ANTHROPOGENIC CHANGE IN THE RELATION BETWEEN SCALE AND PREDICTABILITY AND ITS IMPACT ON THE SPATIAL DISTRIBUTION OF MARINE ANIMALS

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For ecologists, variability is an inherent property of the organisms and systems we seek to understand. Confounding issues of variability in ecological data is its dependence on spatial and temporal scale; for example, what appears to be random or stochastic at small scales of observation can at once become predictable when viewed through a larger lens. If patterns of variability are inherently dependent on scale, it is reasonable to suspect that selection has worked on traits and strategies to exploit this relationship. We review the foraging literature to test the hypothesis that a positive relation exists between predictability and scale, and that marine animals have adapted their foraging strategies to this relationship. We then explore how changing this relationship through anthropogenic activities may have consequences for organisms that are adapted to cope with or exploit natural patterns of environmental predictability. We suggest that the study of resource predictability is important because the introduction of novel and highly predictable resource patches is wide spread, and may have an ecosystem effect.

Oral CCFFR (General Session)

EVIDENCE OF RANGE SHIFTS IN ONTARIO FRESHWATER FISH

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Very few studies have investigated the effects of climate warming on the distributions of freshwater species. We used contemporary and historical survey data to measure the magnitude and direction of range shifts in a suite of freshwater fish species in more than 1500 lakes across Ontario. We found that warm and coolwater sport fishes have significantly shifted their distributions northward by approximately half a degree latitude over nearly 30 years. Baitfish, however, did not significantly shift their distributions. We also related differences in species distributional shifts to species traits (including those related to dispersal, reproduction, and ecological generalization). These species traits explained much of the variation in species distributional shifts. Understanding the range shifts already underway in Ontario lake communities should help us to predict future range shifts by freshwater species.

Oral CCFFR (Climate Change)

BEAVER CANALS PROVIDE TRAVEL CORRIODORS FOR DISPERSING WOOD FROGS

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Beavers (*Castor canadensis*) significantly alter their surroundings and, in so doing, link terrestrial and freshwater systems. In low gradient areas, they commonly dig extensive networks of canals that radiate out from ponds towards forested uplands where beavers forage and collect construction materials. These canals offer connectivity between wetlands and uplands for other species as well. We examined the use of beaver canals by wood frogs (*Lithobates sylvaticus*), particularly focusing on dispersing, young-of-the-year animals. Our study was conducted in Miquelon Lake Provincial Park, Alberta, a morainal landscape supporting high densities of basin ponds with little surface connectivity. From late July to the end of August, we counted young-of-the-year frogs along shoreline transects at 14 ponds. We also counted frogs on 4.5 m long drift fences set perpendicular to beaver canals on 4 of these ponds. The relative abundance of young-of-the-year wood frogs was greater on transects along beaver canals than along unmodified shorelines. On drift fences, the number of frogs encountered was highest immediately adjacent to beaver canals, and declined with distance from canals. With canals reaching lengths of over 100 m, and typical wood frog dispersal distances of 400 m, canals may provide travel corridors that reduce dehydration and predation on recently metamorphosed frogs. In a landscape of isolated wetlands, beaver canals could influence metapopulation dynamics of wood frogs and other amphibians.

Poster CSWS (Wetland and Land/Water Linkages)

IS THE LATEST GREAT LAKE INVADER, *HEMIMYSIS ANOMALA*, A THREAT TO INLAND LAKES?

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Hemimysis anomala was first detected in 2006 and has since been found throughout the Great Lakes (except Lake Superior), the St. Lawrence, and several inland lakes in the USA. *Hemimysis* has a patchy distribution, occupying littoral regions in large swarms. In invaded European waters, *Hemimysis* establishment has been associated with changes in phytoplankton and zooplankton, and in some cases fish growth and condition. Using stable isotopes, we found that *Hemimysis* has been incorporated into nearshore fish diets, although it will likely have a minor impact on Great Lakes food webs as any effects of *Hemimysis* will be localised to nearshore areas where densities are high. Impacts, however, may be greater in inland lakes where the proportion of nearshore habitat is larger. Although not yet detected in Canadian inland lakes, its presence in Seneca Lake, NY and its broad environmental tolerances suggest they will be susceptible to colonization. To assess the threat of *Hemimysis* to inland lakes we 1) Sampled

boats in the Rideau Canal, 2) Surveyed boat owners to assess invasive species awareness, 3) Sampled nearshore habitat along the Rideau Canal, 4) Assessed the efficacy of decontamination methods, and 5) Conducted experiments to estimate feeding rates of *Hemimysis* in the presence/absence of native fish predators. Our findings indicate there are effective decontamination strategies that could reduce secondary spread and that boater awareness should be increased. High predation rates on zooplankton, irrespective of fish presence, suggest impacts on food webs in inland lakes could be significant.

Oral SCL (Invasive Species)

ZOOBENTHIC COMMUNITY COMPOSITION TRENDS IN CONSTRUCTED BOREAL WETLANDS – RESIDUAL EFFECTS OF OIL SANDS MINING-BYPRODUCTS

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Production of oil through open-pit mining and extraction from oil sands near Fort McMurray Alberta is an important economic resource for Canada that causes extensive disturbance to the landscape. When the mining is completed, the companies must reclaim the landscape to pre-mining levels of productivity, diversity, and abundance. One reclamation strategy involves constructing wetlands using waste materials (clay-rich tailings and process waters enriched in salts, napthenic acids and residual bitumen). Over the first seven years after construction, zoobenthic taxa accrue more slowly in such wetlands than in constructed wetlands of equivalent age containing fresh water and mineral soils. Community composition appears to become more similar with increasing age. To better understand whether use of mine materials is an effective reclamation strategy we tracked changes in invertebrate richness, abundance and composition in a suite of oil sands material affected and reference constructed wetlands sampled over a 20-year period. Zoobenthos were collected from colonization tiles set in place for 8 days, and from D-net sweep samples and enumerated and identified in the lab. Preliminary analysis suggests that mine-affected wetlands support equivalent abundance and slightly lower richness than reference constructed wetlands, but that there are persistent differences in community composition. This study will help to determine whether or not these approaches to wetlands constructions will ultimately support acceptable zoobenthic communities in the reclaimed landscape after mine reclamation has been completed.

Poster CSWS (General Session)

A REVIEW OF RECENT PROGRESS IN THE MANAGEMENT OF AQUATIC INVASIVE SPECIES VECTORED BY SHIPS' BALLAST WATER

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Ballast water became the most important vector of aquatic invasive species to the Great Lakes after the opening of the St. Lawrence Seaway in 1959. While at least 34 ballast water introductions have been recorded since that time, regulatory actions taken by Canada and the U.S. - notably mandatory requirements for transoceanic vessels to exchange ballast water for mid-ocean water that took effect in 1993 - appear to have reduced the importance of the ballast water vector; the rate of discovery has been in decline since 1995, and no new species attributed to ballast water have been reported since 2006. Despite this success, a number of recent studies have identified limitations of ballast water exchange, while risk assessments have identified alternate vessel pathways (domestic and coastal shipping) which may pose a risk for new invasions. As a result, Canada is proposing new ballast water regulatory requirements, which should reduce the risk of ballast-mediated invasions even further.

Invited Oral SCL (Invasive Species)

CONTRIBUTIONS OF CRUSTACEAN ZOOPLANKTON AND CHAOBORUS PUNCTIPENNIS TO ACOUSTIC DOPPLER CURRENT PROFILER BACKSCATTER INTENSITY

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Acoustic techniques provide quantitative *in situ* observations of the spatial and temporal dynamics of zooplankton distribution which is important for understanding population dynamics and predator-prey interactions. The purpose of this study was to ground truth a long time series of Acoustic Doppler Current Profiler (ADCP) observations of zooplankton diel vertical migration (DVM) in Lake Opeongo, Ontario. Frequent stratified net hauls of the zooplankton community were collected over a 24-hour period on June 23-24 and July 27-28 2010 near a moored ADCP in the South Arm basin. Zooplankton abundance was calibrated to the acoustic backscatter signal, and interpretations of the seasonal patterns in DVM were made. 2^{nd}, 3^{rd}, and 4^{th} *Chaoborus* instars and pupae had stronger statistical relations to acoustic backscatter than crustacean zooplankton in June, while 4^{th} instars were the most significant contributors in July. In June, 4^{th} instar *Chaoborus* and pupae underwent normal DVM whereas 2^{nd} and 3^{rd} instars underwent reverse DVM. In July, 2^{nd}, 3^{rd}, and 4^{th} instars and pupae underwent normal DVM. However, a double rise and fall was measured by the ADCP in July. 2^{nd} and 3^{rd} instars started their upward migration before the 4^{th} instars and began their downward migration after them. These results suggest that *Chaoborus* is the main contributor to acoustic backscatter and their migration patterns may be influenced by the seasonal dynamics of predators. Using this information we can interpret the long time series of ADCP observations from 2009 to 2010 on *Chaoborus* DVM.

Poster CCFFR (Migration, Mixing and Dispersal)

TURBIDITY PROVIDES AN INVASION PATHWAY FOR NON-VISUAL EXOTIC FISH

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Worldwide, freshwater ecosystems are adversely impacted by increasing turbidity and associated native fish declines and extinctions. It is within these degraded habitats that the majority of fish invasions occur, and our analysis reveals these invasive species typically possess specialized non-visual sensory systems. We propose that non-visual capabilities, including foraging, combine with turbid conditions to provide an invasion pathway for these fish. Distributional and behavioral predictions of this hypothesis were tested for the invasive mosquitofish and New Zealand native inanga. Across a strong natural turbidity boundary the alien species was found to dominate turbid habitat less than a meter from clear water where both species were found. Behavioral trials confirmed that between clear and turbid water mosquitofish maintained similar feeding rates, whereas the native species exhibited a marked decline in feeding efficiency. These results show for the first time that the interaction between fish sensory physiology and habitat degradation is a key factor in invasive success, and native fish decline, within aquatic ecosystems.

Oral CCFFR (Invasive Species)

INCORPORATING DISSOLVED ORGANIC CARBON INTO A REGION-SPECIFIC RELATIONSHIP BETWEEN PHOSPHORUS AND CHLOROPHYLL *A*

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Numerous log-linear equations have been proposed to describe the relationship between total phosphorus (TP) and algal biomass, as indicated by chlorophyll *a* (Chl *a*). In dystrophic lakes, high concentrations of dissolved organic carbon (DOC) increase light attenuation coefficients, decrease photic zone depth and may impose an upper limit on phytoplankton photosynthesis. Existing relationships between TP and Chl *a* may be unsuitable for dystrophic lakes where light limitation may affect Chl *a* concentrations. Nine lakes were chosen across a gradient of DOC and TP to assess the impact of DOC on the TP-Chl *a* relationship. Water samples were collected from the photic zone on a bi-weekly schedule from May until October and were analysed for TP, DOC, and Chl *a*. Preliminary data analysis suggests that sample lakes exhibited smaller increases in Chl *a* per unit of TP than is suggested by existing relationships in the literature, most notably in lakes with DOC concentrations higher than 7.0 mg/L. The findings of this research will affect

the use of commonly employed indices and relationships in predicting lake trophic status and managing freshwater ecosystems in characteristically dystrophic regions.

Oral SCL (Carbon Flux and Nutrient Cycling)

COD SPERM MOTILITY PLASTICITY TO TEMPERATURE IS SIMILAR BETWEEN NEWFOUNDLAND AND NEW BRUNSWICK POPULATIONS

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How increasing ocean temperatures will influence plasticity in reproductive performance of aquatic animals is unknown. Fish sperm are very useful for studying male phenotypic plasticity; sperm from a single ejaculate can be exposed to different conditions, there are tools available that allow an accurate measurement of the motility under different conditions, and motility has been shown in several species to be highly correlated with fertilization success.
We examined sperm swimming ability of at least 25 fish from each of three groups of cultured Atlantic cod (*Gadus morhua*) in response to temperature (3, 6, 9, 12^{o}C). All fish were mature F1 generation of wild broodstock: cod of Newfoundland (NFC) and New Brunswick (NBC) origin that were kept under the same conditions their entire lives, including spending several years in outdoor cages and being fed with pellets before the start of the experiment, and cod from the same New Brunswick population but had experienced a different culture environment (NBT); they were always kept in indoor tanks and fed with fish. The average reaction norm to temperature was similar in the three groups, with higher swimming velocities at higher temperatures, but the NBT group had significantly higher values than the NFC group. Both genotype and past environmental exposure where shown to affect sperm motility.

Oral CCFFR (Genetic Diversity and Adaptation)

RAPID RESPONSE TO ALIEN INVASIVE SPECIES: ERADICATION, CONTROL THE SPREAD AND SUPPRESSION STRATEGIES

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Human population growth and development have resulted in the spread of alien invasive species (AIS) in novel environments world-wide. AIS have received much attention for their harmful effects on health, ecology and the global economy. In response to this emerging threat, many countries, including Canada, adopted the *Convention on Biological Diversity* which requires the eradication of AIS. In 2004, Environment Canada unveiled its *An Invasive Alien Species Strategy*

for Canada which emphasized the need for development of early detection and rapid response methods. We have compiled 206 exclusive data sets involving attempted management of aquatic AIS around the world. Factors which potentially determine AIS intervention success were catalogued, including habitat size, habitat type, species characterization and management method. In certain cases, it was more favourable to employ an alternative management method, when the same result was achieved at lower cost. In other cases, methods were successful in combating certain AIS but completely ineffective against others. I will highlight cases of both successful management, including eradication of black-striped mussel in Darwin, Austrialia as well as failed management, including attempted eradication of round goby in Pefferlaw Brook, Ontario. Future work will involve statistical quantification of the key factors influential to management success. This data will aid countries in managing AIS when prevention measures have failed. Most importantly, end users will be able to identify the suite of rapid response options most appropriate for management of AIS in their regions.

Poster SCL (Invasive Species)

WIND EXPOSURE'S CONTRIBUTION IN EXPLAINING NEAR SHORE FISH HABITAT USE

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In lentic ecosytems, near shore habitats are known to support higher biodiversity and fish biomass than any other habitat of these ecosystems. These attributes of fish community are extremely heterogeneous along the perimeters of lakes. Identifying which environmental conditions may explain spatial variations of fish community attributes is essential for conservation purposes. Wind exposure (i.e. fetch at a given location) has been hypothesized to affect fish distribution patterns. Given the temporal variability of wind conditions, the effect of this variable on fish may complicate the identification of the environmental conditions that affect fish community attributes at a location and the development of fish habitat use models in the littoral zone of lakes. The objective of this study was to test the hypothesis that fetch can explain a statistically significant proportion of variations of fish community attributes along the perimeter of lakes. Snorkeling was used to map environmental conditions and fish abundance, biomass and biodiversity along the complete perimeter of 3 lakes. Each lake was surveyed 3 times for fish between 12h and 16h during a 3 week period of the summer. Fetch was estimated at different time intervals (from hourly to seasonally) and according to different lags (from 24 h before sampling for fish to 0 h lag) using Piedmont Environment Canada Weather Observatory. Analyses indicate that fetch always had a minimal role on fish habitat use. This facilitates the development of models designed to explain fish distribution patterns in the littoral zone of our study lakes.

Oral CCFFR (Climate Change)

HOW IS GCC AFFECTING HABITAT QUALITY AND QUANTITY OF NORTHERN PIKE IN EASTERN GEORGIAN BAY?

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Decreased water levels in the Great Lakes induced by Global Climate Change (GCC) have the potential to negatively alter fish habitat quantity and quality. With water-level declines and increasing water temperatures, suitable fish habitat may be lost, in an interactive or additive manner. Georgian Bay, Lake Huron has experienced over a decade of water level decline, and the effects on keystone species such as northern pike (*Esox lucius*) are not yet known. We created a 3-dimensional model of thermal habitat focusing on the literature-based optima for growth as optimal habitat for northern pike in Tadenac Bay, a pristine embayment in eastern Georgian Bay. This model was validated with location data of 12 radio-tracked northern pike, collected periodically from May 2011 to November 2012. Our data indicate that northern pike used wetland habitat that is warmer than the optima and frequently >27°C. Laboratory-based literature suggests that at 28°C, northern pike will cease to feed. The ramifications of remaining in thermally unsuitable water for significant amounts of time include stunted growth and potential death. The potential for greater negative effects from GCC necessitates further study of habitat use by pike in water that is not thermally optimum for growth.

Oral CSWS (Climate Change)

GENETIC ARCHITECTURE OF OFFSPRING SURVIVAL AND GROWTH IN ATLANTIC SALMON STRAINS USED FOR REINTRODUCTION TO LAKE ONTARIO

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Due to its role as top predator, Atlantic salmon (*Salmo salar*) has historically been the most important salmonid species in Lake Ontario. More than a century ago Atlantic salmon were extirpated from Lake Ontario due to human activity. Following their extirpation there have been numerous failed attempts to reintroduce Atlantic salmon to the Lake Ontario system. However, due to recent revitalizion of the lake's habitat, conditions are now considered more appropriate for Atlantic salmon reintroduction. The Ontario government has recently approved the use of three strains of Atlantic salmon to be stocked simultaneously in this effort. The captive breeding program currently involves crossing adults haphazardly to maximize genetic diversity rather than genetic quality of the offspring produced. This strategy does not consider the complete genetic architecture of the offspring on their growth and survival. The present study investigated the effect of genetic architecture on fitness related traits of the Atlantic salmon strains by elucidating the additive and non-additive genetic effects on survival and growth of offspring. Gametes from

5 females and 5 males (3 replicates per strain) were collected and a full-factorial quantitative genetics breeding design produced 75 full- and half-sib families for each strain (225 families total). Offspring growth and survival metrics were then monitored in the hatchery and the additive and non-additive genetic effects on these metrics were partitioned using a two-way ANOVA. The results of these analyses will be discussed within a framework for future management of reintroduced Atlantic salmon.

Oral CCFFR (Genetic Diversity and Adaptation)

THE ROLE OF MALE REPRODUCTIVE BEHAVIOUR IN THE COLLAPSE AND RECOVERY OF FATHEAD MINNOWS FROM A WHOLE LAKE ESTROGEN ADDITION

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Laboratory-based studies have shown that male fish exposed to estrogenic compounds found in municipal wastewater effluent exhibit altered reproductive behaviour. Male fathead minnows (*Pimephales promelas)* show elaborate courtship behaviour and extended parental care, including defense of the nest from egg predators, and have become a model species for understanding the impacts of estrogenic compounds. However, opportunities to examine male fish exposed to environmentally-relevant concentrations of estrogens under natural conditions are limited. We quantified individual reproductive behaviour of male fathead minnows from in-lake video recordings taken before, during (2001-2003) and after a synthetic estrogen used in birth control pills (ethynylestradiol, EE2) was added to Lake 260 at the Experimental Lakes Area. Male fatheads exposed to EE2 showed marked changes in courting behaviour directed at females that were not observed pre-exposure or in the reference lakes. Exposed fathead males also reduced time spent tending to eggs as a direct result of increasing frequency of aggressive encounters in response to greater numbers of fish surrounding the nest that were likely feminized male fathead minnows. Thus, the few fathead males that were able to breed during the exposure period faced increasing nest threats from conspecifics that reduced their ability to defend egg clutches. Analyses are in progress to examine the extent to which male reproductive success was compromised during the period of exposure and whether this can account for the recruitment failure and population collapse of fathead minnows observed by the second year of EE2 exposure. Our study highlights the complex ecological and behavioural interactions that occur in natural systems and further demonstrates the need for studies conducted at the scale of a whole-ecosystem.

Poster CCFFR (Experimental Lakes Area Research)

WHOLE-CATCHMENT MANIPULATION TO ASSESS AND MODEL IMPACTS OF CLIMATE WARMING TO BOREAL LAKE ECOSYSTEMS

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Climate model predictions for much of central Canada suggest lower levels of precipitation and warmer air temperatures, both of which can be expected to result in reduced water availability to lakes. How lake productivity and fish habitat subsequently respond to reductions in water and terrestrial nutrient transport as a direct result of warmer and drier conditions is complex and difficult to predict in the absence of controlled manipulative research at appropriate scales. We are presently conducting a novel whole-catchment manipulation at the Experimental Lakes Area (ELA) that resulted in a 5-fold reduction in watershed area to a 4th order lake by diverting all upstream water inflow. This experiment represents a rare attempt to integrate hydro-meteorological and ecological processes in boreal lakes in the context of climate change and aims (1) to determine impacts of reduced inflows to in-lake biological production, energy flow, and fish habitat; and (2) to develop and empirically test predictive models on the impacts of drier conditions on the evaporative and thermal regime of lakes. Initial findings from the first two years of manipulation suggest an increase in water clarity and marked reductions in yellow perch, the primary prey of lake trout, a cold-water species sensitive to disturbance and considered a sentinel for the impacts of climate across Canada's boreal freshwater ecosystems. We present an overview of the main findings to date, including modeled predictions of forecasted changes to the lake should this experiment continue.

