recruitment in the Detroit River.

LOSS OF THE LAKE WHITEFISH (*COREGONUS CLUPEAFORMIS*) SPECIES PAIR IN COMO LAKE, ONTARIO

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In Canada, morphologically and genetically different sympatric populations of Lake Whitefish have been identified from seven inland lakes. The status of Lake Whitefish species pairs is currently being assessed by Committee on the Status of Endangered Wildlife in Canada (COSEWIC). During 1989, dwarf (mode: 17-18 cmFL, forklength) and normal-sized (mode: 28-29 cmFL) whitefish were collected from a rocky spawning shoal in Como Lake (near the town of Chapleau, Ontario). The two forms were further differentiated based on mitochondrial DNA haplotypes, age at maturity, and meristic and morphological characters. In October of 2012 and 2014, we returned to Como Lake to assess whether the two Lake Whitefish forms were still present. Spawning shoals (~2-5 m deep) were sampled with gillnets of the same design used 25 years earlier. However, we were unable to identify the previously described dwarf and normal whitefish from the 320 individuals captured in overnight net sets. Alternatively, a faster-growing form that attained greater maximum size (>50 cmFL) and age (31 years) was identified. It has been hypothesized that limnological characteristics and composition of the zooplankton community influence phenotypic divergence between sympatric whitefish populations. At some point over the past 25 years, the invasive zooplankton species, Spiny Waterflea was introduced into Como Lake. Its establishment likely changed the lake ecosystem conditions that maintained the species pair.

ASSESSING EFFECTS OF HABITAT COMPENSATION ON INVERTEBRATES IN AN ARCTIC BARRENLANDS STREAM.

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POSTER PRESENTATIONS

As resource development expands in northern Canada, threats to the ecological integrity of freshwater systems are increasing. As compensation for diamond mine development, Diavik Diamond Mines Inc. constructed a nature-like fishway, using a generally inaccessible and impassable natural outlet stream, to improve ecological connectivity between Lac de Gras and a headwater lake and provide spawning and rearing habitat, especially for Arctic Grayling. Because a substantial reduction in growth and production of young-of-year Arctic Grayling could be attributed to lower densities and smaller sizes of benthic invertebrates, likely due to low amounts of autochthonous and allochthonous organic matter and homogeneous physical habitat in another nearby constructed stream, we initiated a Before-After-Control-Impact study to assess the effects of this habitat compensation on macroinvertebrates and on key components of stream habitat structure and function. At both pool and riffle sites, we assessed channel and bank morphology, substrate, riparian vegetation, water quality, epilithon, coarse particulate organic matter, and wood 3 years before and 2 years after construction. Macroinvertebrates were also collected and will be analyzed for taxonomic composition, abundance, and biomass. Additional data from several reference streams were also collected to establish standards against which characteristics of the fishway could be compared, and to provide a better picture of aquatic macroinvertebrate assemblages in Barrenlands streams. Our study will thus advance our basic understanding of headwater lake-stream systems in the Canadian Barrenlands.

THE BREWER PARK POND ESOCID TRACKING PROJECT

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The portion of the Rideau River that flows through Ottawa, Ontario supports a recreational fishery for northern pike (Esox lucius) and muskellunge (Esox masquinongy). These muskellunge are a globally unique population due to their successful propagation within a large urban centre. To ensure the persistence of these esocid populations and the fisheries they support it is important to maintain existing spawning and nursery habitat and, where possible, remediate historical habitat. Brewer Park Pond was created by reclaiming land from the floodplain of the Rideau River, effectively preventing access for spawning fishes. With support from a variety of stakeholders, a plan is underway to reconnect the pond to the Rideau River. Using radio tracking, our primary goal was to evaluate the pre-reconnection spatial distribution of adult muskellunge and northern pike in the section of the Rideau River adjacent to Brewer Park Pond. Using a seine net, our secondary goal was to determine whether there is successful recruitment of esocids in the area near the Pond. Preliminary results suggest that there is considerable activity by adults from both species in the Brewer Park Pond area; key aggregation areas during the winter, summer and spawning periods have been also identified. Our seining efforts found 14 young-of-year muskellunge and 1 northern pike suggesting that there is successful recruitment for both species in the lower Rideau River. Results from this study will provide an important pre-construction baseline and allow us to determine the effectiveness of habitat restoration activities once complete.

POSTER PRESENTATIONS

FISH COMMUNITIES OF FANGCHENG HARBOUR WATERS IN THE SOUTH CHINA SEA

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Both fishing and pollution due to anthropic activities present great and increasing pressures to the coastal ecosystems, and the depletion of coastal fisheries is one of the obvious outcomes. In order to develop appropriate management strategies of these multi-species fisheries, it is important to understand the community composition and potential regulating factors. In spring and autumn, 2014, bottom trawling methods were used to investigate the fish community structure and assess the biomass. Community statistical analyses were conducted to determine how the species composition varies amongst sampling stations and the relationship to environmental conditions. Ecological groupings of fish species were considered based on the feeding habits and trophic structure. Although the fish community maintains similar levels of biodiversity among locations, the benthic fishes are rare, especially piscivorous species, relative to large quantities of small-sized herbivorous or omnivorous pelagic fish.

THE ROLE OF IRON IN LAKE EUTROPHICATION: A CONTEMPORARY AND PALEOLIMNOLOGICAL STUDY

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The phosphorus cycle is closely linked to the iron cycle in aquatic environments because iron has the capacity to bind to phosphate, then precipitate and retain it in the sediments. Iron is generally sufficiently abundant to precipitate the excessive phosphate, but it has been suggested that certain lakes might exhibit an iron deficiency, especially those lying on bedrocks that contain little accessory minerals, such as marble. Lake Heney in the Outaouais region (Québec) has been subject to property development and logging since the European settlement in the 1850s, as well as fish farming activities from 1994 to 1999, which added a total of 2,300 kg of phosphorus in the lake. After the fish farm closure, phosphorus concentrations remained high. Because the lake and most of its drainage basin lies on marble, it has been suggested that the amount of iron was not sufficient to bind to the excessive phosphorus and precipitate it. Despite the lack of long-time monitoring, the Association for the Protection of Lake Heney set a restoration target of 15 µg/L of total phosphorus. To reduce the phosphorus concentrations, 217 tons of iron chloride were evenly spread over the lake in fall 2007. We sampled a suite of lakes in the Outaouais to determine if iron deficiency occurs in similar lakes of the Canadian Shield, with marble bedrock in catchments. This will provide management tools for local lake associations to improve protection practices since these lakes may be more susceptible to eutrophication.

POSTER PRESENTATIONS

7) Multiple Stressors and Aquatic Ecosystems

EFFECT OF METALS ON THE ALLOMETRY OF PLANKTONIC FOOD WEBS IN LAKES EXPOSED TO MINING OPERATIONS IN NORTHERN SASKATCHEWAN.

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Northern Saskatchewan contains large reserves of uranium. Uranium mining activities can result in high metal concentrations in pit lakes and in nearby lakes (exposed systems). Ecological theory suggests that stressed ecosystems tend to be composed of bottom heavy food webs, due to the tolerance of smaller-bodied organisms to environmental stressors. We tested this theory by examining the relationship between metal concentration and the size distribution of planktonic biomass (food web allometry) in exposed and reference lakes in northern Saskatchewan. Pit lakes with high metal concentrations often contained bottom heavy planktonic food webs; conversely, most reference lakes contained a greater distribution of biomass in larger organisms. For example, elevated arsenic, aluminum, nickel and zinc concentrations were associated with bottom heavy food webs ($p<0.05$ and $0.21< R^2 <0.66$). Hence, ecological theory appears to be supported. However, a confounding variable may concern age and colonization rates of some pit lakes.