Oral CCFFR (Experimental Lakes Area Research)

MONITORING RESIDENT FISH MOVEMENTS IN AN URBAN STREAM AND MUNICIPAL DRAIN USING PIT TELEMETRY

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Urban development can promote environmental change (e.g., water quality, habitat quality) in stream ecosystems driven largely by increases in stormwater runoff. Within the Ottawa Greenbelt, Watts Creek, a small urban stream that supports a cool and warm water fish community, is located downstream from Kanata – Ottawa's largest suburban area. The National Capital Commission (NCC) in Ottawa is responsible for managing the natural watercourses within the Greenbelt. Currently, stormwater runoff from Kanata is collected in an artificial pond, held, and released periodically into the Kizzel Municipal Drain, a highly channelized and maintained (i.e., dredging) tributary of Watts Creek. Very little is known about the movements of

small stream fish, especially within urban areas where stormwater management is crucial to human development. Our goal was to study the interconnectedness between Watts Creek and the Kizzel Drain to determine whether fish use both systems. To accomplish this we use a combination of stationary Passive Integrated Transponder (PIT) telemetry and mark-recapture methods to monitor the movements of fish tagged with 12mm and 23mm tags, around the confluence. Preliminary results from summer and fall sampling have revealed that fish move quite freely between these watercourses, demonstrating that municipal drains can serve as important fish habitats. By revealing the interconnectedness between Watts Creek and the Kizzel Drain, it is possible to gain a better understanding of fish behaviour and habitat use in systems that are impacted by stormwater management and municipal drain maintenance.

Poster CCFFR (Migration, Mixing and Dispersal)

LANDSCAPE GENOMICS IN ATLANTIC SALMON (*SALMO SALAR*): TOWARDS THE UNDERSTANDING OF GENE-ENVIRONMENT INTERACTIONS DRIVING LOCAL ADAPTATION

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Benefiting from genomic innovations, a growing number of studies are examining the drivers of historical and contemporary evolution in wild populations. The application of large mapped SNP-panels coupled with a comprehensive assessment of environmental parameters provides a rigorous framework towards understanding the genomic and geographical extent of local adaptation in wild populations. Here, we utilized a large-scale landscape genomics approach to concurrently examine adaptive and neutral differentiation across 54 North American populations of Atlantic salmon representing seven genetic groups previously defined. Over 5500 genome-wide SNPs were genotyped in 641 individuals and 28 bulk assays. Genome scans, linkage map and 49 environmental variables were combined in an innovative landscape genomic approach. Results provided us with valuable knowledge on the environmental links to both neutral and adaptive genetic divergence. In particular, we identified markers potentially under divergent selection, as well as selective environmental factors and biological functions potentially associated with adaptive divergence. Multivariate landscape genetic analysis revealed strong associations of both genetic and environmental structures. Climate (temperature-precipitation) and geological characteristics were significantly associated with both adaptive and neutral genetic divergence. This indicates that these environmental variables are important drivers of local adaptation at the regional scale in Atlantic salmon. Hence, this study significantly contributes to the improvement of genomic tools towards better conservation and management of Atlantic salmon wild populations.

Invited Oral CCFFR (Genetic Diversity and Adaptation)

FORENSECOLOGY

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The overarching goal of applied ecology is logically evolving from documenting overall impact to isolating specific stressors. This evolution is essential for effective ecosystem management and restoration and is especially important in the face of evolving environmental stressors. Forensic Ecology or Forensecology involves developing novel tools for applied ecologists. What is in our toolbox and what is missing?

Oral SCL (Multiple Stressors)

ASSESSING COMMUNITY STRUCTURE USING TWO DIFFERENT STANDARDIZED GILL NETTING PROTOCOLS

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Standardized protocols are an essential tool for fisheries management in obtaining data from spatial and temporal surveys and assessments. However, interpretation of the data may depend on the method used. The Nordic Index Netting (Nordic) and Broad-scale Fish Community Monitoring Program (BsM) methods are two widely used multimesh gill netting protocols to conduct fish community surveys on northern lakes. In both protocols the sampling effort is volume-weighted or depth-stratified. In part, the BsM protocol was modeled after the Nordic protocol, but differs in gear configuration, deployment and in depth distribution of sampling effort. To date, few comparisons have been made between the Nordic and BsM approaches when assessing fish communities. To compare the two methods, 20 boreal shield lakes were netted using both the Nordic and BsM protocols. Fish species richness, diversity, and evenness were calculated and compared. Species richness resolution was found to be significantly higher using the Nordic protocol in 12 of the 20 lakes sampled. Differences between the methods for both Shannon-Wiener diversity and evenness were found to be insignificant. That the observed difference in species richness could be attributable to sample method suggests resource managers need to carefully consider the limitations of protocols they have employed when making resource management decisions based on available data.

Poster CCFFR (General Session)

BIOENERGETIC EFFECTS OF PREY COMMUNITIES ON MERCURY BIOMAGNIFICATION IN NORTHERN PIKE OF SOUTHERN ALBERTA, CANADA

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Growth efficiency in fish is an important determinant in the biomagnification of contaminants, such as mercury. Absence of key functional groups within the prey community can adversely affect growth efficiency of fish species at higher consumer levels. We investigated the role of lake whitefish, an important link between pelagic and littoral food webs in southern Alberta reservoirs, on diet, growth and mercury biomagnification in northern pike. Trophodynamics were analysed using stomach contents and stable isotope data; pike growth curves were backcalculated and mercury concentrations measured in a spectrum of organisms. In the absence of lake whitefish (LKWH-), despite the presence of other potential forage fish species, stomachs of northern pike contained mainly invertebrates (leeches, amphipods). Stable isotope analyses ($\delta^{15}N$) showed that the trophic position of pike is similar to benthic-feeding fish. Moreover, $\delta^{15}N$ values of pike did not regress significantly against fish length, indicating that pike do not diet-shift towards fish prey as they grow. In the presence of lake whitefish (LKWH+), diets of pike consist of lake whitefish and invertebrates. In these systems $\delta^{15}N$ values in pike also increased significantly with fish size, indicating increasing piscivory in larger pike. Growth rate of pike in LKWH- lakes was lower than in LKWH+ lakes, suggesting the lack of fish prey components in pike diets comes at significant bioenergetic cost, thus resulting in low growth efficiency. Preliminary results suggest that mercury biomagnification factors of pike relative to invertebrate prey are at least 2-fold higher in comparison to lake whitefish prey.

Oral CCFFR (Contaminants and Trophic Transfer)

CANADIAN RECREATIONAL FISHERIES SURVEYS: 35-YEARS OF BIOLOGICAL, SOCIAL, AND ECONOMIC DATA

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Recreational angling is a highly popular activity worldwide that accounts for an estimated 12% of global fish harvest and contributes hundreds of billions of dollars to the global economy. Unfortunately, the aforementioned statistics are actually guestimates or gross extrapolations. Quite simply, little is known about the global state of recreational fisheries - an information gap that needs to be addressed to develop effective management and conservation strategies. Canadian recreational fisheries provide an ideal platform on which to build such a global

recreational fisheries assessment framework. Home to over 2 million lakes and rivers that support popular recreational fisheries, Canada is unique in that there is an extensive long-term dataset on the biological, social, and economic dynamics of these fisheries. Starting in 1975, the Department of Fisheries and Oceans (DFO) has collected these data through mail surveys to recreational anglers at five-year intervals. Longitudinal trends in biological (i.e. catch and harvest by species), social (number of anglers, demographics, and effort), and economic (expenditures and major purchases) dynamics of Canadian fisheries will be discussed, along with the utility of these data for understanding and managing recreational fisheries. This multifaceted approach may serve as a model for research and analysis that can be used to guide national and international fisheries management in the future.

Oral CCFFR (General Session)

LAKE ONTARIO COASTAL WETLANDS AND NATIVE FRESHWATER MUSSELS: REFUGIA FROM INVASIVE ZEBRA MUSSELS?

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Over the past twenty years, the invasion of zebra mussels (*Dreissena polymorpha*) has resulted in a catastrophic decline of Great Lakes native mussels. However, refuge sites for native mussels have been found in nearshore wetland habitats of Lake St Clair and Lake Erie where fewer zebra mussels are present. Identifying the importance of coastal wetlands in other Great Lakes is critical for maintaining native mussel diversity and the recovery of mussel species at risk. During 2011 and 2012, we intensively sampled 24 Lake Ontario coastal wetlands for freshwater mussels and compared the effectiveness of two sampling methods (tactile and clam rake) to detect mussel species. As many as 12 different species were identified from live individuals collected at different wetlands; with Giant Floater (*Pyganodon grandis*) being present at 22 of the 24 wetlands. Tactile searches resulted in the collection of twice as many live individuals and species than clam rake searches. Live dreissenids were found in 11 of the 24 sites. Although suspected to have been extirpated from Lake Ontario, populations of the federally endangered Eastern Pondmussel (*Ligumia nasuta*) were discovered at six wetlands. Surveys also found Lilliput (*Toxolasma parvum*) populations in both Hamilton Harbour and Jordan Station, with Jordan Station also carrying a population of the federally threatened Mapleleaf (*Quadrula quadrula*). Although occurring at low densities, our research indicates that Lake Ontario coastal wetlands provide a refuge for native freshwater mussel species from the catastrophic effects of zebra mussel invasions.

Poster CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

FISH DIET COMPOSITION AND RESOURCE USE UNDER DIFFERENT OPERATING REGIMES IN REGULATED RIVERS OF ONTARIO AND NEWFOUNDLAND

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Globally, hydropower is an important source of renewable energy, however flow regulation can have significant impacts on river hydrology, morphology, and on the structure and function of downstream riverine communities. This study aims to address knowledge gaps regarding the biological consequences of flow regulation by investigating the differences in food web structure and function in paired natural and dam regulated rivers in Ontario and Newfoundland. Stomach content data from Newfoundland indicates that over the short-term, fish from the regulated river consumed more filter feeders such as Trichoptera and Dipteran larvae, while fish from the natural flow regime river had a broader diet that included more collector-gatherers, such as Ephemeropteran nymphs, gastropods, and terrestrial invertebrates as prey sources. Stable carbon ($\delta^{13}C$) isotopes indicated similar resource use between species, rivers, seasons and years. Stable nitrogen ($\delta^{15}N$) ranges did not differ between rivers, indicating similar food chain lengths. Both stomach content and stable isotope data will be compared between regulated and natural rivers, through time within each river type, and between Ontario and Newfoundland where the rivers are influenced by different operating regimes.

Oral CCFFR (General Session)

A COMPARISON OF FISH INDICES OF BIOLOGICAL CONDITION AT GREAT LAKES COASTAL MARGINS

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Indicators of biological condition (including indices of biological integrity (IBIs) and multivariate models) quantify the relationship between species assemblages within a habitat and the environmental condition of that habitat. IBIs and similar measures can be used as tools by managers to assess biological responses to anthropogenic disturbance affecting a site. Several biological indicators of fish condition have been developed independently of one another. Using overnight fyke net catch data collected at approximately 100 coastal margin sites across the Great Lakes we compared the fish community indicator measures developed by Uzarski *et al.* (2005), Seilheimer and Chow-Fraser (2006) and Bhagat *et al.* (2012). We determined which indicator most accurately and consistently summarized the levels of agricultural and development-related human disturbance at in the watershed draining into each coastal margin location. Additionally, we used data sampled from benchmark sites over multiple years, to determine which set of interannual measurements most consistently reflected the level of human disturbance.

Poster CCFFR (Wetland and Land/Water Linkages)

A REGIONAL COMPARISON OF BENTHIC MACROINVERTEBRATE COMMUNITY FUNCTION IN PRECAMBRIAN SHIELD AND ST. LAWRENCE LOWLAND LAKES: A STABLE ISOTOPE APPROACH

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Benthic macro-invertebrates (BMI) are functionally important in freshwater ecosystems, and as such it is crucial to understand how these complex communities function. More specifically, we are interested in understanding the relationships between different environmental variables, and community trophic interactions and carbon transfer dynamics. The main objective of this study is to determine how trophic interactions and carbon transfer dynamics differ within BMI communities along gradients of dissolved organic carbon, nutrient enrichment, and catchment land use (extent of shoreline development and agriculture), and to assess the relative importance of these and other parameters. Here we employ a stable isotope approach using $\delta^{15}N$ and the $\delta^{13}C$ as indicators of relative trophic position and dietary carbon origin, respectively. Twenty lakes from two distinct regions of southern Ontario, the Precambrian Shield and St. Lawrence lowlands, were sampled. Lakes were specifically chosen to represent gradients of different chemical and physical parameters within and among each region. Understanding which parameters drive the function of these communities could be important in forecasting future community changes.

Oral SCL (General Session)

AN INVESTIGATION OF THE EFFECTS OF PRE-ANALYSIS ACIDIFICATION ON FRESHWATER MACROPHYTE $\delta^{15}N$ AND $\delta^{13}C$

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Stable isotope analysis has become a popular tool in aquatic ecology, however there is not yet a standardized method for sample preparation. Many investigators acidify samples pre-analysis to eliminate inorganic carbonates, but it is still unclear what, if any impact this has on carbon and nitrogen signatures. Macrophytes form the baseline of many aquatic ecosystems, and as such, it is imperative accurately determine $\delta^{15}N$ and $\delta^{13}C$ of them. This is the first study to investigate the effects of acidification on freshwater macrophyte $\delta^{15}N$ and $\delta^{13}C$. Ten common macrophyte species, both submergent and emergent, were collected over four lakes spanning from northern

to south-eastern Ontario. The lakes dramatically vary in chemistry, particularly inorganic carbon concentrations. Plants were separated, prepared into acidified and un-acidified treatments, and carbon and nitrogen isotopic ratios were determined. No significant difference in $\delta^{15}N$ or $\delta^{13}C$ was detected between treatments. It was additionally found that within species variability was greater in acidified samples. The data also show notable, yet statistically insignificant differences in un-acidified $\delta^{15}N$ signatures between species. Based on these results we assert that pre-analysis acidification of freshwater macrophytes is unnecessary and ill-advised. Additionally we caution those using freshwater macrophytes in isotopic food web studies to acknowledge and compensate for the visible differences in $\delta^{15}N$ when establishing a baseline.

Poster SCL (General Session)

IMPACT OF THE ROUND GOBY ON NATIVE FISHES IN THE ST. CLAIR RIVER, MICHIGAN

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Round gobies (*Neogobius melanostomus*) were documented within the St. Clair River in 1990, and subsequently put pressure on native benthic fish that occupy the same ecological niche. The study goal was to identify long-term changes in species diversity and fish diets associated with round goby invasion in the St. Clair River. I compared fish catch and diet data gathered during 1993 and 1994 to similar data collected in 2011. Preliminary results indicate a dramatic decrease in native fish species diversity, and one species, the mottled sculpin (*Cottus bairdii*) has likely been extirpated from the St. Clair River. To assess diet overlap between round gobies and native fishes, stomach content analysis was performed using the Schoener Index method. Preliminary results show that diet overlap exists between round gobies and native, benthic fish in the St. Clair River. However, this overlap varies spatially, temporally, and ontogenetically. Juvenile gobies have a more varied diet and were more likely to show overlap with native fish populations. In deeper waters round gobies of intermediate maturity were found to consume native fish eggs and juveniles, implying a potential direct, negative impact on native fish populations. Mature round gobies feed almost exclusively on invasive mussels (*Dreissena sp.*). These results suggest a causal linkage between round goby invasion and establishment, and long-term changes in fish species diversity within the St. Clair River. The establishment of the round goby within Great Lakes tributaries and nearshore environments has likely impacted native fish that seek out similar habitat and prey.

Oral CCFFR (Invasive Species)

EVALUATING FISH HABITAT COMPENSATION AT DIAVIK DIAMOND MINES, NWT

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In fall 2011, Diavik Diamond Mines Inc. undertook a fish habitat compensation project to offset habitat losses due to mining in the Barrenlands region, Northwest Territories. The compensation site features three small, headwater lakes ("M-Lakes") with connecting streams that were impassable to fish. One choke-and-pool and two gabion-weir fishpasses were built to increase inter-lake connectivity and improve access to these lakes from the larger Lac de Gras, to increase the productive capacity of this pristine system. The objectives of our study are to (1) evaluate the efficacy of the fishpasses using a combination of abiotic and biotic criteria, and (2) determine if such habitat manipulations enhance the productive capacity of the M-Lakes system. Our evaluation process includes three years of before-construction baseline data, and integrates ecological and hydraulics criteria. The choke-and-pool fishpass increased duration of flows suitable for fish passage, and Arctic Grayling were observed using the structure. Gabion-weir style fishpasses were ineffective at providing flows suitable for fish passage, and few if any fish used these fishpasses. Habitat, invertebrates, and ecosystem processes are still being monitored to assess productive capacity. Our preliminary results were used in fall 2012 in an adaptive management approach to improve the M-Lakes gabion-weir fishpasses, and guide design and construction of another stream compensation project in the area. We recommend against using gabion-weir style fishpasses in Arctic headwater lake-stream systems, characterized by limited and highly seasonal flows, uncertainties associated with predicting flows, and limitations in aligning "as-built" structures with design specifications in remote, wilderness settings.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

ESTIMATING PARAMETERS FOR CATCH EQUATIONS OVER MULTIPLE REGIONS WITH DISPERSION

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Arguably the most important equation in fisheries, the Baranov Catch Equation relates the initial population, catch, (assumed constant) natural mortality rate, and (assumed constant) fishing mortality rate over a season for a single, theoretical, homogeneous region of fish. In practice, some of these parameters are measurable whereas others are not. Here, we will present bounds on the fishing mortality rate—or, equivalently, the *q*-factor—in terms of the other parameters and use these bounds to compute the fishing mortality rate—and, consequently, the end-of-season population—to any desired accuracy. These results will be extended to include multiple seasons, age structure, and gear selectivity. Moreover, we will consider the case of multiple asymmetric regions and derive bounds on the fishing mortality and (assumed constant)

dispersion rates and use these bounds to compute the fishing mortality and dispersion rates to any desired accuracy.

Oral CCFFR (Migration, Mixing and Dispersal)

ZOOPLANKTON IS THE MOST IMPORTANT TROPHIC LINK IN AN UNSTABLE RESERVOIR ENVIRONMENT

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Zooplankton is a critical link in the pelagic food web within lakes and reservoirs. In reservoirs zooplankton biomass can decline when the flushing rate exceeds the doubling time of the zooplankton. Southern Alberta storage reservoirs are susceptible to major changes in water levels throughout the summer season due to imposed water requirements. In reservoirs with extreme level fluctuations during the summer, habitat such as littoral zones can decrease or lost. The loss of littoral zone forces a greater reliance on the pelagic food web of which zooplankton is an extremely important link. It is predicted that the zooplankton densities will be greater in the reservoirs with the longer retention times. It is also predicted that zooplankton densities will increase as it moves through the reservoir to the outflow. Samples taken on eight reservoirs in south western Alberta over the summer of 2012 will be utilized to determine the zooplankton productivity of each reservoir. These reservoirs exhibit different water retention times and different magnitudes of water level fluctuation. Preliminary data indicates that there is a strong correlation between water residence time and zooplankton density. Furthermore, that there is an increase in zooplankton densities along the axis of the reservoir from inlet to outlet.

Oral CCFFR (Multiple Stressors)

A FISH-BASED INDEX OF BIOLOGICAL INTEGRITY FOR ASSESSING ECOLOGICAL CONDITION OF THE BEAVER RIVER WATERSHED

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Urban development, agriculture and industrialization over the last century has resulted in land use modifications to Alberta's landscape that pose serious threats to the biological integrity of aquatic ecosystems in the province. Developing management plans that are driven by a good understanding of the relationship between land use and aquatic ecosystem conditions are crucial to protecting these ecosystems. In this study, we developed an index of biological integrity (IBI)

for assessing the health of the Beaver River watershed using data collected on fish assemblages and a suite of physicochemical variables. Fish sampling was completed using boat electrofishing. Physiochemical and GIS data were used to assess the level of disturbance of each site. White suckers represented 52% of the total catch, while the sportfish species, walleye and northern pike, represented less than 2% of the catch. Interviews with long-time anglers in the watershed indicate that sportfish have decreased in size and abundance over the past 30 years. We developed candidate metrics based on the fish community and screened them for responsiveness to disturbance; five metrics were used to calculate the IBI. The resulting multi-metric IBI was highly sensitive to change in cumulative anthropogenic disturbances. The IBI we developed is a useful tool for assessment and biological monitoring of the Beaver River watershed. It could be used in the future to assess the effects of industrial development and remediation strategies on the health of the aquatic ecosystems throughout the watershed.

Oral CCFFR (Multiple Stressors)

ON THE POTENTIAL CONTRIBUTION OF AMMONIA VOLATILIZATION TO AMMONIUM DECREASE ON A SUBSIDIZED RIVER (GRAND RIVER, ONTARIO)

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Ammonium (NH_4^+) is the conjugate acid of ammonia (NH_3) in solution, which equilibrium [$NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$] depends on pH ($pk_A = 9.24$). Volatilization has been described from soils (after application of fertilizers or manure), and in water was described by a first-order reaction, directly proportional to concentration, pH, turbulence and temperature, and restricted by limited movement of air. Ammonia volatilization has been calculated around 1.5% of the total ammonium nitrogen removal, and field studies have reported aerial rates in sludge or manure ponds. We present here an experiment under controlled conditions (pH 9.2, 23 ºC, and continuous aeration=10 ml/min) in order to assess NH_3 volatilization from a buffered aqueous solution (15 ml, 0.025 M Borate buffer) trapped into acidified water (10 ml, pH 4,HCl). Ammonia volatilized measured from the acidified traps described a parabolic curve, with a maximal recovery of 78% at 25 days. The trend could be explained as an initial exponential volatilization (up to 25 days) and later linear decrease (60 days), with potential mass loss from the source bottle (buffered) and uncollected volatilized ammonia. Complementary analysis with different pH, flow rates and stable Nitrogen isotopes analysis would give us a better understanding of the potential volatilization in the Grand River (Ontario) which have reached values as high as 9.7 (May 2008) and 9.88 (November 2007).

Poster SCL (Migration, Mixing and Dispersal)

TRANSPORT PATHWAY INFLUENCES THE RELATIONSHIP BETWEEN PROPAGULE PRESSURE AND COLONIZATION PRESSURE IN INVASION ECOLOGY

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The number of introduced individuals per species (i.e., propagule pressure) and the number of introduced species (i.e., colonization pressure) are key determinants of the number of species that successfully establish in new environments. While considerable research has been undertaken to examine the role of propagule pressure and colonization pressure in establishment success, much less is known about the relationship between the two variables and factors that may affect this relationship. We sampled 58 trans-Atlantic ships to investigate the relationship between propagule pressure and colonization pressure for invertebrates in ships' ballast water. Ships sampled underwent mid-ocean exchange and were grouped into three categories based on destination: Great Lakes, Atlantic and Arctic. We found a significant positive relationship between propagule pressure and colonization pressure for invertebrates collected from Arctic and Great Lakes ships, though not for Atlantic ships. Our results suggest that voyage characteristics, such as voyage length and changes in water temperature, influenced the survival of invertebrates in ballast water, and thus the relationship between propagule pressure and colonization pressure. The effects of these selective pressures were first evidenced through decreases in propagule pressure, followed by colonization pressure. In contrast to theory, our study provides empirical evidence that propagule pressure is not always positively related to colonization pressure. Therefore, future studies that investigate factors influencing establishment success should consider propagule pressure and colonization pressure separately.

Poster SCL (Invasive Species)

SYSTEMATIC REVIEW OF THE EFFECTS OF SILTATION ON FRESHWATER FISH AND THE EFFECTIVENESS OF COMMONLY USED SILTATION CONTROL MEASURES

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Siltation is well recognized as a contributor to habitat degradation, particularly in freshwater ecosystems. Suspended sediments decrease primary production, alter aquatic plant species composition and homogenize invertebrate communities. In terms of resident ichthyofauna, changes in fish abundance, species diversity, feeding behaviour and spawning success have been attributed to increased sediment levels. Though a large body of research has addressed varying parameters surrounding this issue, current syntheses are qualitative and do not include detailed meta-analyses. To that end, we conducted a meta-analysis on the effects of siltation on fish: i) abundance and diversity; ii) feeding and growth; and, iii) spawning success. To mitigate the

incidence of siltation, various devices are used to reduce point-source sedimentation that occurs during riparian development, including silt fences and sediment traps. We further investigated the effectiveness of siltation-control devices, including: iv) silt fences; and, v) sediment traps. This research will clarify the effects of silt on freshwater fishes, and assess the effectiveness of commonly used siltation devices.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

TURNOVER RATE OF SULPHUR IN BROOK TROUT, *SALVELINUS FONTINALIS*, THROUGH DIET SHIFT EXPERIMENTS IN FIELD AND LABORATORY TRIALS

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Sulphur stable isotope analysis (SIA), like carbon and nitrogen SIA, can be used in food web, movement, and nutrient dynamics research. Sulphur SIA is of particular interest for movement studies of anadromous fishes because of the large variation between freshwater and marine sulphur ($\delta^{34}S$) stable isotope values. The successful application of this tool is dependent on our knowledge of the trophic discrimination factor (TDF – the isotopic difference between a consumer and its diet), and the turnover rate of the element in the organism's tissues. The objective of this study is to determine the TDF and the turnover rate of sulphur in brook trout tissues, using laboratory and field diet shift experiments. A controlled diet shift experiment was performed on brook trout at the aquaculture fish facility at the University of New Brunswick. Brook trout were fed a diet with a low $\delta^{34}S$ value, relative to their previous diet. For the field experiment, hatchery-reared brook trout (reared on a high $\delta^{34}S$ diet) were introduced to Otter Brook (where naturally occurring food items have low $\delta^{34}S$ values), a tributary of the Little Southwest Miramichi River, NB; sulphur turnover rate and TDF were monitored *in situ*. Subsequent sampling over several months permitted comparisons of natural and laboratory-derived turnover rates. The results of this study will facilitate the use of sulphur as a third ecological tracer in food web studies, and to successfully track freshwater fish movements and nutrient dynamics.

Oral CCFFR (General Session)

USING HIDDEN MARKOV MODELS TO IDENTIFY BEHAVIOUR IN THE GULF OF ST. LAWRENCE SNOW CRAB (*CHIONOECETES OPILIO*) FIXED GEAR FISHERY

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Tracking vessel movements has become increasingly important in fisheries research in order to identify fishing grounds, monitor responses to area closures and other actions for fishery managers. Vessel monitoring systems (VMS) have given fishery managers and researchers the ability to study vessel interactions by automated tracking of vessels throughout fishing seasons. The high resolution spatial and temporal data obtained from VMS records in the Gulf of St. Lawrence snow crab fishery provide information on movement patterns and fishing locations. With the use of hidden Markov models (HMM) we identified behaviours exhibited by the fishermen during the course of fishing trips and related these behaviours to catch rates and across years with varying abundance estimates. The HMM successfully classified 3 behavioural states in the VMS data that were identified with travelling, setting traps in novel locations and retrieving previously set traps. Catches within a trip were predicted by combining estimates of these behaviours with logbook information in a generalized linear model (GLM). Preliminary analyses from the GLM show that behavioural variables can improve the prediction of catch beyond that obtained with classical effort measures and could provide a novel index of abundance.

Oral CCFFR (General Session)

SYMPATRIC POLYMORPHISM IN LAKE TROUT: THE COEXISTENCE OF MULTIPLE SHALLOW-WATER MORPHOTYPES IN GREAT BEAR LAKE

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Intraspecific morphological variation, ranging from subtle to large enough to result in misidentification, is commonly observed among fishes in recently glaciated lakes of the Canadian Arctic. A UPGMA cluster analysis of 558 Lake Trout distinguished three different morphs that co-exist in the shallow waters of Great Bear Lake, NT. A fourth distinct albeit rarer morph has also been identified from other collections.
We combined classical morphometric/meristic measures with shape analysis (geometric morphometrics) to quantify morphological differences among adult and juvenile shallow-water Lake Trout from Great Bear Lake. The most important differences among adult morphotypes are associated with variation in head and fin measurements, whereas body shape variation is less distinctive. These patterns are consistent with many evolutionary adaptations in fish that involve traits associated with feeding and swimming. However, no consistent patterns of variation were found among juveniles, suggesting that divergence develops at later stage. Due to the large size and complex morphometry of Great Bear Lake, we also examined to determine patterns across different regions of the lake. Within a single morphotype, morphological variation, including body shape differences, was found to vary among lake areas.
This unusual endemic diversity challenges prevailing ideas that Lake Trout forms are segregated primarily by depth and have a low degree of phenotypic variation compared to their congeneric relatives, especially Arctic Char. Although the deep-water habitats of Great Bear Lake have not

been well studied, additional morphotype are possible such that the Lake Trout of Great Bear Lake could challenge the iconic diversity of Arctic Char by equaling or exceeding the number of morphotypes found within a single system.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

ENVIRONMENTAL FATE AND ECOLOGICAL CONSEQUENCES OF SILVER NANOPARTICLES: DATA FROM THE LAKE ECOSYSTEM NANOSILVER PROJECT AT ELA

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Commercial use of nanoparticles is widespread and their discharge to aquatic ecosystems is an emerging environmental concern. Release of nanoparticles with antimicrobial properties, such as silver nanoparticles (AgNP), may have consequences for ecosystem structure and function. We investigated the environmental fate and ecological effects of AgNP in mesocosms in L239 at the Experimental Lakes Area (ELA). Mesocosms were open to the sediments with the following treatments: continuous exposure to final concentrations of PVP-capped AgNP of 5, 20, or 80 ppb, continuous exposure to 80 ppb citrate-capped AgNP, and a single-dose exposure to 80 ppb PVP-capped AgNP. Over six weeks, we measured AgNP concentrations in biological and physical fractions, responses of zooplankton, algae, and bacterioplankton abundance and composition, and changes in organic matter decomposition, ecosystem metabolism, and nitrogen cycling. Final AgNP concentrations in the water column were approximately 80% of nominal in continuous exposure mesocosms. Water column concentrations in single dose mesocosms decreased over time, with a half life of approximately 20 days. Preliminary data show rapid recovery of algal and bacterioplankton abundance and ecosystem function following AgNP exposure. However, zooplankton biomass decreased with increasing AgNP concentration, perhaps due to AgNP-induced shifts in algal community composition. Our results show that AgNP persist in the water column and that upper planktonic trophic levels may be more sensitive to AgNP exposure in natural environments. The whole –lake addition of AgNP proposed by the LENS project will allow for investigation of community level responses and will reveal potential cascading effects of differential trophic responses.

Invited Oral SCL (Experimental Lakes Area Research)

CARBON DYNAMICS, FOOD WEB STRUCTURE AND RECLAMATION STRATEGIES FOR ATHABASCA OIL SANDS AFFECTED WETLANDS: REVIEW AND SUMMARY OF A 5-YEAR STUDY

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Environmental assessment criteria vary according to evaluators' perspective. Biodiversity measures emphasize rare taxa. Common taxa dominate measures of processes. Successional indicators reflect relative composition of taxa. Assessment is more difficult when reference systems themselves are regulated by marked interannual variation.
We contrasted biological, ecotoxicological, and carbon dynamic aspects of 16 wetlands constructed or forming over the last 5-30 years in post-mining landscapes of the Athabasca oil sands. Wetlands were operationally classified according to "age since construction" (<7 y vs. >7 y, at study start), reclamation materials (oil sands process tailings/water (OSPM) vs. reference sediments/water), and augmentation with stockpiled surface materials (peat/mineral soil mixture vs. none). We surveyed composition, determined carbon fluxes, and measured compartment standing stocks for residual hydrocarbons, organic substrate, bacterioplankton, phytoplankton, biofilm, macrophytes, litter, zoobenthos, and aquatic insect emergence. Carbon pathways, fluxes and budgets were determined by measuring sediment and water gas fluxes, microbial, plant, zoobenthic, amphibian, and tree swallow nestling production, and stable isotope signatures. Coarse taxon richness in reference wetlands reached an asymptote in 5-7 y. Richness, composition, and emergent plant cover of OSPM-affected wetlands converged slowly (15-20 y) with patterns seen in reference wetlands. Peat additions accelerated development of emergent but not submergent plant cover and associated biota. Water chemistry was a more important regulator of submergent biological properties than sediment characteristics. Ultimately, residual salinity will likely be the most important regulator of community composition. Food webs are becoming more similar to 'reference' wetlands, but trends are slower than those observed in more temperate biomes.

Oral CSWS (Wetland and Land/Water Linkages)

INADEQUATE REPLICATION IS GENERATING FALSE DISCOVERIES AND INFLATED EFFECT SIZES IN THE LITERATURE

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The literature shows that that most single-variable-effects in nature account for less than 10% of the variance. Ecology isn't special---surveys of thousands of literature findings in a wide variety of fields reveal that *median* effect sizes are almost all well below 10% of the variance. We seem reluctant to accept that the world is so messy. Perhaps we are skeptical because our brain unconsciously uses hindsight to rationalize what has just happened, and sells us a story of the present that includes plausible, but spurious causal explanations for many truly random events. Consequently, we continue to design experiments with only 30% power to detect even medium-sized effects ($r^2 = 0.1$). Unfortunately, that low power does more than simply reduce the fraction of real effects we can detect. It also substantially increases the proportion of significant effects

that are false discoveries. For a survey of experiments in the literature the actual probability of a false discovery was commonly 3 or more times the 5% that the authors sought to achieve. Furthermore, surveys of effect sizes in ecology indicate that large single-variable effects ($r^2 >$ 0.20) are almost never described from well-replicated studies; they only occur where small sample sizes could have generated large effects by random sampling errors. Accepting the real level of disorder in the world would help us recognize when we should be skeptical about large effects and help us appreciate that a medium effect is worth our further attention, not our scorn.

Poster CCFFR (General Session)

BENTHIC MACROINVERTEBRATE COMMUNITIES OF LAKE SIMCOE (ONTARIO, CANADA): INVESTIGATING A 85 YEAR TIME-SCALE

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Lake Simcoe is the largest inland waterbody in southern Ontario and has been the focus of much scientific study over the past 30 years. Increases in phosphorus loading over the past century have impacted algae and aquatic plant biomass, deepwater anoxia, and the sustainability of the coldwater fishery. Management efforts have been made to restore Lake Simcoe to an ecologically sustainable state, but colonization by invasive species, climate change, and the rapid urbanization of the watershed continue to complicate management strategies. Benthic macroinvertebrate communities can be used to investigate both historic and present-day ecological change in Lake Simcoe and the first comprehensive benthic survey was carried out by Rawson from 1926-1928. This study was both spatially and temporally comprehensive of the lake, making it a fundamental investigation of lake benthos in North America at the time. By comparing data collected in 2011to the published results of the Rawson study, there is a novel opportunity to investigate the change in the benthic community both spatially (across the lake) and through the 85 year time scale.

Poster SCL (General Session)

TWO DECADES OF RESEARCH ON PERCEIVED RECRUITMENT PROBLEMS OF A LARGE-BODIED BENTHIC CYPRINID, EUROPEAN BARBEL *BARBUS BARBUS* (L.), IN AN URBANISED RIVER OF SOUTHEAST ENGLAND

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Circumstantial evidence, including field data, can give the impression of recruitment problems in a fish population. Such is the case of the European barbel, *Barbus barbus*, a species believed to be threatened in some parts of its native European range, including the River Lee, a major tributary of the River Thames. This communication provides a review of the 20 years of research to assess aspects of environmental biology relevant to barbel recruitment in the River Lee, including habitat and diet during early ontogeny, responses of 0+ barbel to discharge variations, the effects of river management, movement and growth patterns of adults, and environmental threats (pollution and non-natives). Laboratory studies on inter-gravel movements prior to larval emergence highlighted the importance of good water quality and un-clogged substrata for early stage recruitment. Diel studies of 0+ barbel resource use partially refuted the initial impression of very low abundance, with elevated densities at night contrasting the low abundances observed during daytime sampling. Juvenile barbel responses in an artificial stream to discharge variations indicate different strategies by individual fish to deal with discharge increases. Studies of tagged adults confirmed the presence of two population components (resident, mobile), despite the confinement of the fish between water retention structures during normal discharge conditions, as well as movement patterns and site fidelity of the species before, during and after an unexpected pollution event in the lower section of the river. Studies of potential predators during early life revealed that invasive signal crayfish, *Pacifastacus leniusculus*, is a likely predator of barbel eggs and larvae, which contrasts the native, threatened white-clawed crayfish *Austropotamobius pallipes*. Overall, the assumed poor recruitment suggested by initial survey data was not supported by the results of both the diel 0+ fish investigations and the mark-recapture and growth studies. However, maximum potential recruitment is probably not achieved due to the reduced mobility of the fish imposed by water retention structures.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

GLOBAL APPLICATIONS OF THE FISH INVASIVENESS SCORING KIT (FISK) TO SCREEN NON-NATIVE FRESHWATER FISHES FOR INVASIVENESS RISK

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The Fish Invasiveness Scoring Kit (FISK) is a semi-quantitative risk screening tool adapted for freshwater fishes from the widely-used Weed Risk Assessment of Pheloung et al. Initially applied to non-native fishes in England & Wales, FISK has subsequently been applied in other north temperate countries including Belgium, Belarus, Finland and Japan, as well as to non-

native aquacultural fishes in Brazil. To permit suitable applications in warm temperate and tropical regions, FISK (v1) was revised to produce FISK v2, which also includes major improvements to the user interface and overall functionality. FISK v2 was then applied to non-native fishes relevant to Australia, peninsular Florida (U.S.A.), Iberia and four Balkan countries (Bulgaria, Macedonia, Montenegro, Serbia). The number of assessors in these applications has ranged from single (e.g. Belarus, Finland, Australia), dual (e.g. Belgium, England & Wales), triplicate (Florida, Iberia) and quadruplicate (i.e. cumulative of single assessments in the four Balkan countries). In the Florida application, for example, FISK v2 was up to 80% accurate in identifying invasive fishes as high risk whilst simultaneously maintaining 85% accuracy at identifying non-invasive fishes as low risk. Significant differences in scores from the three assessors for the same species indicated the importance of minimizing uncertainty and user-subjectivity. In this communication, the various applications of FISK are subjected to a geographical comparison, which reveals differences in score patterns between colder and warmer climate zones, the former being relatively consistent among countries and the latter characterised by considerable variability among countries/regions. The potential use of FISK v2 as decision-support tool for resource managers is discussed.

Oral CCFFR (Invasive Species)

BUOYANCY CONTROL MECHANISMS OF FISHES IN DEEPWATER NEARCTIC LAKES

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In the deep lakes of post-glacial North America, some fishes evolved the ability to exploit prey that show diel vertical migration. To accomplish the task of rapidly moving through large-pressure gradients, specialized buoyancy control mechanisms were required. Three co-occurring species have successfully occupied the depth-based habitat niches of boreal lakes using different gas exchange and buoyancy control strategies. Lake trout (*Salvelinus namaycush*) have physostomous swim bladders that require initial filling with atmospheric air and lack glands to permit gas exchange. Lake trout have radiated into distinct morphs of different lipid content to occupy different depth strata. The ciscoes (*Coregonus* sp.) are also physostomous, but have gas gland-like *micro rete* that permits limited gas exchange at depth. Like lake trout, the ciscoes have radiated into different depth-based morphs with differing lipid contents and are considered separate taxonomic units, such as the cisco species flock of the Laurentian Great Lakes. The burbot (*Lota lota*) has a physoclistous swim bladder with a well developed gas gland and varies little in terms of lipids. This feature has allowed burbot to occupy the greatest depth range of any boreal fish, and has done so with no known depth-segregated morphological differences. Understanding the role of buoyancy control can provide insight into the functioning and energy

flow of deep-water ecosystems. From a practical sense, understanding the buoyancy limitations of a particular morphotype can inform deep-water fishery restoration efforts. Knowledge of the physiological constraints associated with a fish's gas-exchange system can enable sampling methods to be employed that can avoid barotrauma.