TOXICOKINETICS AND BIOACCUMULATION POTENTIAL OF PARENT AND ALKYL POLYAROMATIC COMPOUNDS IN WOOD FROG TADPOLES (*LITHOBATES SYLVATICUS*) EXPOSED TO ATHABASCA OIL SANDS SEDIMENT

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Many polyaromatic compounds (PACs) are toxic, carcinogenic and mutagenic compounds of great concern to aquatic biota and ecosystems. Although there has been research on the accumulation and kinetics of PACs in developing amphibians, most studies only follow the kinetics of a few individual compounds, but typically overlook alkylated PACs that are predominant PACs in oilsands regions, and generally focus on water as the main uptake route. In order to study the uptake and elimination toxicokinetics of PACs and compare bioaccumulation potential of parent and alkyl PACs, over 300 Gosner stage 28-29 wood frog tadpoles (*Lithobates sylvaticus)* were exposed to oil sands sediment from the MacKay River for 8 days and removed for depuration for 2 days. Preliminary results show that alkylated benzo(a)anthracenes, chrysenes and dibenzothiophenes were the PACs most bioaccumulated in the wood frog tadpoles, with C4-dibenzothiophenes reaching up to 274 ng/g in tadpole samples (N=3) after only 24 hours. Likewise, the total uptake of alkyl PACs was greater than that of parent PACs, with those with three to four alkyl groups reaching higher body concentrations than PACs with only one to two alkyl groups. However, concentrations of PACs in the bodies of the tadpoles did considerably decrease within as shortly as 24 hours, concurring the ability of vertebrates to metabolize PAHs. A more thorough understanding of these preliminary accumulation and elimination parameters

was accomplished using a contaminated water exposure experiment where wood frog tadpoles were exposed to only water, naturally contaminated with PACs.

INVESTIGATION ON THE IMPORTANCE OF ENHANCED ATMOSPHERIC NITROGEN DEPOSITION AND CLIMATE WARMING ON PRIMARY PRODUCTION OF SCALED CHRYSOPHYTES IN NORTHERN SASKATCHEWAN

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Bitumen extraction and processing in the Athabasca Oil Sands Region (AOSR) began in the early 1960's, while modern production is increasing near exponentially. This has resulted in increased emissions of sulphur and nitrogen oxides, both of which have the potential to impact nearby aquatic ecosystems. Lakes are also susceptible to impacts from climate warming, due to a ~2.4°C increase in mean annual temperature observed in Fort McMurray. To date, paleolimnological analyses of lakes in the AOSR and northern Saskatchewan (a region more downwind of the AOSR) indicate that even in the presence of acidic deposition, there is little evidence of lake acidification. However, the same research provides evidence of increased primary production over the last several decades. Enhanced atmospheric nitrogen deposition has been suggested as a potential driver for changes in lake primary production, however the relative importance of climate warming and nitrogen deposition on primary production remains unknown. My research aims to disentangle the relative importance of these two stressors on primary production in northern Saskatchewan lakes. To do this, I will investigate scaled-chrysophyte assemblages in sediment cores of potentially nitrogen-limited and phosphorus-limited lakes that are both subject to enhanced nitrogen deposition, and those that are not. This will reveal the relative importance of each stressor on primary production, information that is particularly important for the development of policies and regulations of industrial activities in the oil sands. Preliminary data from two lakes indicate that the scaled chrysophytes are a recent phenomena, suggesting conditions are only recently conducive to their growth.

DEVELOPMENT OF METAL BIOSENSORS AND THEIR APPLICATION TO THE MINING INDUSTRY

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Acid mine drainage is a global concern. Mine drainage, enriched with heavy metals and in contact with sulphide minerals, are poised by a series of chemical and biological processes which typically lead to highly acidic waters. Tailings, waste and open pits, are all mining practices which tend to yield a substantial amount of arsenic (As) contamination. Chronic low-level intake of arsenic and heavy metals can promote neurotoxicity, induce anemia and immunosuppression as well as carcinogenesis for the skin, lung, liver and more. Traditional methods require specialized laboratories and costly instruments. Current methodologies for the monitoring of

heavy metal environmental pollutants are costly yet sensitive. However, precise estimations of the total concentration of trace metals are far from a true estimation of their potential environmental toxicity. Subsequently, whole-cell biosensor assays have been designed for the detection of the presence and quantity of a variety of chemicals. In all, bacterial reporters are customizable and reliable for the measurement of the biologically relevant fraction of environmental contaminants. Here, we present a novel arsenic bioreporter construct that allows to rapidly estimate concentrations of bioavailable arsenic as well as perform As speciation.

PRESENCE AND BIOCONCENTRATION POTENTIAL OF POLYCYCLIC MUSKS GALAXOLIDE AND TONALIDE IN FATHEAD MINNOWS FROM NORTH SASKATCHEWAN RIVER, EDMONTON

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Synthetic musks are fragrances added to personal care products, including perfumes, detergents and other household cleaning products to make them fragrant. These contaminants resist degradation, are persistent in the environment and are eventually released into rivers and lakes. Previous studies showed musks to have sublethal effects and endocrine disruption properties. This project examines two synthetic products of the polycyclic musk family : Galaxolide, or 1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethylcyclopenta(g)-2-benzopyrane (HHCB) and Tonalide, or 7-acetyl-1,1,3,4,4,6-hexamethyltetrahydronaphtalene (AHTN), which are the most extensively used musks in the industry. The presence and bioconcentration potential of these musks were studied in fathead minnows (Pimephales promelas) exposed at 6 different sites in North Saskatchewan River, near the Gold Bar wastewater treatment plant (Edmonton, Alberta). Results indicate that these musks are widely detected in fish near these wastewater effluents. The concentrations of HHCB and AHTN in fish exposed in the plume of the treated waste water discharge ranged from 1,99 to 4,96 µg/g of fish and from 39,36 to 292,80 ng/g of fish, respectively.

CHEMICAL, PHYSICAL AND CATCHMENT FACTORS INFLUENCING THE PHYTOPLANKTON COMMUNITY IN TEMPERATE LAKES OF THE MUSKOKA-HALIBURTON REGION

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The Muskoka-Haliburton region of Ontario contains 1000s of temperate freshwater lakes, many of which experience different types of algal blooms throughout the ice-free season. Currently it is unknown what environmental factors and anthropogenic stressors are operating across the landscape to influence the phytoplankton communities within these lakes. In general a complex

array of environmental factors can affect phytoplankton growth, productivity and community structure; therefore in this spatial study we assessed the importance of chemical, physical and catchment factors influencing the phytoplankton community in 45 lakes. Here we used a combination of direct ordination and correlation statistical methods to: (a) examine spatial patterns in our phytoplankton group-level data, and chemical characteristics among lakes, and (b) determine drivers of spatial covariance in community composition. Preliminary results indicate that three chemical variables: Gran alkalinity, dissolved organic carbon and total phosphorus, explained significant, independent sources of variation in phytoplankton group level data. Two-category variance partitioning analysis show that chemical parameters accounted for most of the total explained variance with only a small portion shared between the chemical, physical and catchment characteristics. These results suggest that even though physical parameters and catchment characteristics can influence the phytoplankton community in Muskoka-Haliburton lakes, chemical variables are comparatively more important.

ATLANTIC SALMON MOVEMENT IN THE MACTAQUAC HEADPOND

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The Mactaquac Aquatic Ecosystem Study (MAES) was designed by the Canadian Rivers Institute (CRI) to provide an informed, science-based decision to NB Power regarding the Mactaquac Generating Station, and to assess the structure and function of a large river ecosystem.

"Reservoir transit and downstream approaches to a large dam by Atlantic salmon" is a project under the Fish Passage theme of the MAES. The 100 km Mactaquac reservoir has minimal current, restricting natural environmental cues for salmon movement. The main objectives are to (1) determine whether juvenile (smolt↓), adult (↑), and post-spawning adult (kelt↓) salmon find their respective up- and downstream exits, and (2) determine how smolts and kelts approach the large dam structure.

The first objective is being determined through Vemco acoustic telemetry. Forty smolts (20 wild/20 hatchery) were tagged in May 2014, and 20 wild adults were tagged in July 2014. These fish were passively tracked by 32 receivers spanning ~135 km, and actively within the reservoir. Fish movements will be related to limnological conditions to inform habitat use. Preliminary results are being analyzed and will be presented.

The second objective will be determined through HTI acoustic telemetry beginning spring 2015. Twelve receivers will be placed at differing depths within a 1 km^2 array at the face of the dam. Smolts and kelts will be tagged and released near the array, and their position will be tracked in real-time 3D. Their position in the water column and their surrounding flow conditions will inform engineering of fish passage structures.