Invited Oral (Northern Ecosystems)

DEVELOPING BEST MANAGEMENT PRACTICES FOR TRANS-BOUNDARY ANADROMOUS ALOSINES

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The recent 2012 stock assessment by the US Atlantic States Marine Fisheries Commission reveals alewife, *Alosa pseudoharengus*, and blueback herring, *Alosa aestivalis* populations are depleted coast-wide. The stocks appear to be faring better in the northern rather than southern portion of their range. Both species are trans-boundary anadromous Alosines, with alewife (gaspereau) ranging from Newfoundland (Canada) in the north to North Carolina (United States) in the south, while blueback herring extend as far south as Florida (United States). The assessment, however, ignores the northernmost extent of these species by leaving out Canadian information. Furthermore, the National Oceanic and Atmospheric Administration is investigating whether to list these species under the Endangered Species Act. Inclusion of Canadian data could provide insight on improving their management.
This work bridges US and Canadian information to provide insight on the best management practices for trans-boundary anadromous Alosines. Findings from research trips to New Brunswick and Nova Scotia to understand Canadian management of these species are summarized. In addition, population estimates are compared with published ecosystem indicators, directed fishery catches, and oceanic bycatch in a discussion of trade-offs of population, ecosystem, and economic needs. Outcomes of the analysis provide for recommendations on how to improve existing trans-boundary management of these species.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

FOOD WEB RELATED HABITAT USE BY LAKE TROUT

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Food web structure affects habitat use by Lake Trout, a cold-water top predator. As a consequence, foraging costs may also be influenced. Depending on the season, Lake Trout use different parts and depths of a lake. During the summer, habitat constraints force fish to make choices regarding depth occupancy in order to maintain access to their prey. As a result fish may engage in foraging excursions to shallower or deeper parts of the lake that are outside of their thermal preferenda. The metabolic cost of these excursions can be significant. In this study we employed acceleration – depth transmitters to quantify the food web related habitat use by Lake Trout across four lakes that differed in forage species: two small lakes in the Experimental Lakes Area, and two larger lakes in Algonquin Provincial Park. Lake Trout showed high variability in depth occupancy and activity levels. In general they occupied depths that matched their expected thermal and dissolved oxygen preferenda; however, we also observed frequent high-acceleration excursions to shallower or deeper areas. Activity estimates corresponded well with changes in depth, revealing a positive relationship between these two variables. For this study we also used hydroacoustic surveys to link habitat use by Lake Trout with prey distribution and behaviour. Lake Trout showed movements and behaviours that were strongly associated with prey distribution and food web structure across the four lakes in this study.

Oral CCFFR (Experimental Lakes Area Research)

LIMNOLOGICAL AND ENVIRONMENTAL CHANGE AT THE EXPERIMENTAL LAKES AREA: A PALEOECOLOGICAL PERSPECTIVE

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This talk will summarize the research that my lab has been involved in at the Experimental Lakes Areas (ELA) over the last eight years. We assessed environmental change since pre-industrial times in network of lakes from ELA over the past century, and have developed a new approach to track limnological change in over centuries to thousands of years. This later approach was inspired and based on the long-term limnological data collected at ELA, which showed drastically reduced runoff and decreases in dissolved organic carbon and changes in light penetration associated with drought, and takes advantage of the sensitivity of biological assemblages to changes in light transparency, as well as lake level. Changes in diatom assemblages over the last 200 years in a regional set of ELA lakes show increases in planktonic diatoms in many lakes, a result that is consistent with the ~2 ^{o}C increase in temperature over the last century. Lake 239, a main reference lake at ELA, was the focus of our centennial to multi-millennial studies. From Lake 239, we assessed cores from nearer-shore environments, as well as a deep core using a variety of proxies including diatoms, chrysophytes, and pollen. Results indicate variations in Lake 239 over the period of monitoring since 1968, were greatly exceeded over the last several thousand years, which were once again dwarfed by the changes in the lake during the warmer mid-Holocene Period (MHP). During the MHP water volume was estimated to be less than 60% of modern, nutrient levels and production were elevated, and fires were much more common. These results suggest that the impact of future climate change on lakes in northwest Ontario could be severe.

Invited Oral SCL (Experimental Lakes Area Research)

VIABILITY ANALYSIS OF THE NATURAL POPULATION OF SALMO SALAR L. IN THE ALLIER CATCHMENT: IMPACT OF 35 YEARS OF STOCKING

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Due to its conservation value, the Allier's salmon population has been monitored and several datasets such as fisheries catches, spawning nest counts, juvenile index of abundance and the number and life-stage of salmon stocked every year have been collected from 1975 to present. Synthesizing the information brought by these heterogeneous data sources in a formal statistical modelling framework is a difficult task. In order to reflect the natural process governing the population renewal it is also important to account for regulation mechanism such as density dependence as well as variability in the different transition parameters such as survival. Hierarchical Bayesian modelling (HBM) offers an efficient way to deal with such constraints while accounting for various forms of uncertainty. The model built during this study and presented here brings together 35 years of heterogeneous data in a coherent framework while accounting for uncertainty. The results show a retrospective estimation of the past abundance of Atlantic salmon in three different spatial areas of the Allier River as well as the intergenerational renewal rate of the population. One of the main challenges of this modelling exercise was to incorporate the annual stocking data. The model provides estimates of the contribution of the different categories of salmon life-stage stocked (egg, fry and smolt) over the time series considered. These results provide useful information to the managers to apprehend the impact of the different restoration program over the last decades in the Allier River and make decision about the future programs.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

RECOVERY STRATEGY FOR A STRADDLING STOCK: 3LNO AMERICAN PLAICE

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There is an increasing demand for governments and regional fisheries management organisations to demonstrate that they are implementing sustainable fisheries management strategies in which fishery removals are adjusted with regard to changes in the magnitude and productivity of the fish stock being exploited. The aim of this study is to develop implementable recovery strategies for the 3LNO American plaice stock which would allow both rebuilding of the biomass and a reopening of the fisheries on a sustainable basis. Recovery strategies should take in account relevant precautionary approach reference points as well as performance statistics relevant to the fishery such as average catch and variation in total allowable catch (TAC). The first step is to complete the specification of the precautionary approach framework for the considered stock. The following step involves developing conservation and fisheries performance statistics in collaboration with fisheries managers and industry in mathematically explicit terms. Additionally, current stock assessment models will be refined and applied as a basis for simulation testing of candidate recovery strategies against the performance statistics. Simulations will account for observation error, process error, model uncertainty and implementation error. The performance of two kinds of harvest control rules will be examined – model-based rules that adjust the catch based on model estimates of stock size and survey-based rules that adjust the catch based on recent survey trends.

Poster CCFFR (General Session)

CONSIDERING POTENTIAL PLASTIC AND GENETIC/MATERNAL EFFECTS ON DEMOGRAPHIC SUBSIDIES: NATIVE SPECIES PERSISTENCE WITH DETRIMENTAL EXOTICS

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Native species sometimes persist in the face of a detrimental exotic invader by occupying refuge habitats in which the exotic is not successful. These refuges can then provide demographic subsidies that enhance the persistence of the native in areas of coexistence with the exotic. Phenotypic plasticity of the native species could play a critical role in this process by allowing individuals dispersing from refuge to invaded habitats to alter their phenotypes to better suit the new habitat. By contrast, genetic or maternal differences between native populations from refuge versus invaded habitats might reduce the effectiveness of demographic subsidies from the former to the latter. To consider this possibility, we studied plasticity in a native amphipod (*Gammarus fasciatus*) facing an exotic amphipod (*Echinogammarus ischnus*) along an environmental gradient that determines refuge versus invaded habitats. We tested for plastic versus genetic/maternal contributions to variation in potentially adaptive traits (larval survival, time to first reproduction, body size, fecundity, and post-moult calcification) from native amphipods that inhabit a refuge and invaded habitat. Strong plasticity was evident for several traits (body size and post-moult calcification), whereas genetic/maternal effects were evident for other traits (larval survival, time to first reproduction, and fecundity). We explore how these various effects

might influence the role of un-invaded, ion-poor refuges in providing demographic subsidies of native amphipods to invaded habitats.

Oral SCL (Genetic Diversity and Adaptation)

MODELLING OCCUPANCY AND ABUNDANCE OF AN IMPERILLED STREAM FISH WHILE ACCOUNTING FOR IMPERFECT DETECTION

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Occupancy and abundance models that incorporate imperfect detection were developed to examine factors that affect the distribution and abundance of the Threatened Eastern Sand Darter (*Ammocrypta pellucida*), a small benthic fish with a discontinuous and declining range in eastern North America. Candidate models included physical habitat, biotic and anthropogenic covariates that were hypothesized to affect Eastern Sand Darter distribution and abundance. Detection probabilities differed between the two Ontario study streams, but factors affecting site occupancy were very similar. The most important factor affecting site occupancy was the proportion of sand and fine gravel, but water clarity and biotic indices had support in additive models. Life stage models suggest that adult and young-of-the-year Eastern Sand Darter occur in similar habitats although young of the year appear to be more tolerant of silt substrates. At larger scales, Eastern Sand Darter occupancy was more closely related to substrate at the site level than factors measured at the reach and valley segment levels, lending support to the substrate specificity of this species. At the watershed scale, Eastern Sand Darter populations in the Great Lakes basin are most likely to persist in large watersheds with high discharges. Multi-state and zero-inflated negative binomial models showed that factors affecting site abundance differed between the two streams and were different than factors affecting occupancy. Model predictions suggest that formerly occupied watersheds in Ontario have the potential to support Eastern Sand Darter and should be considered for repatriation efforts.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

BACK FROM THE BRINK: GENETICS OF A RECOVERED FATHEAD MINNOW POPULATION FOLLOWING AN ESTROGEN-INDUCED COLLAPSE

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A whole-lake experiment in Lake 260 at the Experimental Lakes Area showed that chronic exposure of fathead minnow (*Pimephales promelas*) to low concentrations of the synthetic estrogen used in birth-control pills led to feminization of males and near extinction of the species from this lake (Kidd et al. 2007 PNAS 21: 8897– 8901). The population collapsed in 2002, after the second season of estrogen addition, because of recruitment failure. Reproductive failure was also observed in the third and final season of amendments and for the next two years, with only a few individuals caught each year. By 2006, however, appreciable numbers of fathead minnow were again found. We therefore conducted genetic analysis to determine: 1) the source of these fathead minnow; and 2) whether the population experienced a genetic bottleneck effect. Using 12 microsatellite loci, we analyzed over 450 specimens from Lake 260 and two reference lakes (neither of which are connected to Lake 260) prior to the collapse (1999–2001) and in 2010. This also included samples collected in 2010 from a fourth lake that has the greatest potential to provide a source for immigration of fathead minnow into Lake 260. The genetic results clearly show that the existing fathead minnow in Lake 260 represent recovery of the estrogen-treated population (rather than recolonization from elsewhere). Furthermore, it appears that the observed demographic bottleneck did not produce a lasting genetic bottleneck effect.

Oral CCFFR (Experimental Lakes Area Research)

PATTERNS AND MECHANISMS OF SEX-BIASED ARRIVAL OF FISHES AT SPAWNING SITES IN LAKE ONTARIO STREAMS

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Males and females often differ in their time of arrival at breeding sites. The magnitude and frequency of sex-biased differences in timing of arrival have been studied in birds, but remain poorly studied in fishes, even though timing of arrival at breeding sites is an important component of mating systems. We tested for evidence of sex-biased arrival in 17 fishes co-inhabiting six adjacent tributaries of Lake Ontario by using netting and PIT tag tracking observations collected for close to 8,000 fish. The commonest form of sex-biased arrival was males arriving earlier than females (protandry), observed in 40 of 69 populations, but only significant in 20 samples. We then tested four hypotheses for protandry: males arrive earlier than females (1) to secure the best reproductive territories (rank-advantage), (2) males arrive earlier to maximize their mating opportunities (mating opportunity), or females arrive later than males to (3) avoid adverse environmental conditions early in the breeding season (susceptibility), and (4) females arrive later to minimize time spent waiting while males prepare for mating (waiting cost). Seven predictions involving body size, degree of sexual dimorphism, territorial behaviour, and sex ratio were used to distinguish among the hypotheses. No hypothesis was fully supported. However, timing of arrival was strongly related with body size in males and females, as predicted by the susceptibility hypothesis, and contrary to what is observed in birds.

Invited Oral CCFFR (Migration, Mixing and Dispersal)

HARVEST MODELS AND STOCK CO-OCCURRENCE: PROBABILISTIC METHODS FOR ESTIMATING BYCATCH

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A primary goal of ecosystem-based fishery management is to reduce non-target stock impacts, such as incidental harvest, during targeted fisheries. Quantifying incidental harvest has generally incorporated fishery-dependent catch data, yet such data may be biased by gear non-retention, observation difficulties, and non-random harvest patterns that collectively lead to an impartial understanding of non-target stock capture. To account for such issues and explicitly recognize the combined influence of ecological and harvest factors contributing to incidental capture within targeted fisheries, we demonstrate a probabilistic modeling framework that incorporates: 1) background rates of target and non-target stock co-occurrence as the primary ecological basis for incidental harvest; 2) the probability of harvesting at localities exhibiting co-occurrences; 3) the probability of selecting for non-target species with fishery gear; 4) and, as a function of harvest effort, the overall probability of incidental capture for any non-target stock contained in the species pool available for harvest. To illustrate application of the framework, simulation models were based on fishery-independent data from a freshwater bait fishery in Ontario, Canada. Harvest simulations of empirical stock data indicated that greatest species-specific capture values were over 4000 times more likely than for species with lowest values, indicating highly variable capture probabilities due to the combined influence of stock heterogeneity and harvest dynamics. Estimated bycatch-effort relationships will allow forecasting incidental harvest on the basis of effort to evaluate future shifts in fishing activity against specific ecosystem-based fishery management objectives, such as reducing the overall probability of bycatch while maintaining target landings.

Oral CCFFR (General Session)

SPRING CLIMATE CHANGE DISRUPTS PLANKTON PHENOLOGY IN BOREAL LAKES

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Warming conditions over the last 44 years at the Experimental Lakes Area (ELA), Ontario, have led to an increasingly earlier ice break-up by 2.4 days per decade. In addition, variability and extremes in the timing of ice break-up have increased over the years. We studied the implications of earlier spring conditions, using ice break-up date as a proxy, on timing and biomass of spring plankton populations. A long-term phytoplankton and zooplankton dataset (up to 44 years long) from multiple un-manipulated lakes (Lakes 239, 373, 442) at the ELA was used in this study.

Early ice-off years were associated with a shift in timing of the spring peak in most phytoplankton groups and rotifers but not in copepods and cladocerans. Results suggest this led to a trophic mismatch between edible phytoplankton and crustaceans and caused a decrease in spring biomass of calanoida copepods (decrease of 1.8x) and cladocerans (decrease of 3.0x). A laboratory experiment suggested that decoupling of the rate of warming and day length during earlier spring conditions decreases hatching success of cladocerans from the resting egg bank, potentially leading to delayed population development. It is currently unknown if this trophic mismatch impacts fish species that rely on zooplankton for prey during spring.

Oral CCFFR (Experimental Lakes Area Research)

INTERACTIVE EFFECTS OF CALCIUM DECLINE AND PREDATION RISK ON THE POTENTIAL FOR A NORTHWARD RANGE EXPANSION OF THE RUSTY CRAYFISH, *ORCONECTES RUSTICUS*

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Over the last three decades**,** the rusty crayfish, *Orconectes rusticus*, has been expanding its range northward via human-mediated dispersal. If this species is to continue expanding its range northward, it will move onto the Canadian Shield, where calcium (Ca) availability is low and is predicted to decline further in the future. Dissolved Ca is a vital functional component of mollusc and crustacean physiology, important for exoskeletal condition and strength, as well as metabolic activity. However, some organisms are able to compensate for reduced structural integrity by modifying their behaviour. In this study, we asked whether the invasive rusty crayfish can survive low levels of ambient Ca and, if it can, whether it exhibits modified anti-predator behavior in response to the physiological limitations imposed by low [Ca]. We found that, under reduced Ca levels, *O. rusticus* reduced the frequency of standard activities (such as grooming and foraging) and was more likely to engage in vigilance and/or escape behavior. We also found that some individuals, in extremely low [Ca], died while molting. This study suggests that Ca limitation on the Shield, especially where predators are present, may limit the northward expansion of *O. rustucus* beyond their current range limit.

Oral CCFFR (Invasive Species)

A MORE CONSISTENT METHOD FOR MEASURING OTOLITHS

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The current technique for measuring otoliths for age and growth patterns is problematic in that it uses landmarks that are not easy to view on all otolith sections. This increases the chances of taking educated guesses to where the measurements should start. The current method measures from nucleus to edge on the leading side of an otolith. This measurement is usually done with a straight line or on a constant curve, although most otoliths are curved and they do not all curve in the same way. I have devised a technique that avoids using hard to recognise landmarks and it also standardises how annuli are measured from an approximated nucleus while avoiding the issues with inconsistent curvature of otoliths. This new method was tested against the previously most common method (of measuring on a straight line) using lake trout, *Salvelinus namaycush*, otoliths. Otolith length measured in this way was found to have a higher correlation to the known length of the fish (R^2=0.91 compared to R^2=0.88). Having this new method as a standard for measuring otoliths will create a more clearly defined relationship between otolith and body length, and will help to more accurately estimate the age and/or growth rate of fish based on their otoliths. In the future I plan to use my new measurement technique to formally assess the accuracy of size estimates backcalculated from lake trout otoliths.

Poster CCFFR (General Session)

A TEST OF THE SERIAL DISCONTINUITY CONCEPT

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In Canada, more than 60% of the total power supply is from hydroelectric generation and it is widely accepted that hydroelectric developments lowers habitat and biological diversity and ultimately impacts ecological integrity. While the River Continuum Concept (RCC) by Vannote et al. (1980) and Serial Discontinuity Concept (SDC) by Ward and Stanford (1983) have been highly influential in stream ecology theory, there has been relatively little testing of these concepts, particularly the latter. The SDC recognized that most rivers experienced breaks in the continuum from impoundment, and provides predictions on the recovery of various abiotic and biotic variables (ie. discontinuity distances or zone of influence). We sampled benthic invertebrates, and measured resource and habitat variables in two hydropower and two natural rivers on the north shore of Lake Superior, to 1) test the validity of the RCC and SDC, and 2) determine the most useful biotic and abiotic parameters to estimate the recovery distance below hydroelectric impoundments. Preliminary results provide some support for SDC predictions and suggests that two distinct gradients exist in regulated rivers: 1) a rapid attenuation of resources (drift, periphyton) and 2) a longer attenuation in temperature and flow. In addition, the presence of stoneflies may be a useful indicator to estimate recovery distance or zone of influence below impoundments.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

RANGE AND SURVIVAL OF TWO NONINDIGENOUS SPECIES (*EICHHORNIA CRASSIPES* AND *PISTIA STRATIOTES*) IN THE GREAT LAKES

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There are at least 182 non-indigenous species (NIS) currently reported in the Great Lakes (GLs). Though ballast water is the most common vector for introduction of aquatic NIS, the pond and aquarium trades also play a role. The latter vector is the most probable cause for the introduction of two invasive macrophytes, water lettuce (Pistia stratiotes) and water hyacinth (Eichhornia crassipes). Both are native to South America, and are believed intolerant of winter temperature in temperate areas like the GLs. We surveyed the Canadian shoreline of the GLs by boat to determine the species' current range, whilst also investigating three hypotheses that may account for the species' continued presence: 1) adult plants (APs) survive winter exposure; 2) APs perish during the winter, but produce viable seeds that germinate the following spring; and 3) APs are reintroduced each year but do not survive or reproduce. Surveys conducted in 2010, 2011 and 2012 demonstrated that the species are recurring in some GLs tributaries in consecutive years. We deployed a series of cages in Lake St. Clair and the Detroit River, with pre-measured plants, to assess survival under winter conditions. Results to date suggest that neither species are capable of surviving winter conditions. However, evidence has been found that water hyacinth is capable of reproducing sexually. Seeds have been collected directly from a population in Essex County and from local sediment. We are also aware of local residents discarding plants into area waterways, so evidence is currently consistent with hypotheses two and three.

Oral SCL (Invasive Species)

REGIONAL CARBON SEDIMENTATION AND STORAGE IN BOREAL AND TEMPERATE LAKES

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Lakes play a dual role in the landscape carbon budget; in that they simultaneously act as a source of carbon to the atmosphere and a sedimentary carbon sink. Whereas gas evasion from lakes has been extensively studied in northern landscape, much less is known on the magnitude and regional patterns of carbon accumulation in lake sediment. We measured the total (Holocene) sediment organic carbon accumulation using a new approach involving the precise determination of the lake sedimentary basin using a sub-bottom profiling ecosounder. We did this in 59 lakes located in 4 distinct northern landscapes: The James Bay lowlands in boreal Québec, the Laurentians in the Québec Canadian Shield, the Eastern townships in the Appalachian region of southern Québec, and in northern boreal Sweden. In the two boreal regions, we additionally measured the centennial-scale carbon accumulation rate based on lead-210 profiles. Our results

show that organic C accumulation in boreal regions is between 1.3 and 2.5-fold higher than in temperate regions, on the same, and the deglaciation history seems to be a critical factor determining the long-term carbon accumulation in lakes at regional scales. Further regional differences in carbon accumulation rates are well explained by the morphometry of the lake basin, particularly with the dynamic ratio. The centennial and Holocene C accumulation rates are overall very similar, suggesting little C degradation beyond 50 to 100 years post-sedimentation. Based on our boreal results, we estimate that sediments in boreal lakes on Earth should range from 14.3 to 35.9 Tg C.

Oral SCL (Carbon Flux and Nutrient Cycling)

CHANGES IN NITROGEN DEPOSITION ARE OBSERVED AT THE EXPERIMENTAL LAKES AREA: DOES INCREASED NITROGEN DEPOSITION ALTER THE ^{15}N IN LAKES?

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Nitrogen deposition at the Experimental Lakes Area (ELA) has doubled in the last 40 years. Intensification of Manitoba agriculture (700% increase in swine and 640% increase in fertilizer application), west and up-wind of ELA, co-occurred with large increases in ammonium deposition. ELA is no longer among the low-nitrogen deposition sites in North America. Two years of precipitation sampling indicates a very large range in the ^{15}N of ammonium (19‰ range), nitrate (5‰), and total nitrogen (11‰) in precipitation. Few other ^{15}N of nitrate and ammonia values have been published for Canadian precipitation. Total nitrogen, primary inorganic nitrogen in ELA precipitation, followed the ^{15}N increases of ammonium and nitrate and peaked in late July. These values will be compared to precipitation collected in 1994–1995. The wide range of ^{15}N values in ELA precipitation mean that studies characterizing nitrogen inputs to watersheds require a comprehensive annual sampling regime. The atmospheric values will be compared to ^{15}N-POM from different lake at ELA. Recently published trends of nitrogen deposition in lake sediments suggest that global trends of declining ^{15}N of nitrogen deposition are evident in the lake sediment record of western and northern North America.

Poster SCL (Experimental Lakes Area Research)

WHAT IS HAPPENING TO WILD SALMON IN YOUR COMMUNITY?

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The Canadian Okanagan Basin Technical Working Group (COBTWG) is a tri-partite working group that deals with technical issues associated with management of salmon and the associated habitat requirements. COBTWG members include the Fisheries and Oceans Canada, Okanagan Nation Alliance Fisheries Department, and the B.C. Ministry of Forests, Lands, and Natural Resource Operations. The main initiatives include the Re-introduction of Sockeye Salmon into Skaha Lake**,** a 12-year experiment to reintroduce and re-establish the indigenous sockeye salmon back into their historic habitat in Skaha Lake. This project reaches to stabilize and rebuild the declining wild Okanagan Sockeye population, to return sockeye to their former habitat and migration range, and to revitalize the Okanagan Nation salmon fishery. Other habitat works include the Okanagan River Restoration Initiative (ORRI), which has re-naturalized a section of one of the most biologically important sections of the Okanagan River. This project has now commenced phase II and will reconnect other oxbows and natural sections of the river to continue the ecosystem based approach to habitat restoration. Also, one of the innovative projects under the purview of COBTWG has been the implementation of the The Fish Water Management Tool (FWMT). FWMT is a computer model developed specifically to help authorities manage water flows in the Okanagan River in a "fish friendly" manner. The model uses real time field data to make predictions and decisions which benefit kokanee and sockeye salmon while respecting the needs of other water users.

Poster CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

THERMAL INFLUENCES ON LIFE-HISTORY TRAITS OF NON-NATIVE PUMPKINSEED (*LEPOMIS GIBBOSUS*)

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Pumpkinseed populations exhibit more 'opportunistic' life history traits (earlier maturity, smaller size at maturity, higher reproductive allocation) in their introduced European range than in their native North American range. To evaluate the influence of thermal regime on these life history differences and to assess how established non-native species will respond to predicted warmer climatic conditions, we used a two-tier approach involving thermal and life history comparisons: (1) between 90 North American and European populations, and (2) among 11 populations in the Moselle River Basin (northeastern France) from waterbodies with different thermal regimes. Within continents, mean age at maturity of a population was negatively related to the juvenile growth rate as well as air temperature degree-days, whereas mean length at maturity and gonadosomatic index of a population was not significantly correlated with either juvenile growth rate or temperature degree-days on either continent. European pumpkinseed populations mature earlier than North American populations even when juvenile growth and temperature are accounted for, whereas these differences were better explained by differences in piscivore

communities and the absence of congeneric competitors in Europe. In the Moselle River Basin, populations in warmer waters were characterised by faster juvenile growth, precocial maturity and elevated reproductive effort. These findings suggest that the more opportunistic life history traits of non-native Pumpkinseed are the result of broad-scale biotic differences between North American and European continents, but that global warming will accelerate the expression of opportunistic traits and result in increased range expansion of the Pumpkinseed in Europe.

Oral CCFFR (Climate Change)

REGIONAL DISPERSAL INFLUENCES ZOOPLANKTON COMMUNITY RESPONSE TO DREISSENA POLYMORPHA INVASION

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Aquatic systems are becoming increasingly susceptible to invasive species whereby local species are reduced in abundance or richness resulting in changes in trophic dynamics. Regional dispersal may provide a natural mechanism to increase local resistance by providing a diversity of locally-adapted species and genotypes to colonize affected communities. This study examined how dispersal could potentially mitigate the effects of the invasive zebra mussel, *Dreissena polymorpha,* on zooplankton community total abundance, species richness and overall diversity. Field experiments were conducted in 20 large cattle tanks using a 2x2 factorial design with five replicates to observe zooplankton community response to (1) the presence and absence of zebra mussels, and (2) the presence and absence of regional disperser zooplankton. All mussels were cleaned and sorted by size, then placed on elevated mesh supports in each tank. Live regional zooplankton, from six surrounding lakes, were added fortnightly to dispersal treatments, while heat-killed zooplankton were added to no-dispersal treatments. All tanks were sampled for chlorophyll a and a 9-L zooplankton community sample prior to the dispersal addition. The effect of zebra mussels depended on the taxonomic group; cladoceran richness and abundance decreased but copepod richness increased in the presence of zebra mussels. Dispersal did not affect cladoceran community structure. However, dispersal influenced the effect of zebra mussels on rotifers, decreasing richness in the presence of zebra mussels and decreasing abundance in the absence of zebra mussels. This suggests that metacommunity dynamics may influence community response to zebra mussel invasion but the effect is taxon-dependent.

Poster SCL (Invasive Species)

PERSPECTIVES ON RECENTLY REVISED POLICIES TO MANAGE GREAT LAKES FISHERIES IN THE FACE OF UNPRECEDENTED UNCERTAINTY

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Scientists today use a variety of tools, including field and laboratory experiments, long-term monitoring and modeling to predict response of fish populations to environmental and fishery management actions. Such predictions are especially challenging in this day and age of overlapping and often interacting factors, including the continual invasion and establishment of exotic nuisance species, effects of climate change, resurgence of eutrophication, and topsy-turvy changes in Great Lakes fish populations. On the policy side in the face of such uncertainty, there has been a renewed interest in the Great Lakes and other ecologically and economically important marine and freshwater resources around the world in the ecosystem approach, or as more commonly coined today, ecosystem-based management (EBM). This paper will discuss recently revised policy instruments in the Great Lakes in light of EBM and the realities of uncertainty. Emphasis will be on the Great Lakes Water Quality Agreement as revised by the 2012 Protocol, the most recent revision of the Canada-Ontario Agreement Respecting the Great Lakes Basin (COA) and the Canada Fisheries Act, specifically changes evoked by passage in spring, 2012 of the omnibus budget bill (C-38).

Invited Oral CCFFR (Great Lakes Fisheries and Environmental Policies)

SHALLOW WATER BATHYMETRY AND AUBMERGED AQUATIC VEGETATION DISTRIBUTION IN PENETANG BAY, LAKE HURON, ON: DEMONSTRATION OF A REMOTELY OPERATED VESSEL FOR ENVIRONMENTAL RESEARCH (ROVER)

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Lake margins are especially sensitive to coastal alteration by human activity. Yet, limited technology exists to survey shallow waters. We developed the remotely operated ROVER to collect high-resolution (HR) bathymetric data and assess submerged aquatic vegetation (SAV) distribution and biomass. Penetang Bay is a former Area of Concern (AOC) with a complex shoreline, organic substrates, and dense macrophyte beds. ROVER uses real-time differential GPS, a recording depth sounder, and shallow-water scanning sonar to collect real-time georeferenced bathymetric and epibenthic information. Transects were were taken 200 m (perpendicular to shore) from sites around the bay to capture changes in submerged plant distribution from offshore to nearshore sites. Petite Ponar grabs were taken to assess substrate and, where possible, 1 x 1-m quadrats were sampled for vegetation cover and identification. Data collected in 2011 were supplemented with sidescan sonar data, while 2012 data were supplemented with georeferenced
Underwater video. ROVER operated in water depths unsuitable for most watercraft, and collected bathymetric data even where SAV densities were high. Comparison of the 200 kHz and downscan data (455 kHz) allowed us to map both mineral substrate depth and the upper surface of SAV. Mapping SAV distribution, volume and density describes the distribution of aquatic

habitats important to fish and invertebrates, can identify nutrient loading sources, and provides fundamental data for quantifying ecosystem services.

Poster CSWS (Wetland and Land/Water Linkages)

GREAT LAKES COASTAL WETLAND MONITORING PROJECT: PROGRESS REPORT FOR CANADA

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The Great Lakes Coastal Wetland Monitoring (CWM) project is a bi-national, multi-institution effort funded by the US Environmental Protection Agency as part of the Great Lakes Restoration Initiative. Using a stratified-random selection technique, the purpose of the five-year project is to conduct status and trend ecological assessments of all coastal wetlands (meeting certain *a priori* criteria) on the Great Lakes shorelines, using a suite of Indices of Biotic Integrity for fish, macroinvertebrate, plant, bird, and amphibian communities. Now entering the third year, the work is on schedule on both sides of the border, and approximately 40% of over 1,200 candidate wetlands have been sampled, with most data having been enumerated and summarized. The large quantity of data collected includes significant range extensions of some Canadian Species-At-Risk, aquatic invasive species, and species categorized as rare or sensitive in the US. We will summarize selected species ranges and provide an overall synopsis of the project's efforts to date, with particular emphasis on the Canadian shores.

Poster CSWS (Wetland and Land/Water Linkages)

PHYLOGEOGRAPHY OF THE INVASIVE CTENOPHORE *MNEMIOPSIS LEIDYI* IN EURASIA

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The introduction and spread of non-indigenous species (NIS) in marine ecosystems accelerated during the 20th century owing to human activities, notably international shipping. Genetic analysis has proven useful in understanding the invasion history and dynamics of colonizing NIS, and for identifying source population(s). Here we investigated sequence variation in the nuclear ribosomal Internal Transcribed Spacer (ITS) region of the ctenophore *Mnemiopsis leidyi*, a species considered as one of the most invasive globally. We surveyed five populations from the native distribution range along the Atlantic coast of the United States and South America, and ten populations in the introduced range from the Black, Azov, Caspian, Baltic, and the Mediterranean Seas. Allelic and nucleotide diversity of introduced populations were comparable

to those of native populations from which they were likely drawn. Introduced populations typically exhibited less genetic differentiation (lower F_{st} values) than native populations. Populations genetic analysis supported the invasion of Eurasia from at least two different pathways, the first from the Gulf of Mexico (e.g. Tampa Bay) to the Black Sea and thence to the Caspian Sea, the second from the northern part of the distribution range (e.g. Narragansett Bay) to the Baltic Sea. The relatively high genetic diversity observed in introduced populations is consistent with large inocula and/or multiple invasions, both of which are possible given ballast water transport and the extensive native distribution of the ctenophore in the Atlantic Ocean.

Oral CCFFR (Invasive Species)

THERMOCLINE INDUCED MIXING EXPERIMENT (TIMEX): THE EFFECTS OF THERMOCLINE DEEPENING ON FISH COMMUNITY AND TROPHIC ECOLOGY

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A SolarBee® lake mixer was used to experimentally deepen the thermocline of one basin in a small (19ha) three basin lake (Lake Croche) to investigate the effects of changing wind speed and other climatic factors on fish habitat use and trophic interactions. Lac Croche, a high DOC lake, contains a small reproducing lake trout population but has an anoxic hypolimnion even before the manipulation. After the installation of the lake mixer thermocline depth set up at 4, 6, and 8m across the three basins during the summer of 2009 and 2010. In the spring of 2011 the mixer was removed to allow for natural stratification across all basins to occur at 4m depth. In 2009 (thermocline deepening) and 2011 (no thermocline deepening) depth stratified sampling procedures (Nordic Index Netting) was used to assess effects on fish population between basins. Fish community abundance increased with thermocline depth, well biomass remained unchanged. Stable isotope ($\delta^{13}C$) analysis showed that creek chub and biofilm scraping mayflies exhibited differences in trophic dimensions represented by depletion of $\delta^{13}C$, across basins during all study years. This may suggest the observed differences in trophic ecology among treatment basins maybe related to differences in internal lake processes such as microbial respiration and increased CO_2 content rather than dietary changes. Stable isotopes analysis of nitrogen ($\delta^{15}N$) rather displayed a year effect across all basins, where annual warm air temperatures related to higher $\delta^{15}N$ values in brown bullhead and mayflies.

Poster CCFFR (Climate Change)

THE EFFECT OF DREISSENIDS ON DENSITY-DEPENDENT GROWTH AND RECRUITMENT OF LAKE HURON LAKE WHITEFISH

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Lake whitefish constitute an important resource in the Laurentian Great Lakes as its largest and most valuable commercial fishery. While Lake Huron lake whitefish catches have been extremely high since the mid-1990's, individual growth and condition of lake whitefish in Lake Huron, among other Great Lakes, have decreased drastically. These declines are concerning as similar decreases in growth and condition preceded, and may have contributed to, the collapse of fisheries in the past. Observed declines in growth and condition have mainly been attributed to changes in lake whitefish diet with the introduction of dreissenids and the subsequent loss of Diporeia. We hypothesize that the dramatic changes that have taken place have also affected key density-dependent relationships in lake whitefish populations, which can influence population dynamics and in turn fisheries yield. We used growth data from annual surveys and population estimates from the current stock assessment model for lake whitefish from southern Lake Huron to compare density-dependent growth and stock-recruitment relationships before and after dreissenid establishment. While we found a clear relationship between growth and density prior to dreissenid establishment, no such relationship was apparent post-establishment. The nature of the relationship between mature biomass and recruitment also changed through time, with recruitment in recent years being half to one-third of what it was prior to dreissenid establishment, despite biomasses of parental stocks being comparable. Given the important role that density-dependence can play in population regulation, these observed changes in density-dependent growth and recruitment should be of particular interest to managers.

Poster CCFFR (Great Lakes Fisheries and Environmental Policies)

BEHAVIOURAL RESPONSES OF DAPHNIA TO NATIVE AND EXOTIC PREDATORS

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Predation in freshwater systems is well recognized as an important mechanism in structuring zooplankton communities and has resulted in many adaptations among zooplankton prey. *Daphnia* in particular have been shown to exhibit a wide range of adaptions to predation, including diel vertical migration. The introduction of *Bythotrephes longimanus*, an exotic predatory cladoceran, to inland lakes of the Canadian Shield provides an opportunity to explore the potential for adaptive responses by *Daphnia* to a novel predator. We conducted a series of lab experiments to examine the migration response of *Daphnia* when exposed to kairomone cues from different predator types. More specifically, we determined the mean vertical distribution of *Daphnia* from two *Bythotrephes*-invaded lakes and one uninvaded lake in the presence of a ubiquitous native predator (*Chaoborus* spp), a novel exotic predator (*Bythotrephes*), as well as a planktivorous aquarium fish native to Southeast Asia (*Oryzias latipes* - medaka). *Daphnia* from two of our study lakes decreased their vertical position in the medaka treatment, suggesting that they are able to recognize kairomone cues from non-native planktivorous fish. *Daphnia* from our uninvaded lake also responded to *Bythotrephes* kairomone, suggesting some inherent ability to

recognize kairomone cues from novel predator types. Interestingly, *Daphnia* from one of the invaded lakes showed no response to any of the predators, suggesting that lake-specific factors are also important in determining the depth distribution of *Daphnia*. Overall, results from our study demonstrate that both native and exotic predators can induce behavioural responses in *Daphnia*, but the presence of a response may depend on lake-specific factors.

Oral CCFFR (Invasive Species)

FLEXIBILITY IN TERRITORY SIZE OF STREAM-DWELLING SALMONIDS: IMPLICATIONS FOR POPULATION REGULATION

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The degree to which territorial behaviour limits the number of individuals that settle in a habitat will depend on the flexibility of territory size to changes in key environmental variables. In a series of laboratory and field experiments, we manipulated 5 variables identified by optimal territory size models as being key predictors of territory size: population density, food abundance, habitat visibility, predation hazard, and the synchrony of arrival of competitors. A doubling of population density caused territory size to decrease by 50%, but further increases in density caused territory size to approach an asymptotic minimum size. Territory size was relatively insensitive to changes in food abundance, as a doubling in food caused only a 15% reduction in territory size. Adding boulders to a stream caused territories to shrink by 50% and the density of fish to double, whereas increasing the predation hazard of a stream section by adding conspecific alarm cues caused a 33% decrease in territory size. Territories were 15% smaller when fish arrived simultaneously rather than sequentially, but the difference was not significant. While all variables caused territory size to change in the direction predicted by optimal territory size models, the asymptotic minimum territory size would seem to limit the maximum density of fish that can settle in a habitat. Our results suggest that fisheries biologists interested in increasing the maximum carrying capacity of a stream should focus on increasing habitat structure rather than stream productivity.

Oral CCFFR (General Session)

INVESTIGATIONS OF GEAR MODIFICATIONS TO REDUCE THE BYCATCH OF GREENLAND SHARK IN THE CUMBERLAND SOUND GREENLAND HALIBUT LONGLINE FISHERY

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The Greenland Shark (*Somniosus microcephalus*) is captured incidentally in Greenland halibut (*Reinhardtius hippoglossoides*) longline fisheries prosecuted in Cumberland Sound. Life-history characteristics exhibited by sharks result in high vulnerability to overfishing and the Greenland Shark is listed as Near Threatened by the International Union for the Conservation of Nature and Natural Resources (IUCN). The current study investigated whether longline gear could be modified to reduce the bycatch of Greenland Shark without negatively influencing capture rates of Greenland halibut. Gear modifications tested were 1) an increase in gangion length and 2) the introduction of a commercially available hook (i.e., SMART hook) that incorporates electropositive metals and magnetic material that have been shown to act as deterrents to shark attacks and fishing gear depredation. The six Greenland Sharks captured during the SMART hook experiment were captured on SMART hooks or entangled in the SMART hook section/replicate of the experimental longline. These results indicate SMART hooks are not a practical solution for reducing the bycatch of Greenland Shark in the Cumberland Sound Turbot longline fishery. When longlines were configured with a greater gangion length compared to the typical configuration used in longline fisheries, there was not only an increase in the mean capture efficiency of Greenland halibut, expressed both as the number of fish/100 hooks and the number of fish/100 m of longline, but also a decrease in the bycatch of Greenland Shark. These results are encouraging, however additional studies are required.