POSTER PRESENTATIONS

LITTORAL FISH COMMUNITY CHANGES IN SOUTHEASTERN ONTARIO
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Canada has nearly 210 freshwater fish species. Of these species, 30% of them have been assessed to be Extirpated, Endangered, Threatened or Special Concern. With rapid loss of fish diversity, it is crucial to monitor and assess our current fish distributions. Ontario has one quarter of a million lakes and has the largest fish diversity of any province: 128 fish species, in 24 families including 17 introduced species with established populations. Anthropogenic factors associated with increases in human populations contribute to species decline from habitat loss and habitat degradation and alien species introductions. Because Ontario is the most populated province in Canada, it is expected to be a hot spot for community change and biodiversity loss in fishes. The objective of this study is to describe changes in littoral fish communities in southeastern Ontario using historical and current records, and to investigate possible mechanisms of changes to contribute to a better understanding of the factors affecting fish communities. Using the same site location, season, gear and effort, seining data from the 1970s were compared to current seining data in 22 lakes between Kingston and Smith Falls Ontario. Preliminary data analyses suggest drastic community changes.

8) Collaborative Fisheries Research in Canada

EVALUATION OF A NATURE-LIKE FISH PASS FOR A SMALL ARCTIC HEADWATER STREAM
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A collaboration involving the University of Alberta, Department of Fisheries and Oceans, and Diavik Diamond Mines, Inc (DDMI), worked to design, install, and evaluate the effectiveness of a nature-like fish pass in a 420 m headwater stream at Lac De Gras, NWT. The fish pass, part of DDMI's fish habitat compensation program, was designed to offset habitat lost during the initial phases of mine development. The overall goal of the fish pass was to improve fish migration in this headwater lake/stream system, which was naturally characterized by a series of small cascades and a poorly defined channel, preventing fish passage. Our objective was to evaluate the ability of fish to move throughout the modified stream. Successful movement would provide native fishes access to spawning, and rearing habitat.
The experimental design incorporated PIT tagged adult Arctic Grayling (*Thymallus arcticus*), three paired antenna arrays, and the manipulation of stream flow by means of pumping to track fish movement during background, medium, and high flow regimes. A second experiment used fin clipped young-of-year Arctic Grayling to determine the ability of these fishes to migrate downstream through the stream. The results of these field experiments reveal the relative effectiveness of fish movement, suggesting that a founding population of fish could be able to access, use, and move within and through the stream. Overall significance, experimental design, and initial results will be presented.

POSTER PRESENTATIONS

RECIPROCAL INTERACTIONS BETWEEN LAKE FISHERIES AND LAKE ORGANIZATIONS

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Current approaches for managing natural resources, including inland lake fisheries, often lead to one-size-fits-all solutions or management panaceas. Research suggests that these panaceas are prone to failure because they ignore local variation in resource supply and demand. In a heterogeneous region, a management panacea at best maintains a sub-optimal, average condition in local resources; at worst it drives resource mismanagement and generates animosity between resource managers and users. Lake organizations (formalized bodies of lake property owners) offer local alternatives to the regional management paradigm. These groups vary in their level of formal structure from unincorporated, voluntary associations to special purpose units of local government. Although lake organizations may represent a promising alternative model for fishery management, we lack a basic understanding of the reciprocal interactions between lakes and lake organizations. We evaluate the efficacy of local-scale lake resource management by lake organizations using a dynamic social-ecological lake fisheries model.

WORKING TOWARD RECOVERY OF AMERICAN EEL IN THE OTTAWA RIVER THROUGH COLLABORATIVE RESEARCH

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Historically, the Ottawa River provided extensive freshwater habitat for adult American eel, *Anguilla rostrata*, populations. Hydroelectric dams constructed on the Ottawa River and its major tributaries have resulted in the decline of the American eel population in recent decades. Recovery of American eel in the Ottawa River will require the willingness and cooperation of a complex set of actors which includes the Algonquin First Nation, Provincial governments, the Federal government, power producers, and civil society groups. Together, this partnership has carried out five years of research on eels in the Ottawa and gradually built common interest in eel recovery. Phase one of the project focused on determining adult movement and downstream migration timing as well as habitat use in the lac des Chats reach of the Ottawa River using radio telemetry. Phase two of the project has focused on juvenile eel upstream migration. The use of temporary eel ladders and intensive trapping has been tested to aid in the monitoring of juvenile eel occurrence and passage at upstream barriers. An acoustic telemetry study is being conducted to determine the movement of juveniles below Chaudière Falls and which channels they use to bypass the barrier. Finally a trap and transfer of juveniles from the St. Lawrence at Montreal to

the Ottawa River was piloted in July 2014. Results of this study will help inform conservation and mitigation measures that can help in the development of successful eel passage opportunities in the Ottawa River and its tributaries.

9) Aquatic Nutrients: Dynamics and Algal Blooms

WATER QUALITY CHANGES IN SMALL SOUTHERN ONTARIO INLAND LAKES - ONE SIZE FITS ALL?

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Small lakes provide many ecological services, and are considered hotspots for nutrient cycling and biodiversity. In the Severn Sound watershed (~1000 km^2) in Southern Ontario, there are five small lakes (1-6 km^2) that provide these services, in addition to being important recreationally. An important question, both ecologically and from a management perspective, is whether temporal changes in lake chemistry and algae are congruent, indicating regional effects, or lake specific, indicating greater importance of within-lake effects. Spanning the transition zone between the Precambrian Shield and the St. Lawrence Lowlands, these lakes vary considerably in morphometric and watershed characteristics given how closely situated they are. Principal components analysis grouped the lakes into three groups based on morphometric characteristics. As part of trophic status monitoring, the lakes were sampled alternately between 2010-2012. Data were also available through previous studies and volunteer sampling programs, although there was inconsistency in the variables measured throughout the historical record. To deal with discontinuous data, means were calculated for two periods (1973-1989 and 1990-2012), and each lake-period combination used in ordinations. Some lakes shifted different distances and in different directions in ordination space from one period to the next, however there were some similarities among lakes that had similar characteristics. This information will help guide lake management decisions by determining whether a "one size fits all" approach can be applied, or if management recommendations must be made on an individual lake basis.

EVIDENCE OF DREISSENID MUSSEL AND TRIBUTARY INFLUENCES ON NUTRIENT DISTRIBUTION IN THE NORTHERN NEARSHORE OF EAST BASIN LAKE ERIE

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Nuisance *Cladophora* growth is a concern in the northern nearshore of East Basin Lake Erie. Observations suggest a positive relationship between *Cladophora* biomass and bioavailable phosphorus (P). Tributary loading into the Great Lakes has generally been meeting or falling below posted guidelines, however. Non-native Dreissenid mussels may be enriching the benthos by feeding on water column phytoplankton and depositing their wastes to the bed (the nearshore shunt). Sampling occurred at stations of varying proximities to the mouth of the Grand River (ON) and at varying depths during May-October 2013 and 2014. Samples were collected at discrete intervals for soluble reactive phosphorus (SRP), ammonium (NH_4), chlorophyll a (chla)

and particulate P (PP). The water column was profiled with a YSI 6600 sonde. SRP at the sites in closest proximity to the Grand River were significantly elevated compared to sites further away. NH_4 did not show any strong vertical or horizontal pattern. Chla and PP did not show any significant horizontal differences between sites, but there was evidence of vertical differences between the deepest and mid-depth sampling intervals at deeper stations. Conductivity tended to be elevated at sites closest to the Grand River, indicating possible river input. These results suggest that the Grand River might still contribute a significant amount of SRP to the system. Chla and PP lend some support to a mussel feeding-mediated P drawdown. Next steps include nutrient concentration measurements nearer to the bottom and factoring near-bottom water movement into the formation and abolishment of near-bed concentration gradients.

CYANOBACTERIA DOMINANCE IN THE LAKE SIMCOE GEORGIAN BAY AREA: A PHOSPHROUS AND IRON APPROACH.