Oral CCFFR (Disturbed Ecosystems, Threatened Species, and Restoration)

DISTRIBUTION OF WOLFFISH (*ANARCHICHAS SP.*) ON THE SOUTHERN GRAND BANK AND SURVIVAL OF ATLANTIC WOLFFISH (*A. LUPUS*) CAPTURED INCIDENTAILLY IN THE YELLOWTAIL FLOUNDER (*PLEURONECTES FERRUGINEA*) OTTER TRAWL FISHERY

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The spotted (*Anarhichas minor*) and northern wolffish (*A. denticulatus*) are designated as threatened by the Committee on the Status of Endangered Wildlife in Canada and the Atlantic wolffish (*A. lupus*) has been designated a species of special concern. All three species are taken as bycatch in Atlantic Canada and when catches are compared among gear types it is found the trawl represents the single largest threat to their recovery. Results of this study suggest the yellowtail flounder (*Pleuronectes ferruginea*) otter trawl fishery on the Newfoundland Grand Bank is unlikely to prevent the recovery of wolffish. This study corroborates Fisheries and Oceans Canada (DFO) research survey findings on the sparse and patchy distribution of spotted and northern wolffish on the southern Grand Bank, a condition that not only minimizes undetected mortality from gear encounters, but also post-capture mortality while directing for yellowtail flounder. This study confirmed the presence of concentrations of Atlantic wolffish in the southwestern region of the yellowtail flounder fishing grounds and hence their vulnerability to capture by otter trawl. However, this study also demonstrated high (92-100%) survival of

wolffish captured in 2-2.5 h commercial tows and following exposure to air for up to 2 h when the ocean surface and bottom temperature difference was within 5.8ºC and air temperatures were <13ºC. These temperature conditions typically prevail for about 70% of the fishing season. Thus, the mortality risk to Atlantic wolffish posed by the Grand Bank yellowtail flounder otter trawl fishery should be substantially reduced since the introduction of DFOs mandatory wolffish live release program.

Poster CCFFR (Disturbed Ecosystems, Threatened Species, and Restoration)

IMPACTS OF INTRODUCED TROUT ON ZOOPLANKTON COMMUNITIES OF MOUNTAIN LAKES: RESTORATION OR LAISSEZ FAIRE?

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The overarching goal of ecosystem restoration in national parks is to conserve ecological integrity, a reversal of historical stocking programs. In western North American parks, the concept has now prompted the removal of introduced trout populations from mountain lakes. This study compared the zooplankton communities (1) in 9 fishless and 10 fish-present lakes of Waterton Lakes National Park (Alberta, Canada), and (2) in sediments formed before and after stocking in 6 lakes. Zooplankton communities were sampled by horizontal tows from several points along the shore, and by extracting cladoceran microfossil remains from subsurface cores. Results indicated that introduced brook and cutthroat trout reduced densities of large, conspicuous zooplankton, but other taxa were unaffected. Multivariate analyses showed no meaningful differences in community structure between fish and fishless lakes. No obvious shifts in zooplankton composition were observed in paleolimnological analyses, but ordinations did show larger distances between pre and post-stocking communities in fish lakes than fishless lakes. Furthermore, only 17% of the variance in zooplankton composition was explained by the presence of fish. A further investigation of trout populations revealed significant variance across lakes in all life-history characteristics measured. The application of results to restoration goals instructed opposing actions: differences in the density of certain zooplankton taxa connote restoration, but the static community composition suggests that all native components are represented, rendering restoration unnecessary. In the case of restoration trout removal is facilitated by understanding variances in life-history traits.

Poster SCL (Disturbed Ecosystems, Threatened Species, and Restoration)

PHYLOGENETICS TO HELP PREDICTING FISH SWIMMING COSTS

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In this presentation we illustrate how to supplement predictive models of fish swimming costs with phylogenetic information. Swimming costs can be estimated using variables such as body mass and swimming speed. The parameters of the relationships between these variables and swimming costs vary among species, for instance as a consequence of each species' particular physiological and behavioural traits. It is now being acknowledged that traits are often structured by phylogeny. These phylogenetic structures arise as the traces of the processes that occurred during evolution. By applying new analytical approaches in is now possible to use these phylogenetic signals to improve models. The resulting models allows one to extend, to a larger set of species, empirical knowledge about traits that we only have for a limited number of species (*e.g.* trait whose values are expensive to obtain). Fish swimming costs are a substantial and often very variable components of fish energy budget. However, fish swimming costs are onerous to obtain and hence are only available for small number of species. That situation limits the scope of bioenergetic models to well-studied species. We propose an analytical framework whereby descriptor of swimming costs, namely body mass and swimming speed, are used together with phylogenetic eigenfunctions (a spectral decomposition methods adapted to phylogenetic signals) to predict fish swimming costs. Using that approach, we built a phylogenetically-explicit model explaining a substantial fraction of the variation of swimming costs ($R^2_{adj.} = 0.88$) observed for 12 fish species and three swimming costs estimation protocols.

Poster CCFFR (General Session)

SIZE-DEPENDENT DIEL AND SEASONAL PATTERNS OF DEPTH AND VERTICAL MOVEMENT IN A FRESHWATER PISCIVORE

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Much of the work examining mechanisms of diel vertical migrations is focused at the population level and on zooplankton and planktivorous fishes. There is little similar work that focuses on individuals or top-level predators, particularly fish. In the current study, we examine size-dependent patterns in the daily and seasonal depth distribution and vertical movement of adfluvial bull trout (Salvelinus confluentus). Acoustic transmitters equipped with pressure sensors were implanted into 187 bull trout that were released and monitored for one year in a large, temperate hydro-electric reservoir. The results showed a typical diel vertical movement (DVM) pattern where fish descended at dawn and ascended at dusk. The extent of DVM differed according to season and body size. During the winter, fish occupied moderate to deep water compared with other seasons and exhibited small changes in depth (mean = 3 m with a 60% probability of changing depth), especially at night. During the spring and compared to smaller conspecifics, the largest fish made significantly greater depth changes during the day, whereas

during the night, depth changes (~ 3m) did not vary with body size. In the summer, small bull trout remained at greater depths (~ 15 m) than larger fish (~7 m) regardless of diel period. Furthermore the likelihood of depth changes was significantly higher for small fish than large ones, especially at night. Bull trout displayed size-dependent DVM patterns in autumn similar to those of the summer, but remained at generally shallower depths. Mechanisms responsible for the observed DVM behaviors are hypothesized to be related to the distribution of light and prey, competition, and to a lesser extent, thermoregulation.

Oral CCFFR (General Session)

HABITAT USE OF PREDATORY FISH SPECIES IN A NORTHERN BOREAL LAKE

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Northern Canada is experiencing a number of changes, including rapid climate change and increased industrial exploitation, threatening its pristine freshwater ecosystems. However, there is little information describing the habitat use by top predatory fishes in these systems, making it difficult to monitor and predict potential effects of climate and human induced disturbances on fish populations. We initiated a whole-lake assessment of habitat use of three predatory fish species; lake trout (*Salvelinus namaycush*), northern pike (*Esox lucius*) and burbot (*Lota lota)* in a northern lake using passive acoustic telemetry. Alexie Lake, located ~30km north-east of Yellowknife, Northwest Territories (NWT) is 420 ha, with maximum depth of 32 m, has food web structure typical of many northern lakes, and is closed to fishing, making results of this study transferable to other northern systems. We deployed an acoustic telemetry positioning system consisting of 73 receivers, and surgically implanted pressure sensitive acoustic tags into 30 lake trout, 10 pike, and 4 burbot. This system provides near full lake coverage of the movements of tagged fish. Detailed bathymetric mapping was conducted to relate fish movements with habitat use. We present preliminary results (June-September 2012) describing fish behaviour in relation to habitat conditions and relate potential habitat overlap of predatory fish species to feeding overlap inferred from stable isotope population metrics.

Poster CCFFR (General Session)

CLIMATE INDUCED EFFECTS ON LAKE TROUT (*SALVELINUS NAMAYCUSH*) AT THE EXPERIMENTAL LAKES AREA, NORTHWESTERN ONTARIO, CANADA

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Climate change has the potential to reduce the amount of cold, well-oxygenated water available to fish in temperate lakes, especially during summer stratification. The volume of habitat available to cold water fish species, like lake trout (*Salvelinus namaycush*), reaches a minimum at the peak of stratification when fish become constrained to areas of the lake bounded between upper and lower physiological tolerance limits set by water temperature (<15°C) and dissolved oxygen concentrations (>6mg/L). As such, lake trout are extremely vulnerable to reductions in cold-water habitat from thermocline deepening resulting from increasing air temperatures. This is especially critical for lakes without pelagic prey fish species, where lake trout are forced to forage in thermally sub-optimal, littoral regions of the lake to access prey fish. In this study, we examine the behavioural and population-level responses of lake trout to climate-mediated changes in preferred habitat availability from a reference lake at the Experimental Lakes Area (ELA) in northwestern Ontario, Canada. The size-structure, age, condition, growth, recruitment and abundance (Jolly-Seber mark-recapture models) of this population have been monitored annually for ~26 years. In addition, for the past 11 years we have been monitoring the spatial and pelagic distribution of lake trout using acoustic telemetry. In this study, we use 11 years of telemetry data to quantify changes in the pelagic distribution and littoral habitat use of lake trout in response to variation in climate variables (e.g., air temperature, date of ice break up and onset of stratification). We predict that altered access to littoral forage fish will be manifested through changes in population traits, such as decreased fish growth and condition.

Oral CCFFR (Experimental Lakes Area Research)

THE DYNAMIC RESERVOIR SIMULATION MODEL (DYRESM): 35 YEARS OF PHYSICAL LIMNOLOGICAL CHANGE IN HARP LAKE, ONTARIO

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Freshwater ecological issues in Canada are now, more than ever, recognized as multiple stressor issues. As meteorological and hydrological conditions are altered by climate change, so too may the physical properties of lakes. To effectively manage lakes in a warming world, an improved understanding of the effects of climate change on lake thermal regime is essential, particularly as biological communities (e.g. algae) are known to be affected by these changes. We used the Dynamic Reservoir Simulation Model (DYRESM), a one-dimensional vertical heat transfer and mixing model, to hindcast and compare lake depth temperature profiles against ~35 years of long-term monitoring data in Harp Lake, Ontario. These temperature profiles were then used to calculate annual thermal stability values since 1977. Comparisons between measured and modelled lake water temperature data for three calibration years showed strong agreement (R^2 = 0.90-0.98). We hypothesize that, in response to increased air temperature, decreased wind and a longer ice-free season over the past several decades in south-central Ontario, both water

temperature and thermal stability have increased in Harp Lake since 1979. Furthermore, given predictions of continued warming in the region, these trends are likely to continue, with unknown consequences for biological communities.

Poster SCL (Climate Change)

HOW CAN LIFE HISTORY ATTRIBUTES OF LAKE TROUT FROM LAKE MISTASSINI, QUEBEC INFORM RECOVERY PLANS FOR LAKE TROUT IN THE LAURENTIAN GREAT LAKES?

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Lake trout *Salvelinus namaycush* collapsed to near extinction in the Laurentian Great Lakes before life history attributes could be described for the numerous forms present. Consequently, recovery plans lack targets for restoration that are based on observations of life history characteristics prior to stock collapse. Therefore, we are studying life history attributes of lake trout in unexploited systems elsewhere in North America. For example, we compared life history characteristics (age, growth, survival, and maturity) between deep-water humper and shallow-water lean forms of lake trout in Lake Mistassini, Quebec, to determine if the two morphotypes may represent resource polymorphism. Lake trout were sampled using graded-mesh (range 51–114 mm stretch) gillnets set in deep and shallow waters. Humpers, typically caught in deep waters > 50 m, averaged 474 mm in total length (range = 389–616 mm) and 852 g in weight (range = 470–1,710 g), whereas leans, typically caught in shallow waters < 50 m, averaged 525 mm in total length (range = 301–865 mm) and 1,210 g in weight (range = 200–6,500 g). Humpers and leans did not differ in weight-length relationships and grew slimmer with length over a common length range (389–616 mm). Humpers averaged 27 years old and ranged 13–49 years. Leans averaged 21 years old and ranged 6–42 years. The two forms did not differ in total annual mortality of fish older than 17 years, the first age beyond which numbers declined with age for both morphs (A = 5.1%; 95% CI = 2.4–7.8%). Humpers grew slower (ω = 53 mm/year) than leans (ω = 68 mm/year) to a shorter mean asymptotic length (L_∞ = 514 mm) than leans (L_∞ = 605 mm). Mature humpers were shorter on average (475 mm; SE = 9.0 mm; N = 58) than mature leans (length = 539 mm, SE = 8.5 mm, N = 65), and were also older on average (27 years; SE = 1.0 years; N = 56) than mature leans (age = 23 years, SE = 0.98 years, N = 61). We conclude that lean and humper forms of lake trout in Lake Mistassini differed in age, growth, and maturity, which is consistent with resource polymorphism that has been observed for other lake trout populations and char species. Studies of other lake trout forms from other lakes in North America are being pursued to further develop understanding of unexploited populations for use in recovery plans for lake trout in the Laurentian Great Lakes.

Invited Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

MATERNAL EGG PROVISIONING IN WILD AND HATCHERY ORIGIN CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA)*

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Maternal influences on offspring phenotypes play a significant role in swaying an individual's life history traits. The maternal environment plays an important role to the offspring, and may ultimately influence the size of the eggs and what is allocated to the young. Selection will favour egg traits that maximize survival, and although these traits may be advantageous in one environment, they may be maladaptive elsewhere. This is an important concept to consider in hatchery supplementation programs, where hatchery-reared fish are released into the wild to help augment native populations. Generally it is found that hatchery reared salmon do not do as well when in the wild, and little is known of how differences in egg provisioning and egg traits may contribute to survival. The objective of this study is to analyse egg traits among wild- and hatchery-origin Chinook salmon (*Oncorhynchus tshawytscha)*. Eggs were collected from both wild- and hatchery-origin salmon spawning in the Credit River, which drains into Lake Ontario. A variety of eggs components will be analysed including egg size, energetic factors, and carotenoids. We predict that the egg quality of hatchery-reared salmon will be substandard when compared to wild salmon population. The divergence of hatchery fish in traits influencing egg quality may be detrimental, thus the results from this study can be beneficial in future supplementation and rehabilitation efforts, where the survival of the species is vital.

Oral CCFFR (General Session)

HABITUATION AND WHITE MUSCLE ANAEROBIC CAPACITY OF FISH EXPERIENCING DAILY FLOW FLUCTUATIONS

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A field study on consequences of chronic flow increments on fish physiological stress response and anaerobic metabolism has been conducted in a context of natural flow regime alteration. The level of habituation to a sudden increase in flow velocity has been assessed in a comparative study on Northern pikes (*Esox lucius*). Besides, to ensure that differences that could be seen in the degree of habituation were not due to an impaired stress response, an experiment on the degree of stress response and muscular fatigue after a standardized angling procedure has been conducted. The study took place in a hydro-peaking river, where events of massive and

unpredictable flow discharge happen daily. A total of 58 fish were caught in Mississagi River, regulated, and Aubinadong River, unregulated, both situated in Northern Ontario. Glucose and lactate have been quantified on both experiments. Results show that the acute stress response and the muscular anaerobic capacities are not impaired by a fluctuating flow environment in wild fish. On the other hand, the blood lactate concentrations of fish subjected to a fast increase in flow velocity were significantly higher in individuals living in the unregulated river. Fish from both rivers were not experiencing different blood glucose concentrations after a flow increase. These experiments tend to show that an increase in flow velocity stressed the fish the same way, independently of the river in which they live. The muscular fatigue, however, seems to be lower in fish habituated to a frequent increase in river flow.

Oral CCFFR (General Session)

FACTORS INFLUENCING THE THERMAL RESPONSE OF NORTH AMERICAN FRESHWATER FISH

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Habitat temperature is a major determinant of performance and activity in fish. We examined the relationship between six temperature metrics describing the growth (optimal growth temperature and final temperature preferendum), survival (upper incipient lethal temperature and critical thermal maximum), and reproduction (optimum spawning temperature and optimum egg development temperature) requirements for 173 North American freshwater fish species. The results showed that all metrics were highly correlated, especially those within each life process. Values for different metrics fell into distinct groups that were associated with reported thermal preference classes, reproductive guilds, and spawning season. Controlling the effect of phylogeny resulted in an overall decline in correlation strength, varying with life process. These results suggest that shared evolutionary history plays an important role in determining species thermal response to their environment.

Oral CCFFR (Climate Change)

MANAGING THE COMMERCIAL FISHERY OF THE GREAT LAKES IN TIMES OF UNCERTAINTY

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The commercial fish industry on the Great Lakes is one of the largest freshwater fisheries in the world. It employs approximately 3,500 people across the province in harvesting, processing and related activities. The amount of fish harvested ranges from 27 to 35 million pounds per year. The landed value of commercially caught fish in Ontario is approximately $33 million annually while the value of processed shipments is approximately $200 million annually. Management of the fishery has become increasing complex due to changing conditions including lake ecology (invasive species, nutrients, algal blooms, climate change), fish populations and dynamics, economics (markets, import/export potential, government budget reductions) and stakeholder expectations (increased involvement, transparency). For example, Lake Huron has undergone what has been referred to as a near shore or benthic shunt resulting in a concentration of nutrients in the near shore areas and the oligotrophication of offshore waters. Lake Erie on the other hand, has experienced extensive blue green algal blooms in the western and central basins. Dealing with these changes requires modifying ecosystem monitoring, updating population modeling techniques and inputs, streamlining of government programs and approvals, and stakeholder engagement. Ontario's commercial fishing industry is guided by the Ontario Commercial Fisheries Association who also provides assistance with managing the resource. They too, are facing challenging times due to uncertainty related to quotas, market value and consumer expectations with regards to eco-certification and traceability.

Invited Oral CCFFR (Great Lakes Fisheries and Environmental Policies)

COMPARISON OF LAKES RECOVERING FROM ACIDIFICATION FROM MINE TAILINGS AND LAKES RECOVERING FROM THE EFFECTS OF ACID PRECIPITATION

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Acid precipitation, caused by emissions from smelting operations that began over a century ago, acidified more than 7,000 lakes in the area around Sudbury, Ontario, Canada. Many lakes in close proximity to the smelters also exhibited elevated levels of metals. Following the imposition of emission reduction measures in the 1970s and 1990s, many of these lakes have experienced chemical and biological recovery. Northwest of Sudbury, the Serpent River watershed was the site of intensive uranium mining activity beginning in the 1950s. Poor mine tailing management caused acidification and other contamination, leading to biological impairment in downstream lakes. Regulated improvements in the management of the uranium mine tailings were implemented in the 1980s and the contaminated lakes in the watershed have since been recovering. In this study, we assembled historical chemistry data for recovering lakes in the Serpent River watershed. Zooplankton and water chemistry samples from both recovering and reference lakes were also collected during the summer of 2012. Results were compared with those from recovering lakes in the Sudbury area.

Poster SCL (Disturbed Ecosystems, Threatened Species and Restoration)

CLIMATE EFFECTS ON BOREAL LAKES: FORTY PLUS YEARS OF ECOSYSTEM MONITORING AT THE EXPERIMENTAL LAKES AREA (ELA)

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The LTER program of the ELA has monitored meteorology, hydrology, chemistry, and aquatic biota (phytoplankton to fish) from the late 1960's to present. Over the 40+ year record mean annual air temperatures have increased by 1.8 deg C, annual heat budgets have increased, the ice-free period has increased by 16.6 days, and total annual precipitation has oscillated from high (early 1970's; 800-1000mm) to low (mid 1970's to 2000; 500-700mm) to high (2000 to present; 650-1000mm) values. Variations in precipitation appear as an important driver of DOC concentrations, water clarity, and phytoplankton (biomass, community structure). The timing of spring phytoplankton and zooplankton peaks became increasingly mismatched during years with early ice-off. Mean size of individual YOY perch caught during the autumn was correlated with degree-days, suggesting higher overwintering success following years with longer ice-free seasons. In contrast, declines in Lake Trout condition and size-at-age over the long-term record appear to have resulted from declines in optimal thermal habitat.