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Cyanobacteria blooms are an increasing concern for cottage owners and tourists in the Lake Simcoe and Georgian Bay area. These blooms are not aesthetically pleasing and they can result in the production of toxins that have led to the illness in children and, in some cases, the death of animals. The annual appearance of these blooms on some lakes has reduced property values and made cottages unsellable. By observing shifts in the chemistry of the water column and sediments as blooms occur over the summer, we hypothesize that it is possible to uncover the cause of cyanobacterial dominance of some blooms. This research is focused on the interactions between phosphorous, iron and sulphur. Cyanobacteria need access to Fe^{2+} to a greater extent than eukaryotic algae. Excess loading of nutrients, especially phosphorous, promotes primary production resulting in anoxia at shallow depths. Anoxia allows internally loaded Fe^{2+} to stay in the water column in dissolved form at depths accessible by cyanobacteria. In three bays of Georgian Bay, Sturgeon Bay, Deep Bay and North Bay, water column profiles of O_2, Fe, SO_4^{2-}, SRP, TP, NH_4^+, NO_3^-, $NO_2^-$and TN were collected monthly throughout the summer. In 2014, cyanobacteria blooms were not present at any of these locations but were present in 2012 at all three sites concurrent with anoxia and internally loaded Fe^{2+}.

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10) Experimental Lakes Area

A STUDY ON THE LEVELS OF RADIOACTIVITY IN FISH SAMPLES FROM EXPERIMENTAL LAKES AREA

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As part of Health Canada's study on background radiation levels in country foods, fish fillets were collected from three lakes at the Experimental Lakes Area (ELA). Naturally occurring radionuclides (such as Ra-226, Pb-210, and Po-210) as well as long lived contaminants (such as Cs-137) were analysed. Preliminary results showed that Po-210 is the dominant contributor to radiation doses resulting from fish consumption. While concentrations of all other radionuclides were below conventional detection limits, Po-210 was measured in most fish samples collected from the ELA. The average concentration was about 1.5 Bq/kg wet weight (ww). The resulting radiation dose from consumption of 1kg of fish containing 1.5Bq of Po-210 would be 2μSv, less than 1/1000 of the annual dose from exposure to natural background radiation in Canada.
We observed an average Cs-137 concentration of 4.9±0.2 Bq/kg ww for Lake 305 Lake Whitefish. We also observed average Cs-137 concentrations of 15.6±0.8 Bq/kg ww in Lake 305 Northern Pike, and 5.4±0.3 Bq/kg ww in Lake 302 White Sucker. Preliminary analyses indicated that the average concentration of Cs-137 in fishes from inland lakes is significantly higher than that found in fishes from Pacific Ocean. The relatively higher concentrations of Cs-137 in fish samples from inland lakes are still considered very low from radiological protection perspective. The resulting radiation dose for people from fish consumption would be a very small fraction of the annual dose from exposure to natural background radiation in Canada, and pose no radiological health concern.

ACTIVITY COSTS BY LAKE TROUT IN DIFFERENT LAKE ECOTYPES

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Swimming activities constitute a large component of the total metabolism in fish. For top predators in particular, metabolic costs associated to foraging activities can represent a large amount of the energy budget. In Lake Trout, for example, the energy spent in feeding behaviour may be diverted from other metabolic processes such as growth and reproduction, which will then influence the body condition of different populations of this fish. In this study, we assessed the activity costs displayed by Lake Trout across different lake ecotypes. We used acoustic telemetry to track four populations of this fish with various availability of pelagic prey for Lake

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Trout: piscivorous populations, where Lake Trout had pelagic prey available, and non-piscivorous populations, where littoral fish and/or mega zooplankton (*Mysis*) were part of Lake Trout diet. Additionally, we used activity transmitters, which are good estimators of the metabolic demands of fish swimming. In general, we found that non-piscivorous populations had higher average metabolic costs, compared with piscivorous populations. This was explained by the increased swimming demand for Lake Trout in lakes where prey was smaller in size and represented low caloric diets. Piscivorous populations were associated with larger sizes at maturity, and overall lager body sizes for Lake Trout.

11) General Contributed Papers

THE WATER QUALITY OF ONTARIO'S INLAND LAKES: AN ANALYSIS OF WATER CHEMISTRY RESULTS FROM ONTARIO'S BROAD-SCALE MONITORING PROGRAM

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In 2005, the Province of Ontario implemented its Ecological Framework for Recreational Fisheries Management, a component of which was the establishment of standardized, long-term monitoring of the province's fisheries resource, referred to as Broad-scale Monitoring (BSM). The BSM program was initiated in 2008, with the aim of collecting detailed fisheries and water quality information on a five-year cycle from hundreds of lakes across the province. In 2012, the first BSM cycle was completed, with more than 800 lakes sampled from southwestern Ontario to the Ontario-Manitoba border, and to within 100 km of the Hudson Bay coast. In addition to gathering detailed biological information from every lake, water samples were collected for chemical analysis, and analysed at the Ontario Ministry of the Environment and Climate Change's Dorset Environmental Science Centre. Here, we summarize the water quality results from the first BSM cycle. Specifically, we interpret the results with respect to established indicators of water quality condition, focusing on several key water chemistry variables (e.g., total phosphorus and calcium concentrations). Further, we use multivariate analyses to examine regional differences (ecozone, ecoregion) in water quality, and to explore local and regional factors that may explain these differences.

SPAWNING MIGRATION AND SURVIVAL OF ATLANTIC SALMON IN TWO NORTHERN CANADIAN RIVERS

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Atlantic Salmon (*Salmo salar*) generally return to their natal rivers to spawn. Many of these fish survive, return to sea and recondition prior to subsequent spawning. Telemetry methods are being used to study freshwater migrations, spawning, and survival of Atlantic Salmon in two Labrador rivers: St. Lewis River in southern Labrador (52º26'N, 56º11'W; Drainage Area = 2590 km^2) and Hunt River in northern Labrador (55º31'N, 60º42'W; Drainage Area = 2590 km^2). Radio tags were applied to 20 returning salmon at St. Lewis River and 29 at Hunt River. Ten salmon tagged at St. Lewis also have acoustic tags. The modal river age of salmon was 4 years (range 3-5 years) and all small salmon (< 63 cm) were maiden one-sea-winter (1 SW). Large salmon (≥ 63 cm) were maiden two-sea-winter (2 SW) or repeat spawners (2 SW consecutive and alternate, 1 SW alternate). Tagged fish are being tracked using fixed receiver stations placed in potential spawning and overwintering areas as well as regular helicopter surveys. Results of upstream migration patterns, timing and location of spawning, movement to overwintering habitat and predominance of autumn returns to sea will be presented.

GEOCHEMISTRY AND MIGRATION OF *CA.* 100 YEAR OLD MINE TAILINGS IN COBALT, ONTARIO, CANADA.

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Tailings migration occurring at the Beaver Mine site, Cobalt, Ontario, Canada, has resulted in tailings deposition downstream at Kirk Lake. This transport of tailings has dispersed metals into the environment, particularly arsenic. The original source area and migrated tailings exceed the regulatory standards for arsenic in soil by up to 240 times the acceptable limit of 18 ppm, and are well above background soil levels in the Cobalt area. Arsenic concentrations in water were found to be up to 268 times the acceptable limit of 5 ppb for the protection of aquatic life. It was found that migrated tailings contained lower metal concentrations than the source area. This loss of metal content likely occurred during transport and is supported by increasing metal content in waters along the migration path. Additionally, analysis of tailings showed that the prevailing redox conditions specific to each location were important for the behaviour of arsenic and its subsequent mobilization. Surface enrichment of metals in the tailings was primarily due to evaporative processes carrying dissolved metal species to the surface during dry summer months and forming enriched metalliferous crusts. These crusts subsequently can be washed away downstream. Tailings regularly exposed to surface waters showed a surface depletion in arsenic likely due to leaching of metals into surface waters. At both sites arsenic mobility was found to be greatly inhibited by the presence of clay minerals within the tailings, noted by depleted metal concentrations adjacent to clay layers and enrichment in clay layers.

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EXAMINING THE HISTORICAL TRENDS IN DIET AND CONTAMINANT EXPOSURE IN A 4,000-YEAR-OLD BAT GUANO CORE FROM JAMAICA

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Insectivorous bats are excellent ecological indicators owing to their long life span, global distribution, and predictable responses to environmental stressors as seen in the bioaccumulation of pollutants from dietary intake. Bat guano deposits are environmental archives of a largely aquatic diet that is well preserved within the cave environment allowing for reconstruction of dietary changes and chemical exposure to contaminants. We present a triple isotopic approach to determining long-term dietary trends in bat guano consisting mainly of insects, which carry local aquatic isotopic signals. In a consumer, the unique $\delta^{13}C$ signature can be an indicator of carbon source as the ratio is dependent on the photosynthetic pathway type of the ingested vegetation. $\delta^{15}N$ is often an indicator of trophic position in bat guano owing to ^{15}N enrichment in higher consumers, such as insectivorous bats. $\delta^{34}S$ may be used to differentiate between terrestrial and aquatic feeding bat habitats owing to differences in salinity. $\delta^{34}S$ may also be used as an indicator of the proximity to which bats are feeding in an aquatic habitat. Here we present the long-term changes in isotopic composition and contaminant exposure within this bat guano deposit in relation to the timing of different anthropogenic activities. Periods of increased atmospheric emissions of metals resulted in an increase in metal concentrations within this bat guano deposit. For example, the Industrial Revolution and the introduction of leaded gasoline increased atmospheric concentrations of metals such as lead and mercury, which peaked at the corresponding times within this guano deposit.

EFFECT OF LAKE SIZE, ISOLATION AND PISCIVOROUS PREDATOR PRESENCE ON NESTED FISH COMMUNITY STRUCTURE

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Nested species co-occurrence patterns have often been identified in landscapes made up of discrete habitat patches or sites; however, multi-trophic relationships such as predation have seldom been examined as a causal mechanism. In nested communities, the species present in small assemblages are subsets of those present in larger assemblages. The goal of our study was to determine if fish communities in the lakes of two watersheds were significantly nested, and whether lake size, isolation and piscivore presence contributed to the nested pattern in this data. We used fish community data from two watersheds in Ontario that differ in terms of range in lake size and lake isolation. The Black and Hollow River dataset represents a watershed of fifty-two lakes. The second dataset is from Manitoulin Island, with forty-nine lakes from a series of short drainages connected to Lake Huron. We tested whether fish assemblages were nested and

evaluated the impact of lake size, isolation and piscivorous fish presence on site nested rank and species richness. We then assessed idiosyncratic species that did not conform to the nested pattern (species that have unexpected absences in the packed portion of the matrix or unexpected presences outside the packed area).
Fish assemblages in both watersheds were significantly nested. Lake size was a significant driver of the nested pattern, but lake isolation and piscivore presence impacted overall matrix nestedness in only one of the two watersheds. However, examination of idiosyncratic species suggested that piscivorous fish did, in fact, affect community structure in both watersheds.

MANAGEMENT OF RECREATIONAL AND DRINKING WATERS IN CANADA AND BRAZIL: A COMPARISON OF PRACTICES REGARDING CYANOBACTERIAL BLOOMS.
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The eutrophication of surface waters combined with global warming have been creating the perfect conditions for the development of cyanobacterial blooms. Because cyanobacteria produce a variety of hepatotoxins, dermatotoxins and neurotoxins, these organisms can pose a threat to human and animal health. Therefore, the work of environmental and public health agencies on the management and quality control of surface waters for cell concentrations of cyanobacteria and levels of cyanotoxins has become crucial for the protection of the affected ecosystems and the populations that utilize those waters. In Brazil, the human fatalities that occurred in Caruaru in 1996 triggered the development of standardized monitoring programs for recreational and drinking waters; as a result, the Brazilian water management legislation includes the analysis of cyanotoxins in water, and defines reference values. Health Canada's guidelines for recreational and drinking waters have oriented the Canadian provinces on the development of their own response protocols for cyanobacteria in surface waters. In this study, we compare the current management practices of recreational and drinking waters regarding cyanobacterial blooms in Brazil and in Canada. Our data compilation was done via interviews with water management agents and assessment of publications by these governmental agencies. Overall, our data indicates that the Brazilian legislation for surface water quality led to more unified responses in the states of the federation, while the bloom response programs found in Canada vary considerably among the provinces and most often rely on the visual identification of blooms.

QUANTIFYING BOREAL LAKE PRIMARY PRODUCTION USING AN OXYGEN-BASED STABLE ISOTOPE MASS-BALANCE MODEL
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In aquatic science, numerous techniques exist to estimate ecosystem gross primary productivity (GPP), each with their own advantages and limitations. One technique that has great potential,

but that is currently underused relative to others (e.g.; Light/Dark incubations, high-frequency sensor techniques, or DIC-C14 additions) is the measurement of GPP using dissolved oxygen (DO) combined with isotopic signatures (O18:O16) of DO and H_2O. This approach is potentially very powerful, as it provides an integrated ecosystem level measure of GPP independent of the limitations linked to bottle incubations. Yet these estimates are confounded by both physical (water column mixing and gas flux) and isotopic fractionation effects that are both complicated to quantify, and can have large associated measurement error. In this study, we evaluated the applicability of a steady-state isotopic mass balance model for estimating boreal lake GPP. We first conducted a sensitivity analysis to characterize the main potential sources of error in the model. Second, we applied a Bayesian statistical approach to the existing model, to incorporate the sources of uncertainty associated with GPP estimates. Finally, we tested the Bayesian GPP model at 3 time points in a 28 day, in-situ, boreal-lake mesocosm experiment, where metabolic gradients were established by additions of either humic-rich dissolved organic carbon (DOC), nutrients (N+P), or a combination of DOC and N+P. Modelled GPP was compared to independent GPP measurements derived from 24hr diel DO curves and floating chamber-based estimates of atmospheric O_2 flux.

SEARCHING FOR ARCTIC GRAYLING IN NORTHERN MOUNTAIN STREAMS: TESTING A DISTRIBUTIONAL MONITORING APPROACH IN THE LITTLE NAHANNI RIVER WATERSHED, NWT

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Aquatic environments in northern Canada face increasing pressure from multiple stressors including climate change and expanding development. Arctic Grayling (*Thymallus arcticus)* are a widely distributed, but sensitive northern species that play an important role in stream ecosystem functioning. An improved understanding of Arctic Grayling distribution and habitat requirements is needed in order to assess their vulnerability to impacts, establish thresholds for development activities, and evaluate species trends over time. However, resource managers require rapid, cost-effective, and defensible methods to accurately monitor the status of stream salmonids and to protect key habitats in remote areas. In the summer of 2014, distributional monitoring techniques based on species occurrence were tested in the Little Nahanni River watershed, Northwest Territories. Fish occurrence and a suite of habitat variables were collected at randomly selected sample sites within suitable habitat patches. Arctic Grayling were detected in 33% of the patches and 14% of sites surveyed. Sites with Arctic Grayling had average water temperatures of >10^{o}C, average elevation <1100m and an average slope of ≤0.02. In contrast Arctic Grayling were absent from sites with average water temperatures of <6^{o}C, elevations of >1250m and slopes of ≥0.06. Using this distributional monitoring approach we were successful in revealing habitat thresholds that appear to drive Arctic Grayling occurrence and distribution in

the watershed; however, further testing is required to refine environmental and biological criteria used to define and identify suitable habitat patches and to improve detection efficiency.

LANDSCAPE DRIVERS OF RIVER DISSOLVED CARBON DIOXIDE AND METHANE IN FIVE DISTINCT REGIONS WITHIN THE QUEBEC BOREAL BIOME

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Boreal rivers are a major component of the land-water interface in a region with a significant portion of the world's soil organic matter and freshwater. Rivers are often supersaturated with greenhouse gases (GHGs), CO2 and CH4, and emit these GHGs to the atmosphere. Although rivers represent a small fraction of the surface area of the boreal region, they are responsible for a disproportionately large amount of processing and export, thus their contribution to the global carbon budget is significant. Despite much study in recent years, the dynamics of CO2 and CH4 supersaturation are poorly understood. This study measures CO2 and CH4 at a large scale in five distinct regions within the boreal biome in Quebec to develop relationships between the landscape and gas exchange with the atmosphere. Throughout all five regions there is persistent coupling of CO2 and CH4 in rivers as well as a decrease in both gases with increasing stream order. The watersheds of the five regions sampled significantly differ in elevation, slope, and land cover analyzed using geographic information systems (GIS). The watershed properties show relationships that could be used to predict CO2 and CH4 in rivers remotely.