Oral SCL (Experimental Lakes Area Research)

MOVEMENT AND SURVIVAL OF OUT-MIGRATING FRASER RIVER SOCKEYE SALMON SMOLTS IN FRESHWATER AND MARINE ENVIRONMENTS

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We used a large-scale acoustic telemetry array to estimate for the first time survival and movement rates of wild sockeye salmon smolts during out-migration from freshwater rearing areas towards and in the coastal Pacific Ocean. Smolts were surgically implanted prior to release with a uniquely coded acoustic transmitter and tracked with a network of individual acoustic sensors positioned within the Fraser River watershed and along coastal areas. From 2010-2012 in April and May, ~ 1,400 smolts from Chilko Lake, the highest elevation (> 1 km) sockeye population in the Fraser system situated 660 km from the ocean, were tagged and released. Chilko smolts migrated swiftly out of freshwater, completing the 660 km migration in ~ 8 days. Total freshwater mortality was 70-80% with most occurring within the first 200 km. This elevated mortality was not related to tagging effects. In all years downstream movement only occurred at night in the clear water regions immediately downstream of release, suggesting anti-

predator behaviour, but occurred at all times of day in more turbid waters further downstream. Smolts transported ~100 km downstream had twice the survival to the Fraser River mouth. Marine migration was steady but slower, and uniform diurnally, taking ~ 30 days to transit 390 km to final marine acoustic sensors; marine mortality was 40-50%. The relatively high freshwater mortality was unexpected and revealed the critical importance of this brief migratory phase to wild salmon populations.

Invited Oral CCFFR (Migration, Mixing and Dispersal)

CAN PHYTOPLANKTON PHOTOSYNTHETIC HEALTH ASSESSMENTS PROVIDE MEANINGFUL INSIGHT TO RESEARCH AND MONITORING EFFORTS IN A EUTROPHIC EMBAYMENT?

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Hamilton Harbour, a eutrophic embayment in the western end of Lake Ontario, is a designated Area of Concern since 1987. The harbour typically boasts total phosphorus (TP) concentrations over 30 μg/L, and over the last decade it has seen repeated cyanobacteria blooms during the growing season. The purpose of this study was to determine whether assays of phytoplankton photosynthetic health could 1) be related to measured environmental conditions; 2) provide information on light vs nutrient limitation; and 3) provide insight into possible environmental triggers that lead to cyanobacterial dominance in the harbour. Preliminary analysis suggests that the time of day a sample is collected has a large influence on photosynthetic health assessments and likely its interpretation in the larger context and that pulse amplitude modulation (PAM) fluorescence is largely driven by light conditions. We will present data from deployed instrumentation (phytoflash, Hobos) and weekly field sampling (profiles, nutrients and WaterPAM) in an effort to evaluate whether our physiological markers are related to phytoplankton nutrient status indicators, whether these data can provide meaningful insight on the response of phytoplankton to dynamic environmental conditions and whether triggers for cyanobacterial dominance can be proposed.

Poster SCL (Multiple Stressors)

LAKE STURGEON MIGRATION IN THE DETROIT-ST. CLAIR RIVER SYSTEM: PRELIMINARY RESULTS FROM AN ACOUSTIC TELEMETRY STUDY

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Early in 2012, the Great Lakes Fishery Commission in conjunction with federal, state, and provincial partners initiated a study of the spatial structure of lake sturgeon populations that spawn in the Detroit-St. Clair River system to provide information on habitat use by different populations as well as on population-scale movements and dispersal patterns at ecologically-relevant temporal scales. From April to early June 2012, spawning-condition adult lake sturgeon were captured in the Detroit River, lower St. Clair River, and upper St. Clair River, implanted with high-power acoustic tags with a battery life of 10 years, and then released near the capture site. Sturgeon movements between spawning, overwintering, and feeding grounds were then tracked using a network of strategically-located acoustic receivers. The goals of our presentation are 1) to communicate the goals, objectives, and expected results of this new project, and 2) to present preliminary results regarding the objective of "to determine whether dispersal of spawning-condition lake sturgeon in the Detroit and St. Clair rivers depends on release site".

Invited Oral (Migration Mixing and Dispersal)

PERMAFROST THAW SLUMP EFFECTS ON TUNDRA LAKE LIMNOLOGY AND Hg CYCLING IN A WARMING ARCTIC

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Accelerated warming in Canada's western arctic has led to increased tundra lake thermokarst activity, resulting in catastrophic collapse of thawing shorelines, via retrogressive thaw slumping, east of the Mackenzie Delta, Inuvik, NT. The influx of thaw slump melt-waters causes dramatic physico-chemical increases in lake water clarity and ionic strength, associated with lower dissolved organic carbon concentrations (DOC). This is contrary to reported DOC increases in other thermokarst lake-rich regions experiencing warming environments, also having implications for enhancing Hg bioavailability. We aim to describe limnological drivers affecting primary production and mercury mobilization, bioaccumulation, and fate, in tundra lakes affected by thaw slumps. Through a paired-lake study design of thaw slump-affected lakes and undisturbed reference lakes, we demonstrate that thaw slump events are the dominant agents of change in this region. Soil analyses indicated that slump scars contribute lower Hg than the surrounding catchment, highlighting the reduced catchment input to lakes. Water column macronutrients (N and P), phytoplankton production (Chl-*a*), and Hg, are also reduced proportionately to the scale of thermokarst degradation. Results also suggest that Hg bioavailability is also reduced as methyl Hg concentrations are also lower in lakes with greater thaw slump activity. Ongoing research will further elucidate the net balance of these Hg sources and fates to ultimately determine the toxicological impacts of thaw slumps on freshwater foodwebs. With estimates of up to 7 million square kilometres of permafrost thaw over the next century, the delineation of net Hg toxicity in thaw slump-affected tundra lakes will become increasingly important.

Oral SCL (Contaminants and Trophic Transfer)

RESOURCE POLYMORPHISM AND DIVERGENCE OF CISCO IN GREAT BEAR LAKE, NORTHWEST TERRITORRIES

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Historical reports indicate that more than one form of cisco may occur in Great Bear Lake; these include *Coregonus artedi* and possibly *C. sardinella*. More recent depth stratified sampling of cisco concurs with earlier studies and includes what may be two or more forms or species. Cisco captured in deeper waters of Great Bear Lake showed characteristics that are consistent with those described for shortjaw cisco (*C. zenithicus*) including shorter, fewer and more widely spaced gillrakers, lighter paired fins and a diet consisting mainly of *Mysis relicta*. Other characteristics such as longer paired fins and greater body depth were not consistent with *C. zeniticus*, but are often associated with adaptation to vertically migrating in deeper water and have been noted in other deepwater coreginids such as *Coregonus kiyi*. Deepwater cisco were found to differ in their life history traits, being smaller, later maturing and slower growing than their shallow water counterparts. In addition to variation by depth, we also observed consistent variation among geographically separated populations within deep and shallow water types, suggesting reproductive isolation and parallel evolution of these morphotypes within individual lake arms. With the exception of Great Bear Lake, *C. zenithicus* or a *C. zenthicus*-like form of cisco has been reported from most of the remnant proglacial Great Lakes in North America running from the Laurentian Great Lakes northwest to Great Slave Lake. Thus our findings may represent a northern range extension for this particular form or species and certainly represents the first comprehensive account of distinct cisco morphotypes within Great Bear Lake.

Oral CCFFR (Genetic Diversity and Adaptation)

SHIFTS IN SPECIES COMPOSITION AT MAJOR ARCTIC PORTS: INTRODUCTIONS, CLIMATE CHANGE OR INCREASED SURVEY EFFORT?

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Although most aquatic invasive species (AIS) introductions have occurred in temperate latitudes where there is the greatest shipping activity, the combination of global warming, resource exploitation and the resulting increase in Arctic shipping activity are expected to increase the risk

of AIS introductions to Arctic waters in the near future. Given that Canada has the longest coastline in the world, the majority of which is located in Arctic waters, this region is at high risk. At least 10 AIS have been reported from Arctic and sub-Arctic waters outside of Canada, while up to 207 AIS have been reported from Antarctic and sub-Antarctic waters. There have been no reported ship-mediated AIS in Arctic Canadian waters to date, however few systematic surveys have been conducted in this region of the country making it problematic in determining if newly reported species are native or introduced. This knowledge gap is now being addressed through surveys of estuarine and coastal marine biota in major Arctic ports (expected to be at highest risk for introduction of NIS) as part of the DFO AIS monitoring program and CAISN. Arctic surveys have recently been completed in the ports of Tuktoyaktuk, NT, Churchill, MB and Iqaluit, NU, Deception Bay, QC and Steensby Inlet, NU. Preliminary taxonomic results from the ports of Tuktoyaktuk, Churchill and Iqaluit indicate a high proportion of new species in recent samples from these areas. We discuss potential origins for these new records.

Poster CCFFR (Invasive Species)

THE RESPONSE OF FISH MERCURY LEVELS TO CHANGES IN INORGANIC MERCURY LOADING

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Methylmercury (MMHg) is by far the most prevalent contaminant in North American freshwater fish. A principal need for regulators is an understanding of the response of fish MMHg levels to decreases in inorganic mercury (Hg^{2+}) deposition. At the Experimental Lakes Area (ELA; ON, Canada), we conducted tank, fish transfer, and whole-ecosystem experiments that incorporated isotopically-enriched forms of mercury ('spike Hg') to examine accumulation and elimination of MMHg by fish. The METAALICUS project employed annual additions of spike Hg^{2+} to a pristine lake and its watershed for 7 years (loading) followed by 4 years of recovery. By the end of loading the food web reached a new steady state for lake spike; forage fish MeHg concentrations were 55-60% higher than they would have been without Hg additions and 40% higher for northern pike (*Esox lucius*). Shore-based tank experiments demonstrated that fish accumulated spike Hg predominantly from food (>80%), but that water can also be an important exposure pathway (<20%). Four years after mercury loading to the lake ceased, the proportion of spike MMHg declined by 73-80% relative to peak levels in forage fish, and by 40% for pike. These rates of recovery of Hg-contaminated fish are consistent with findings from parallel studies in which we transferred yellow perch (*Perca flavescens*) and northern pike from Lake 658 to a 'clean' lake. Elimination of MMHg from fish occurred much slower (half-lives of 1.3 y [perch] and 4.5 y [pike]) than indicated in past, short-term studies. We suggest that decreases in atmospheric Hg^{2+} deposition will yield lower MMHg concentrations in fish populations, but that reductions will occur more slowly than predicted because current models over-estimate rates of MMHg elimination by fish and do not include water as a source of MMHg exposure.

Oral CCFFR (Experimental Lakes Area Research)

CARBON DIOXIDE AND METHANE DYNAMICS IN BOREAL STREAMS AT THE LANDSCAPE SCALE

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The boreal biome contains 50% of the world's soil organic carbon, 25% of which is in Canada. Moreover, 7.5% of the Earth's freshwater is found within Canada's boreal region. The land-water interface in this region is a major contributor to the global carbon cycle. Rivers and streams are a significant component of this interface, functioning as both conduits and reactors of organic carbon. In addition, streams have recently been shown to be supersaturated with the greenhouse gases carbon dioxide (CO_2) and methane (CH_4), making boreal streams an important source of atmospheric carbon. However, most research on CO_2 and CH_4 in streams has focused on the quantification of these gases rather than factors that affect their production. Presented here is a study of streams within two distinct boreal regions of Quebec; Chicoutimi and Chibougamau. This study investigates CO_2 and CH_4 production using watershed landscape and water chemistry. At the landscape scale, topography affects the amount of organic matter (OM) within watersheds; this means less carbon circulating in watersheds with high slope and elevation. As a result, less carbon is available for production of CO_2 and CH_4 in higher elevation streams. Subsequently, lower CO_2 and CH_4 concentrations result in less downstream flux and atmospheric evasion. In summary, watershed characteristics, such as topography, strongly determine the greenhouse gas emissions from streams on a regional scale.

Oral SCL (Carbon Flux and Nutrient Cycling)

THE ROLE OF THE OKANAGAN BASIN FISH-AND-WATER MANAGEMENT TOOL IN BOOSTING SOCKEYE PRODUCTION

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Record breaking returns of sockeye salmon from 2008 to present marks the culmination of a remarkable turnaround for this species in the Columbia River Basin. The sockeye salmon aggregate in the Columbia is composed of two populations originating from the United States and one from Canada (Osoyoos Lake, Okanagan, B. C.). Although all three populations have

exhibited recent-year increases in returns relative to their multi-decadal averages, Okanagan sockeye have accounted for more than 80% of the aggregate return in the last 10 years. Average, annual returns of 235,000 of Okanagan sockeye salmon over the last 5 years exceed the 40 year average of 47,000 by roughly a factor of 5. Both intentional management actions and fortuitous events have contributed to the rebound in Okanagan sockeye production. Actions and events include: (1) rejection of historic escapement objectives that capped total production far below the carrying capacity of freshwater spawning and rearing environments, (2) development and operational deployment of the FWMT decision support system to facilitate "fish friendly" water storage and release decisions where the latter have greatly reduced density-independent losses of sockeye eggs and fry to flood-and-scour or drought-and-desiccation events, (3) FWMT enabled identification and mitigation of rearing habitat reductions for juvenile sockeye due to oxygen-temperature "squeeze" conditions in Osoyoos Lake, (4) supplemental production from recent introductions of hatchery-origin sockeye fry into Skaha Lake and (5) improvements in juvenile fish-passage in the Columbia River combined with a coincidental return to survival-favourable conditions for southern sockeye stocks in coastal marine waters.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

TEMPORAL TRENDS IN THE $\delta^{13}C$ AND $\delta^{15}N$ ISOTOPE VALUES OF *HEMIMYSIS ANOMALA*, A RECENT INVADER IN THE GREAT LAKES BASIN

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Invasive species are a known and significant stressor on aquatic systems, and are prevalent in the Laurentian Great Lakes. Over 180 invasive species have been documented within the Great Lakes basin, yet few temporal studies have been conducted on how resource use or trophic position of the invaders changes within the invaded food web either seasonally or inter-annually. To examine temporal variations in the food web niche of the recent invasive mysid, *Hemimysis anomala*, two sites, one in Lake Ontario and one in the St Lawrence River, were repeatedly sampled for *Hemimysis* and related food web items between May 2009 and January 2012. Samples were processed for carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope analysis to examine temporal trends in the main food sources and trophic position of *Hemimysis*. *Hemimysis* have previously been found to show significant spatial variation in food web niche use in the Great Lakes basin. In this study *Hemimysis* were found to vary by > 3 ‰ in both mean $\delta^{13}C$ and $\delta^{15}N$ over time. Significant relationships were found between *Hemimysis* isotopic values and site characteristics such as water temperature and the isotopic values of particulate organic matter (POM). Consistent seasonal trends were observed among years at Bronte in *Hemimysis* $\delta^{15}N$, but not in $\delta^{13}C$. Some differences in seasonal trends were found between the lentic and lotic sites.

Oral SCL (Invasive Species)

PEDIGREE ANALYSIS PROVIDE ESTIMATES OF THE EFFECTIVE NUMBER OF BREEDING ADULTS AND NUMBER OF SPAWNING EVENTS FOR WHITE STURGEON IN THE UPPER COLUMBIA RIVER

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The white sturgeon population in the Upper Columbia River has experienced recruitment failure for several decades. Using 12 microsatellite loci, genetic data and pedigree analysis of captured eggs and larvae, the number of adults spawning annually and effective breeding number were estimated. We also produced a timetable of white sturgeon larval development that incorporated variation due to family and temperature to estimate fertilization date of wild caught larvae. The number of contributing adults, breeding adult effective size and degree of spatial genetic structure among spawning areas were low. We used inferred adult contributions to pedigreed larvae produced within and among events to validate the inferred timing of different spawning events based on developmentally staged eggs which is commonly used as a surrogate measure of adult spawning events. Low estimates of the number of spawning adults and inferred reproductive skew based on pedigree analysis revealed that effective breeding numbers are considerably lower than the number of breeders suggesting that the genetic diversity of progeny during this early life stage is low and effective population size is likewise small. Results from this work increase our understanding of white sturgeon reproductive ecology and can be used to revise ongoing recovery strategies including broodstock programs.

Oral CCFFR (General Session)

INVESTIGATION OF THREATS TO SPECIES AT RISK FISHES IN GRAND BEND ONTARIO

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The Grand Bend, Ontario, area supports three species at risk (SAR) fishes: the Pugnose Shiner (Endangered), Lake Chubsucker (Threatened), and Grass Pickerel (Special Concern). Recent fish monitoring by Fisheries and Oceans Canada (DFO) and the Ausable Bayfield Conservation Authority (ABCA) has shown that these SAR fishes live in three water bodies: the Old Ausable Channel (OAC), L Lake, and Old Mouth Lake (OML). These water bodies have still, clear water

and abundant aquatic vegetation, providing unique fish habitat. Three current issues in the OAC may represent threats to SAR fishes and their habitat. Nutrient inputs from adjacent subdivisions may be resulting in a rapid succession of the pond-like ecosystem to a more terrestrial ecosystem. The additional nutrients may also have contributed to recent winter kills. Finally, fluctuating water levels in the OAC may be affecting available habitat. A comparison of the trophic status and aquatic vegetation and fish communities in the OAC, L Lake, and OML will help to better manage the SAR fish habitat. Relationships between SAR fish abundance, aquatic vegetation, and water quality in the three systems, and an evaluation of the impacts of recent water level changes in the OAC on SAR fish abundance, will be presented.

Poster CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

THE GENETIC IMPACT OF INVASIVE HYBRIDISING SPECIES ON A THREATENED NATIVE POND FISH: A GENOMIC APPROACH

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Research on biological invasions is essential for understanding and predicting potential impacts on biodiversity and ecosystem services. Furthermore, invasive species and invaded communities are excellent model systems with which to address fundamental questions of ecology and evolution. This PhD, which is now in its second year, focuses on the genetic impacts of three hybridising, non-native species (the goldfish *Carassius auratus* (UK, continental Europe(EU)), the common carp *Cyprinus carpio* (UK, EU) and the gibel carp *Carassius gibelio* (EU only)), on the native crucian carp Carassius carassius across its UK and EU range. The first objective is to provide quantitative information on the genetic impacts of these non-native species, namely bottlenecks, hybridisation and introgression. Parallel to this, two fundamental research gaps associated with species invasions will be addressed; 1) the importance of hybridisation and introgression in invasions, and 2) how neutral and selected regions of the genome react differently to the genetic impacts of non-native spp. Preliminary microsatellite data for populations across Europe show that heavily bottlenecked populations are common, as are populations in which hybridisation and further backcrossing has occurred. This data may also shed light on disputes concerning the origin of *C. carassius* in the UK (native vs. invasive). Microsatellite data will also identify populations to be examined using a powerful new populations genomics tool; RAD-tag sequencing, which will provide genome wide data in neutral and selected loci that can be used to identify species, hybrids and potentially introgression at a fine scale. The objectives of this project will provide the means to put forward comprehensive and much needed Biodiversity action plans for this threatened species whilst also addressing important “blue skies” research areas associated with invasive species impacts.

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Oral CCFFR (Migration, Mixing and Dispersal)

MAYBE WE SHOULD ADMIT WE HAVE NO IDEA WHAT WE'RE DOING: MANAGING GREAT LAKES FISHERIES IN THE FACE OF GREAT UNCERTAINTY

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Fisheries managers throughout the world have begun to adopt a more realistic perspective on the magnitude of uncertainty faced by decision makers when allocating harvests or making other critical resource management decisions. During the past decade we have accumulated experience with this in the Great Lakes, on issues including sea lamprey control, hatchery-based salmon fisheries, and exploited cold- and cool-water fisheries. We have learned that using state-of-the-art assessment and simulation strategies does not substantially reduce these uncertainties, or point more clearly to the "correct" solution, but does allow a more objective and transparent process for accounting for them in the management process. Much of the conflict in fishery management comes from poor communication and vaguely stated objectives leading to a lack of trust among stakeholders. We believe that our recent experience applying a highly technical, management strategy evaluation approach to Lake Erie fisheries within an inclusive, stakeholder-driven process, points the way to a better, more transparent approach to management of Great Lakes fisheries.