NITROGEN AND PHOSPHORUS LOADS AND NUTRIENT LIMITATION IN LAKE DIEFENBAKER

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Lake Diefenbaker (LD) is a multi-purpose dimictic reservoir. Average flow into the reservoir from the main tributary, the South Saskatchewan River (SSR), is approximately 300 m^3/s. Although highly variable, the reservoir's water residence time is 1-3 years. The magnitude and ratio of nutrient loads were examined as a function of riverine inflow into LD during the 2011 to 2013 period. In turn, the nutrient limitation in the reservoir will be examined as a function of these fluctuating loads. This would then provide an understanding of the sensitivity of LD to changes in nutrient loads as affected by extreme flows (climate related events). Extreme flows entered the reservoir from the SSR in early summer (June to early July) in all three study years. TN peak loads were 88.4, 104.9 and 338.6 Tons/Day, TP peak loads were 32.8, 21.8 and 415.8 Tons/Day in 2011, 2012 and 2013, respectively. Mean average peak flow from 1967 to 2010 was 1337 m^3/s; however, peak flows during the three years of this study were greater than the mean peak flow: 2665, 1593 and 5274 m^3/s in 2011, 2012 and 2013, respectively. Large loads of TP, TDP, DIN and TN during the study period were significantly correlated with peak flows in early summer. The ratio of the nutrient loads (e.g., TN:TP and DIN:TDP) as a function of flow showed

a significant inverse relationship where the lowest TN:TP and DIN:TDP ratios occurred during peak flows and vice versa. The effect of these fluctuating loads on nutrient limitation in the reservoir will be evaluated and discussed.

SPATIAL AND TEMPORAL TRENDS IN PHOSPHORUS AND NITROGEN IN LAKE DIEFENBAKER, SASKATCHEWAN

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Lake Diefenbaker is a large multi-purpose reservoir located on the South Saskatchewan River. The limnology of the reservoir is poorly understood relative to its importance to the province. Effective management of reservoirs often requires an understanding of the availability of nutrients such as phosphorus (P) and nitrogen (N). Fractions of these nutrients represent different aspects of the biotic and abiotic water column environment and provide a firsthand appreciation of the trophic status and type of nutrient limitation in reservoirs. Hence, we measured various forms of P and N including totals (TP and TN), dissolved (TDP and TDN), and particulate forms (PP and PN), as well as bioavailable forms such as phosphate (PO_4^{3-}), nitrate (NO_3), and ammonia (NH_3) during the ice-free seasons of 2011-2013 to infer nutrient limitation and planktonic dynamics (spatially and temporally). In all three years the greatest TP and TN concentrations corresponded with peak flows into the reservoir. During peak flows the majority of P input was in particulate form and the concentrations decreased along the length of reservoir. In contrast, the majority of N input was NO_3 which increased in concentration along the length of reservoir. Although nutrients were highly variable, the reservoir can be characterized as mesotrophic, and P limitation is likely, based on bioavailability of nutrients. Incoming flows and associated nutrients have important implications on nutrient availability, limitation, and the trophic status of the reservoir.

COMPARISON BETWEEN WATER COLUMN AND SEDIMENT TRAP STOICHIOMETRY IN LAKE DIEFENBAKER, SASKATCHEWAN

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Lake Diefenbaker is a multi-purpose reservoir located on the South Saskatchewan River. An ongoing project through the Global Institute for Water Security has been looking at several aspects of water quality within the reservoir, including nutrient limitation. Preferential uptake of phosphorus (P) by planktonic organisms has been shown to be indicative of P limitation in marine systems. We compared water column stoichiometry to that of particulate matter collected in sediment traps throughout the length of the reservoir during the open water seasons of 2011 and 2012 to determine if preferential nutrient uptake agrees with concurrent measurements of

nutrient limitation. Differences between water column and sediment trap stoichiometry show an overall trend toward nitrogen (N) scavenging. This trend is independent of sample location, stratification, or time of year. The apparent preferential uptake of N is in contrast to the concurrent findings of the project, which indicate that the system is primarily P limited. In both years more than 90% of P entering the system was in particulate form and was largely not available for planktonic uptake, whereas more than 60% of N entering the reservoir was in dissolved forms. We conclude that stoichiometric comparisons between the water column and sedimenting particulate matter is not a good predictor of nutrient limitation in a system with such high sediment loads consisting of largely unusable particulate P. A closer look at the bioavailable forms of P and N may agree more with the nutrient limitation measurements and previous studies in marine systems.

PHOTOAMMONIFICATION IN PLAINS AND BOREAL SHIELD LAKES WITH AN EXPANDED DATASET

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Conversion of dissolved organic nitrogen (DON) to ammonia by UV radiation (photoammonification or PA) is known to be a significant process in marine ecosystems, but has received little attention in lakes. A handful of studies have shown variable PA rates among lakes, but have not been able to attribute this variability to any one factor (e.g., water chemistry). We compared PA rates across 42 lakes from Saskatchewan and Ontario (summer and fall of 2010, 2013 and 2014). Rates were related to the following water chemistry parameters: TN (total nitrogen), TDN (total dissolved nitrogen), DON, DOC (dissolved organic carbon), CDOM (chromophoric dissolved organic matter), pH and conductivity (multiple linear regression, $p<0.05$). Shield lakes had relatively low DOC, DON, pH and conductivity, and a greater proportion of CDOM. Plains lakes had greater conductance and higher pH, DOC and DON, but low CDOM. A greater proportion of shield lakes showed detectable PA rates (93%) compared to plains lakes (71%), however plains lakes converted more DON to NH_4^+ (0.071% compared to 0.029% for shield lakes). Overall, PA was most strongly correlated with DOC (explaining 42% variance in PA rates). PA rates appear to be affected both by DON availability and DOC photosensitivity. Greater concentrations of DON in plains lakes results in greater rates of PA, but in shield lakes, the lower concentrations of DON is partly compensated for by higher CDOM. We have expanded our dataset with greater DOC and CDOM containing lakes to further isolate the best predictors of PA rates.

BEHAVIOURAL GUIDANCE OF LARGEMOUTH BASS USING LIGHT EMITTING DIODES

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Freshwater ecosystems are threatened by the infrastructure related to hydropower development, irrigation and municipal water-taking as well as industrial cooling. This is especially apparent when taking into consideration the risk of entrainment or impingement that such infrastructure presents to fish. To minimize these threats, mitigative strategies have been developed which aim to direct fish away from "dangerous" areas to "safer" areas. Behavioural guidance systems provide a cost effective method by exploiting the sensory physiology of a species where stimuli can be used to manipulate their natural behaviour. These systems often incorporate light, as sight is one of the primary sources of information used by fish for interacting with their external environment. Previous studies that have taken this stimulus into account for behavioural fish guidance have primarily focused on flash frequencies with white light alone and are thus limited in regards to the light spectra being explored. The primary objective of this study was therefore to investigate the behavioural responses of largemouth bass in terms of orientation and movement to varying light spectra (red, orange, yellow & green) as well as flash frequencies (120 min^{-1}, 300 min^{-1}, 600 min^{-1}) as a potential form of behavioural fish guidance.

THE INFLUENCE OF SAMPLING TECHNIQUES ON BIOLOGICAL DATA

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Differences in biological data collected using various sampling gear is compared. Selection of appropriate aquatic sampling gear is often influenced by habitat characteristics, manpower availability, and the objective of the study. The Environmental Effects Monitoring (EEM) program requires regulated facilities to sample specific target fish species at exposure and reference areas. Multiple gear types have at times been combined in order for a facility to capture fish. To explore some potential sources of variability inherent in biological datasets, we investigate differences in EEM fish, benthic invertebrate, and water quality data collected independently from comparable areas within the same bay of a lake in Manitoba over several years. Variability in the fish species captured and catch-per-unit effort is compared among years (2004-2011) and among different gear types (gill nets, seine nets, minnow traps and electrofishing). Bias introduced into fish data (e.g., fish age, length, weight, growth, and condition) by the type of sampling gear used to capture the target fish species, yellow perch (*Perca flavescens*) and brook stickleback (*Culaea inconstans*), is discussed. Differences in benthic invertebrate community composition and total abundance and is explored among benthic invertebrate samples collected with similar gear and in comparable habitat.

AN ANALYSIS OF PROFITABILITY AND RESOURCE UTILIZATION EFFICIENCY OF AQUACULTURE FIRMS IN KOGI STATE, CENTRAL NIGERIA

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Nigeria imports over 75% of the fish she consumes although aquaculture could produce over 90% of her need. In this work we investigated the profitability and resource utilization in aquaculture firms Kogi state, Nigeria. Data were obtained from 180 randomly selected fish farmers through questionnaire method. Gross margin, financial ratios and production function analyses were employed in data analysis. Results revealed that the venture was largely male dominated. These operators were mostly within the productive age of 41-50 years, fairly experienced (11.5 years) and mostly uneducated, operating on small fish farm (between 0.04 and 1.2 hectares). The average profit margin of ₦ 902,178.3 per year showed that fish farming in the area was profitable but financial indices like gross ratio - total revenue / total cost (0.8) and rate of returns of invested capital (0.3) showed that the enterprises in the area will be unsustainable unless resources are optimally utilized. Also, coefficients for fingerlings (0.58), quantity of feed (0.3) and labour (0.12) were positively signed and significant. Furthermore, number of fingerlings (efficiency index - r=8.5), size of fish farm (r=4.2) and labour (r=1.94) were underutilized, while quantity of feed(r=0.52), and water (r=0.03) were overutilized indicating lack of optimality (inefficiency) in resource allocation. Strategies leading to appropriate reduction in quantities of underutilized resources and increment in quantities of overutillised resources; including an invigorated sector-specific extension delivery system and an on- the-farm training programme are canvassed.

CALCULATING RATES OF FALSE DISCOVERIES FOR MEDIUM AND LARGE EFFECTS IN ECOLOGY AND EVOLUTIONARY BIOLOGY

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We have been taught that the frequency of false positive statistical results is controlled by holding alpha at 0.05, but the false positive rate is also powerfully increased as the *a priori* probability that our alternative hypothesis is true declines. The probability of a hypothesis being true depends on the probability in nature of effects being large enough to be ecologically or practically important. Our objective was to estimate those probabilities for large (r^2 >= .25, Cohen 1988) and >=medium effects (r^2 >= .09), and to use those estimates to calculate the actual percentage of false discoveries that the rarity of these substantial effects produces. From meta-analyses we collected about 300 individual effect sizes that were supported by sample sizes >90 and were therefore relatively free of sampling error. The types of effects being measured ranged very widely, but they were all measured outside the lab and were responses to "treatments" not dominated by pollution or anthropogenic manipulations. Effect measurements were transformed to r^2 using meta-analytic conventions. Our frequency distribution of "natural" effect sizes indicated that the *a priori* probability of an effect being medium-sized or larger is ~40%; about 20% of effect sizes are large. Experiments with 80% power to detect medium and large effects (requiring n=85 and n=25, respectively) yielded false positive rates of 10% and 23% based on the observed frequency of these effect sizes in nature. With the typical observed sample size down around 30, the reduced power for medium effects means that 42% of statistically significant findings will be false positives.

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SMALL-SCALE RESERVOIRS EFFECTS ON SIZE SPECTRA OF FISH ASSEMBLAGES

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Large dams are known to have a major impact on fish communities of rivers and can drastically change the biological diversity. While the effects of large dams on the environment merit highlighting, most developments around the world are for small size undertakings. Size spectrum approaches have increasingly been applied as an indicator of the aquatic ecosystem structure, so the use of size distribution models allowed a better understanding about how these constructions affect the aquatic communities. The sampling design of this study included the lotic, transition and lentic zones of three small reservoirs in Southeastern Brazil, at two different points in time: in the first and in the second year after closing the dam. The size spectrum slope, given by the maximum likelihood estimator of the Pareto type I distribution, did not change in the lotic zone, where the riverine condition is better preserved. The lentic zone, representing the more altered habitat, had a much steeper size distribution in the first year, implying in relatively higher dominance by small fish, but then showed the greatest change in slope in the second year towards the values typical for the lotic zone. The transition zone showed intermediate trends in slope. These results can be explained by concomitant changes in phytoplankton production, water transparency and occurrence of predator fish observed between the two years, suggesting that the fish size distribution can readily track changes in environmental conditions following major perturbations.

PALEOLIMNOLOGICAL ASSESSMENT OF THE BRIDGE RIVER DIVERSION AND CLIMATE CHANGE ON SOCKEYE SALMON FOOD WEB IN SETON AND ANDERSON LAKES SYSTEM (BRITISH COLUMBIA)

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Seton Lake and Anderson Lake are important spawning sites of the Fraser River watershed for sockeye salmon and Kakonee. Between 1934 and 1960, a water diversion of cold and turbid water from Bridge River into Seton Lake was created hydroelectric generation thereby changing the limnology of Seton Lake. My project uses a paleolimnological Before-After-Control-Impact approach to assess the cumulative impact of the diversion and climate change on the primary and secondary producers in Seton Lake. Anderson Lake was used as a reference for regional changes, as it was not directly impacted by the diversion of the Bridge River, and has similar morphological, geological and climatic conditions as Seton Lake. The last ~500 years of the trophic status of both lakes will be reconstructed leading a multiproxy analysis using cladocera, diatoms, chrysophytes, algal pigments, chlorophyll a, stable isotopes and sediment lithological indicators. This timeframe will give an insight on the natural variability of the trophic status of these lakes as well as the potential change from the water diversion. This study is of significant importance as changes in the primary and secondary producers can impact salmon production. In

August (2014) 3 cores were removed from Seton Lake and 2 cores from Anderson Lake. A color transition from a dark bottom to a light grey top was observable on the cores from Seton Lake witnessing of an actual change in the sediment composition. Initial findings from this project will be presented and discussed.

SEASONAL VARIATION IN THE SENSITIVITY OF LARVAL SEA LAMPREYS TO THE PESTICIDE 3-TRIFLUOROMETHYL-4-NITROPHENOL (TFM), USED TO CONTROL INVASIVE SEA LAMPREY IN THE GREAT LAKES

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Sea lamprey (*Petromyzon marinus*) are invasive to the Great Lakes. The chemical 3-trifluoromethyl-4-nitrophenol (TFM) is widely used to control sea lamprey populations because it is selectively toxic to larval sea lampreys. Sensitivity to TFM in larval sea lamprey varies seasonally, but the underlying causes are not understood. The objectives of this research were i) determine if sea lamprey captured from the same stream at different times of the year exhibit differences in TFM sensitivity ii) determine if these differences are due to temperature effects, independent of additional seasonal changes iii) determine the effects of temperature on sea lamprey sensitivity to TFM. Accordingly, larval sea lampreys were collected in the spring, summer and fall 2013 and held at the same temperature as their natal streams; they were also collected in August 2014 and acclimated to three experimental temperatures. Toxicity tests were performed at the Hammond Bay Biological Station and whole-body TFM concentrations and energy stores were quantified in the laboratory. We conclude that there is a seasonal variation in TFM sensitivity and the results suggest that temperature seems to be a large contributing factor; this is likely related to the metabolic rate. Thus, lower concentrations of TFM may be effective if applied in the spring, but higher doses may be needed later in the year, when the animals are larger and have greater energy stores

HORIZONTAL DISTRIBUTION OF ZOOPLANKTON AND HYDRODYNAMICS OF A URBAN TROPICAL RESERVOIR (VARGEM DAS FLORES - MINAS GERAIS, BRAZIL)

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This study aimed to evaluate if the spatial distribution of chlorophyll-*a* and zooplankton was a function of the hydrodynamic of reservoir. Thus, we collected samples of chlorophyll-*a* and zooplankton in 27 points along the longitudinal axis of an urban tropical reservoir, in Brazil. The organisms' density was interpolated by kriging. A finite element mesh was built in the software ArgusOne. In SisBaHiA software, a 3-D hydrodynamic model was fed with the bathymetry data, finite element mesh, flow, wind and contour of the reservoir. We also generate a Lagrangian

model, for of residence time data of the water. The models' results were compared with the horizontal distribution of phytoplankton and zooplankton. We found that the highest concentrations of chlorophyll-a corresponded to dominant direction of wind and residence time of the water. Yet zooplankton's distribution was determined by the chlorophyll and the currency of water. The results suggest that the reservoir is characterized by different regions mainly influenced by the entry of streams, morphometry and hydrodynamic of the system, as well as the extent and use of its respective drainage basin, probably constituting the factors determining the structure of phytoplankton and zooplankton in this ecosystem.

COMPARING FLUOROMETRIC AND SPECTROPHOTOMETRIC DETERMINATIONS OF CHLOROPHYLL A IN LAKES: THE INFLUENCE OF SAMPLE COMPLEXITY AND HOLDING TIME

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The spectrophotometric determination of chl a is the standard method for the determination of algal biomass in aquatic ecosystems, but is a labour-intensive methodology involving strong solvents and typically generates results for only chlorophyll a and b. Recent fluorometric techniques, based on live samples without pre-treatment and generating data on 5 pigments, hold considerable promise for decreasing analytical time and effort while increasing data availability. We evaluate the relationship between these two techniques with samples from a wide variety of lakes and seasons. We also evaluate the effect of holding time on departure from initial determinations using regression techniques. Results indicate reliable comparisons are possible across larger gradients of productivity, but can be problematic under oligotrophic conditions depending on desired data accuracy. The influence of holding time varies depending on productivity and the pigment in question, but concentrations generally decrease substantially three to four days after collection.

MODELING GRAND RIVER DRAINAGE NETWORK WITH EYE TO UNDERSTANDING LAND-USE EFFECTS ON DRAINAGE NETWORK AND MODELING EFFECTS OF TARGETED RESTORATION.

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The Grand River watershed is an important agricultural area in Southern Ontario, with several large and growing municipalities. As in many watersheds, there have been historical modifications to the drainage network related to various human endeavors. ArcMap has been used to model how a natural drainage network would appear, based on digital elevation maps (DEM) to predict flow paths. Channel lengths and locations of the predicted network were compared with a ground-truthed channel inventory (Grand River Conservation Authority and Ontario Ministry of Natural Resources) to determine efficacy of the model. A model generated using DEM with 10 m resolution was marginally better at predicting the network than a model

using the DEM with 25 m resolution; 88% of the total channel length predicted by ArcMap overlapped with the actual location, and > 90% of the predicted channels laid within 5 m of the actual channel locations. Approximately 5% of predicted channels lay > 40m from actual channel locations. This amounted to 388 km of channel that had no corresponding channels in reality. The model was unable to predict, based on topography, 2535 km of actual channel present in the watershed. Channels not anticipated by topography were mostly first-order, with low sinuosity, and were most common in areas with high agricultural land use, and are likely excavated extensions to headwater streams to facilitate drainage. Agricultural activity has increased the total drainage density in the Grand, and there may be opportunity for increasing sinuosity in these head-water extensions to improve nutrient retention.

MANAGEMENT OF HILSA FISHERY IN BANGLADESH: IMPLICATIONS OF MULTIPLE STRESSORS IN CONSERVATION EFFORT

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Hilsa shad, *Tenualosa ilisha* (Hamilton, 1822) comprises the largest single species fish population in Bangladesh. Until eighties, contribution of hilsa was more than 20% of Bangladesh's total fish production. Currently it contributes about 11 percent to the country's total fish production and 60% to total hilsa catch of the World. An estimated 0.45 million people are engaged in hilsa fishing and it contributes 1% to the Bangladesh GDP. Dramatic decline in hilsa production noticed at early nineties and the backbone of country's fisheries was put under pressure. In 2003, hilsa production declined to 8% of country's total fish production. Purported effects on declines are both anthropogenic and natural and do act together. In the backdrop of sharp decline in production, Hilsa Fisheries Management Action Plan (HFMAP) was adopted in 2003-04. Creation of mass awareness for the conservation of brood Hilsa and *Jatka* (Juvenile hilsa), along with enforcement of the Protection and Conservation of Fish Act through multi-stake participation was the key element of HFMAP. In 2008, the HFMAP was fine tuned, and the Jatka Conservation, Alternate Income Generation for Jatka Fishers and Research Project (JCARP) was undertaken as an institutional innovation. The new management regime and development intervention for conservation resulted with increase in hilsa production. Contrasting existing data from Fisheries Resource Survey System (FRSS) of the Department of Fisheries (DoF), Bangladesh, and evaluations of JCARP, we estimated the cumulative change in hilsa production is 76.47 percent in 2012-13 in comparison with that of 2002-03. Despite the achievements, our study demonstrates that the assessment of current hilsa stock status, protection of spawning and breeding grounds, estimate the impact of critical habitat destruction and climate change on the spatial distribution of hilsa, safeguarding the rights of small-scale fishers to secure livelihoods and mainstreaming integrated management regime are of utmost importance for the conservation of hilsa fishery in Bangladesh.

SMALLMOUTH BASS RANGE EXPANSION IN NORTHERN ONTARIO: ILLEGAL INTRODUCTIONS OR CLIMATE CHANGE?

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During the last two decades, smallmouth bass have experienced a dramatic range expansion, gaining new latitudes in North America with the warming climate. The introduction of smallmouth bass is mainly attributed to natural range expansion because of climate change, or illegal introduction to create new fishing opportunities. Here we study introduction vectors of smallmouth bass in the Turtle River watersheds that were devoid of smallmouth bass until the last two decades. Tissue samples were collected from 610 smallmouth bass angled from 13 lakes in the Turtle River system, and amplified at 15 microsatellite loci. Smallmouth bass populations exhibited comparable levels of genetic diversity across the river reaches. In addition, private alleles were detected in several populations, with more detected in headwater populations. Pairwise populations' differentiation measures reflected high levels of genetic structure, despite the known recent establishment of smallmouth bass throughout the Turtle River system. Genetic structure along with genetic diversity results indicated multiple introduction events in several populations, whereas only three populations were established by secondary diffusion. Our results suggest that there is limited natural dispersal from previously introduced population to invade new lakes within a single watershed. Alternatively, our results show a pattern of recurrent introductions in advancing smallmouth bass range expansion in this river system. More importantly, our results provide an important opportunity to bring managers, conservation agencies, and user groups together to consider the role of legislation, enforcement, and monitoring to address smallmouth bass management and its impact as an invasive species in some watersheds in northern Ontario.

FISH CONTAMINANT TRENDS IN THE TORONTO AND REGION AREA OF CONCERN

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The Toronto and Region Area of Concern (AOC) encompasses 42 km of shoreline and 2000 km^2 of land, stretching from Etobicoke Creek to the Rouge River. This region has been identified as an AOC for a number of Beneficial Use Impairments (BUI), including restrictions to fish consumption due to elevated contaminant levels. Data collected by the Province of Ontario were used to investigate long-term (1975-present) temporal trends of mercury, polychlorinated biphenyls (PCBs), and other contaminants in multiple fish species (sport and forage) from both the waterfront area and tributaries of the Toronto and Region AOC. Where appropriate, contaminant levels in fish from the Toronto AOC were compared to other AOC and non-AOC regions of the Canadian waters of the Great Lakes. In multiple species, fish contaminant levels significantly decreased over time, and recent mercury levels in sport fish from the waterfront area are well below the current consumption advisory benchmarks. However, in most cases, sport fish PCB levels remain above current consumption advisory benchmarks, and forage fish PCB levels are highly elevated at localized sites in some tributaries, indicating potentially ongoing sources to the AOC. Half-life calculations for sport fish species indicate that it may take 8-26 years for total PCB concentrations to decrease below the current consumption advisory benchmarks. Sustained monitoring of PCBs in fish from the Toronto waterfront area is recommended to aid in ensuring that recovery continues.