Invited Oral CCFFR (Great Lakes Fisheries and Environmental Policies)

THE DUPLICITY OF HYDROPEAKING RIVERS: IS ECOPEAKING POSSIBLE?

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Since 2004 we have been investigating longitudinal (up and down stream) and lateral (across stream) patterns in fishes, aquatic invertebrates, water temperature, and other habitat characteristics in two hydropeaking rivers (Magpie and Michipicoten) and 12+ natural river systems along the north shore of Lake Superior. This summary focuses on the findings of three research projects, the ecological challenges organisms face in hydropeaking rivers, and potential implications for ecological monitoring and policy. Philosophically, the natural flow regime concept is appealing; its application however, can be troubling for biologists without the expertise or resources to handle such approaches on their own, particularly on hydropeaking rivers where incorporating natural flow is challenging. Many hydropeaking rivers are ecologically two different rivers in one: the low flow and high peaking flow. Taxa that require a narrow range of habitat (e.g., water velocities, temperatures) or can not withstand rapid changes in discharge would likely be eliminated or competitively disadvantaged under such harsh and

variable environmental conditions. Deviations from a natural flow regime may result in new constraints on fishes and invertebrates, but this does not necessarily mean a loss of productive fish habitat. Acknowledging the idea of two rivers in one and the risks associated with high to low flow ratios may help avoid missed opportunities in maintaining altered, yet productive rivers, while representing a small step towards improving the methods used for managing river ecosystems.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

PHYSIOLOGICAL ADAPTIVE POTENTIAL OF INLAND LAKE TROUT (*SALVELINUS NAMAYCUSH*) POPULATIONS TO CLIMATE CHANGE

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Lake trout (*Salvelinus namaycush*) are a cold-adapted salmonid and relict from the last Ice Age, making them an excellent model to study the effect of climate change on cold-water fishes. The future persistence of inland lake trout populations will depend on their capacity for physiological acclimation and adaptation to elevated temperatures. As a species, the survival of lake trout may depend on existing variation and adaptive ability for thermal tolerance among populations. We studied the thermal tolerance and capacity for acclimation of individuals from four inland lake trout populations across four acclimation temperatures. Individuals were reared from egg-stage in a common environment, and were acclimated to 8ºC, 11ºC, 15ºC, or 19ºC as yearlings. Upper thermal tolerance increased by approximately 2.0ºC with acclimation temperature. Thermal tolerance did not differ among lake trout strains. Standard- and active metabolic rate increased with acclimation temperature up to 15ºC, where metabolic scope peaked. Metabolic rates only differed among lake trout strains following acclimation to 19ºC, suggesting that there is little variation for thermal acclimation among lake trout populations. As a result, climate change may pose a threat to lake trout at the species level, rather than local populations alone. Understanding the effect of elevated temperatures on thermal tolerance and metabolic capacity of an economically and ecologically important cold-adapted species will help develop successful management and conservation strategies to ensure long-term sustainability for lake trout populations.

Oral CCFFR (Climate Change)

LOCAL AND REGIONAL POPULATION GENETIC STRUCTURE OF THE THREATENED CHANNEL DARTER IN ONTARIO

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Genetic information can be a critical tool when designing recovery strategies for species at risk by informing spatial structure and diversity. The Channel Darter (*Percina copelandi*) is a small benthic fish with a naturally disjunct distribution in Central Canada. Within this distribution, dams have further fragmented riverine populations in the Bay of Quinte drainage. A number of Ontario and Quebec populations are presumed extirpated, and recent sampling suggests that populations in Lake Erie and Lake St. Clair are in decline. Its disjunct distribution means that natural re-colonization of extirpated sites will likely not occur. Re-establishment efforts need to identify the location of potential source populations. Ideally, source populations possess a high level of genetic diversity and genetic composition developed under similar historic conditions as the re-establishment site. To assess the genetic variation and relatedness of populations across its range, channel darters from eight Ontario and Quebec populations were genotyped for ten microsatellite DNA loci and mitochondrial DNA (cytochrome-b) was sequenced. The microsatellite DNA both detected significant population differentiation among adjacent populations and across its Canadian range. While the mitochondrial DNA suggests a complex post glacial colonization history. Remarkably, populations in southwestern Ontario and Quebec were more closely related than geographically intermediate populations. In contrast, analysis within rivers showed no evidence of fragmentation or population substructuring resulting from the system of dams or locks, suggesting that either fish are able to circumnavigate barriers and/or that population genetic data do not yet reflect the physical fragmentation of these river systems.

Poster CCFFR (Genetic Diversity and Adaptation)

CAN FISH REPRODUCE AFTER THEY STOP TAKING THE BIRTH CONTROL PILL? RECOVERY FROM A WHOLE LAKE EXPERIMENT

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Municipal wastewater effluents contain hormones and mimics that interfere with sexual development and reproduction in individual fish. To assess the effects of these endocrine disruptors on fish population sustainability, whole lake additions of the synthetic estrogen ethynylestradiol (EE2) used in birth control pills were done from 2001-2003 at the Experimental Lakes Area. In the first year of the additions, male fathead minnow (*Pimephales promelas)* and pearl dace (*Margariscus margarita*) became feminized, with delayed spermatocyte development and high concentrations of vitellogenin, an egg yolk protein precursor. In the second and third summers of EE2 additions, reproductive failures occurred for the shortest-lived fish species, the fathead minnow, with a subsequent collapse in the population. Modest reductions in catch-per-unit-effort (CPUE) and loss of small size classes were observed for pearl dace. To assess potential recovery, from 2004-2010 we continued to monitor these populations in the spring, and

opportunistically collected individuals for vitellogenin and gonad histology. In 2005 and 2006, vitellogenin concentrations were back at baseline levels in male pearl dace and fathead minnow, respectively. The incidence and severity of gonadal abnormalities decreased with time post-exposure, and were absent in fathead minnows and pearl dace three and six years post-exposure, respectively. Size-frequency distributions and CPUE of fathead minnow returned to pre-experiment levels by the spring of 2007. These results indicate that, given time, fathead minnow and pearl dace can recover from EE2 exposure at the biochemical through population levels. Improved wastewater treatment to remove estrogens and their mimics from effluents will reduce risks for wild fish populations.

Oral CCFFR (Experimental Lakes Area Research)

WHY DOES THE TROPHIC TRANSFER OF MERCURY VARY FROM ONE LAKE TO ANOTHER?

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Studies across diverse systems have shown that concentrations of methyl mercury (MeHg) in aquatic organisms are predicted by their relative trophic position ($\delta^{15}N$). Slopes of the log MeHg vs. $\delta^{15}N$ regressions indicate the average biomagnification of mercury within a food web. For reasons that are not understood, some systems have higher trophic transfer of MeHg than others. Here our aim was to assess whether chemical, physical and biological characteristics of lakes explained some of this among-system variability both within and across regions. Food web MeHg and $\delta^{15}N$ data for 11 yellow perch lakes in NS, 5 brook trout lakes in NB, 14 lake trout lakes in ON, SK and MB, and 6 arctic char lakes in NU were compiled. These lakes range in pH from 4.6 to 7.7, productivity from oligotrophic to eutrophic, and surface area from 0.24 to 5569 km^2. Within all food webs, $\delta^{15}N$ was a significant predictor ($p<0.001$) of MeHg concentrations, explaining between 50 and 91% of the data. Slopes of the regressions varied across lakes (0.11 to 0.23) both within and among regions and the differences were related to physical and chemical characteristics. For example, slopes were higher in yellow perch lakes with lower nutrients (e.g. TN and TOC). In contrast, trophic transfer of MeHg through both lake trout and arctic char food webs was highest in high phosphorous systems, and in large lakes (lake trout only). In summary, lake characteristics appear to affect the trophic transfer of MeHg, although the underlying mechanisms are not known.

Oral CCFFR (Contaminants and Trophic Transfer)

LANDSCAPE-LEVEL EFFECTS ON A FRESHWATER AMPHIPOD AT THE LAND-WATER INTERFACE

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Freshwater ecosystem recovery is linked with the terrestrial environment because aquatic systems tend to integrate many complex landscape processes. Recent studies have demonstrated that organic matter subsidies play an important role in aquatic recovery, particularly at the land-water interface of subcatchment confluence sites in lakes. The acid-sensitive amphipod, *Hyalella azteca* has re-established populations across the spatiotemporal gradients of recovery in the Sudbury landscape. Here we present preliminary results from a six lake study assessing how subcatchment characteristics (e.g. topography and vegetation) might influence distribution and abundance of *H. azteca* across spatial (e.g. degree of historical watershed disturbance) and temporal (e.g. colonized for <2 - 20+ years) gradients of recovery. Amphipods were sampled at subcatchment confluence sites and at sites representing dominant littoral substrates. We expected that abundance at subcatchment confluence sites is related to landscape characteristics that relate to organic matter input into lakes and that confluence sites were hot-spots for colonization. Preliminary results suggest that there is a positive relationship between mean abundance in a lake and time since colonization. A positive relationship was also found between abundance and subcatchments with a high potential for water accumulation, i.e. gently sloping and large surface areas. A tendency for occurrences at subcatchment confluence sites in recently colonized lakes to be higher when compared to other sites in the lake was observed. This work will provide insight into the association between recovering land and water and will also provide useful tools for directing restoration efforts.

Oral SCL (Wetland and Land/Water Linkages)

THE IMPACT OF EUTROPHICATION ON MERCURY CYCLING IN LAKE 227 AT THE EXPERIMENTAL LAKES AREA IN NORTHWESTERN ONTARIO

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Mercury is a pollutant of global concern as concentrations of methylmercury (MeHg), the toxic, bioaccumulative form of Hg, in fish are often present at concentrations that may pose health risks to consumers. Although we are beginning to understand the factors controlling MeHg production in freshwater lakes, the impacts of environmental disturbances, such as eutrophication, on Hg cycling are not known. As part of a larger project examining controls on eutrophication, we are studying the impacts of eutrophication on Hg cycling and MeHg production in the artificially eutrophic Lake 227 at the Experimental Lakes Area in northwestern Ontario. In addition to 40 years of ancillary data, Lake 227 is ideal for this study as it has an anoxic hypolimnion which may be an important zone of microbial MeHg production. To determine sources and losses of inorganic Hg(II) and MeHg from the lake, we are using a mass balance approach including: detailed lake profiles to determine water column Hg pools, Hg inputs via precipitation, and Hg

losses from the lake via gaseous elemental Hg(0) evasion and MeHg photodemethylation. In addition, rates of MeHg production are being determined using state-of-the-art Hg stable isotope experiments. 2010 results suggest that eutrophication has a dramatic impact on Hg cycling in Lake 227. For example, the zone of high MeHg concentrations migrated up the water column throughout the summer following the zone of anoxia, suggesting MeHg is being produced in the anoxic hypolimnion. 2011 results will be presented in the context of numerous other water chemistry parameters.

Oral SCL (Experimental Lakes Area Research)

CHARACTERIZATION OF STORMWATER MANAGEMENT PONDS AND THEIR ROLE AS A LAND-WATER LINKAGE IN URBAN ENVIRONMENTS

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Stormwater Management Ponds (SMPs) are common-place throughout urbanizing environments, yet their functional role has not been well established. Though SMPs are designed for hydrological control of stormwater runoff, they can also attenuate the quality of runoff prior to discharge into creeks and rivers. As such, SMPs may serve as an important land-water linkage between terrestrial and aquatic systems in urban areas. In the first stage of a long-term study to improve our understanding of the functional ecology and ecosystem services of SMPs, we characterized 22 SMPs (plus 3 reference ponds) from Durham Region, Ontario representing a gradient in emergent plant cover. Assessment of water quality and algal diversity showed a high degree of seasonality and variability among SMPs. This was a surprising finding considering that all of the SMPs receive urban runoff in the same geographical and climatological region. Multivariate analyses showed considerable dissimilarity among SMPs, yet very high similarity among reference ponds. This indicates that SMPs are very dynamic and diverse systems despite their engineered origins. When the SMPs were assessed based on plant cover, there were no significant relationships with any water quality parameters including algal biomass and diversity. Assessment of microbial community tolerance to copper (a typical runoff contaminant) showed clear shifts to heterotrophic dominance at high copper concentrations. Finally, the results from current studies investigating the biodegradation potential of SMPs will be presented.

Oral SCL (Wetland and Land/Water Linkages)

IMPLICATIONS FOR PHYTOPLANKTON OF LONG-TERM DECLINES IN SPRING PHOSPHORUS DELIVERY TO LAKES

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Phosphorus levels have declined during the past several decades in many Precambrian Shield lakes. Although the processes causing this decline are currently being explored, a recent study indicates it is driven by decreases in watershed delivery of phosphorus, mainly during spring snow melt. These declines may have implications for phytoplankton communities, which vary with changing nutrient levels, and could have long-reaching effects on lake function. The effects may be magnified with climate warming, as thinner snow packs and advances in the spring melt could further reduce spring phosphorus export. As phytoplankton communities may shift in response to such pulse spring phosphorus exports, it will be important to forecast lake responses to future climate change. The potential impacts of changes in phosphorus levels on phytoplankton dynamics are assessed through an investigation of long-term changes in phytoplankton during the spring melt period in Harp Lake and Plastic Lake, located in the Muskoka-Haliburton region of south-central Ontario. More than three decades of archived spring phytoplankton samples collected at each lake by the Ontario Ministry of the Environment have been enumerated at the genus level. Univariate and multivariate statistics will be used to compare variation in phytoplankton biomass and community composition with measured changes in meteorological conditions and lake chemistry, with a focus on quantifying the importance of long-term declines in spring phosphorus exports to changes in the phytoplankton. The outcomes of this research will advance understanding of phytoplankton dynamics and inform lake management plans.

Poster SCL (Wetland and Land/Water Linkages)

CONGRUENCE IN COMMUNITY CHANGE-POINTS IN RESPONSE TO ANTHROPOGENIC STRESS IN GREAT LAKES COASTAL WETLANDS

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Biological attributes of aquatic ecosystems often vary nonlinearly as a function of anthropogenic and natural stress. Plant and animal communities, for example, may exhibit break-point changes in composition at critical environmental thresholds. Despite the potential importance of recognizing such points along a stress gradient, few if any studies have examined the concordance of such responses among different taxonomic groups, and no community threshold studies have been reported at the scale of the entire Laurentian Great Lakes. We surveyed invertebrate, fish, wetland bird, diatom and vegetation communities across a geospatially referenced gradient of anthropogenic stress as a part of the Great Lakes Environmental Indicators project. Change-points in ecological community response to thresholds of individual measures of agriculture and urban/suburban development in the watershed as well as the composite stress score were identified using Titan (Threshold Indicator Taxon Analysis; Baker and King 2010). We previously found surprising congruence in the location of change-points of community

composition among different taxonomic groups with respect to percent developed land within the watershed, and the composite stressor scores reflecting several types of disturbance. Here, we present information on the community responses to water quality and habitat variables in an attempt to pinpoint mechanisms responsible for the watershed-level patterns. We discuss assemblage sensitivity to specific stressors and the relevance of observed stressor thresholds for identifying reference condition boundaries and for informing management and policy decisions.

Oral CSWS (Wetland and Land/Water Linkages)

MOVEMENTS OF LISTED GRASS PICKEREL *ESOX AMERICANUS VERMICULATUS* IN AN AGRICULTURAL DRAIN AND THE IMPLICATIONS FOR DRAIN MAINTENANCE

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Scientists and managers are being pressed to find ways to conserve biodiversity in systems that have been heavily modified by human activities. We combined PIT tags and multi-state models to quantify the movements of listed Grass Pickerel *Esox americanus vermiculatus* in Beaver Creek, an agricultural drain near Fort Erie, ON. The creek requires drain maintenance (digging out) to restore its drainage function. It is also inhabited by one of the largest populations of Grass Pickerel in Canada. Grass Pickerel is listed as Special Concern under SARA. Over 2000 Grass Pickerel have been PIT tagged since 2009 and their movements monitored at seven antenna arrays installed across 13 kilometres of Beaver Creek. Multi-state models are being used to test how the frequency and direction of movement between sections of the creek change with time-of-season, fluctuations in water temperature and depth, and size of fish, and how these movements change following drain maintenance. Movement is an important part of the life history of stream fishes. Our findings will contribute to the development of management practices that balance the needs of the agricultural community and fish habitat managers.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

SELENIUM TOXICITY IMPACTS ON FISH AND MACROINVERTEBRATE COMMUNITY COMPOSITION IN STREAMS DRAINING SURFACE COAL MINES

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Selenium is a micronutrient that can produce toxic effects in fish and other aquatic organisms when present at elevated concentrations. We investigated the impacts of selenium released from surface coal mines on fish and macroinvertebrate communities in mined watersheds in Alberta

and British Columbia. We measured selenium concentrations in water, periphyton, invertebrates, and fish in streams with mining impacts and in reference streams. Fish and invertebrate community data were collected to determine the relationship between selenium exposure and community composition metrics. We found that water selenium concentrations increased with active mine footprint in the upstream watershed. Macroinvertebrate selenium tissue concentrations increased with water concentrations and community composition was altered at highly impacted sites with an overall loss of species richness, community diversity and evenness. Changes in invertebrate community metrics were associated with water selenium concentration as well as other water quality and habitat parameters linked to mining including conductivity, ion concentrations (SO_4^{2-}, NO_2^-+NO_3^-, Ca^+) and streambed calcite accumulation. Fish tissue concentrations and relative fish biomass and abundance were not related to water selenium concentrations. Spatial analyses were performed on water and fish tissue selenium concentration gradients and results suggest that fish tissue concentrations though not directly related to water selenium concentrations at the point of capture, are affected by nearby water selenium gradients. This research indicates that while invertebrate communities appear to respond to high selenium exposure in impacted streams, fish movements and the role of un-contaminated refugia may be significant in determining the extent of toxicity and the response in fish communities.

Poster CCFFR (Contaminants and Trophic Transfer)

MOVEMENT PATTERNS OF LAKE STURGEON (*ACIPENSER FULVESCENS*) IN THE SOUTH SASKATCHEWAN RIVER BASIN

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Lake sturgeon (*Acipenser fulvescens*) in the Saskatchewan River basin have been identified as endangered by the Committee for the Status of Wildlife in Canada (COSEWIC) and are being considered for listing under the federal Species at Risk Act. In this study we examine the population of lake sturgeon in the South Saskatchewan River basin in Alberta and Saskatchewan, Canada, upstream of Gardiner Dam. There are many data gaps for this population, such as extent of migration throughout the system and locations of critical habitat like spawning grounds, feeding areas and overwintering sites. In order to fill in data gaps, a migration study of this population was initiated in 2010. Between August of 2010 and September of 2011, Vemco acoustic coded tags were implanted into 123 lake sturgeon. Stationary Vemco VR2W hydroacoustic receivers were placed in the South Saskatchewan, Bow, Oldman and Red Deer Rivers in order to track the movement of tagged sturgeon and movement data was collected from August 2010 until October 2012. Habitat mapping was also conducted in order to relate sturgeon location to habitat type. Preliminary results indicate a widespread dispersal of lake sturgeon in the study area as well as distinct seasonal movement patterns. In addition, distinct overwintering areas have been identified in the study area. It is hoped that increasing knowledge of lake

sturgeon movement patterns and habitat use will aid conservation and management of this threatened species.

Oral CCFFR (Migration, Mixing and Dispersal)

PRINCIPLES FOR ENSURING HEALTHY AND PRODUCTIVE FRESHWATER ECOSYSTEMS THAT SUPPORT SUSTAINABLE FISHERIES

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Freshwater ecosystems and the fisheries they support are increasingly threatened by human activities. To aid those seeking to manage and protect fisheries of inland ecosystems, we outline nine key principles of healthy and functioning ecosystems based on the best available science using Canada as a case study for north temperate regions. The principles are: laws of physics and chemistry apply to ecology; population dynamics are regulated by reproduction, mortality, and growth; the importance of habitat quality and quantity; habitats must remain connected; species and their habitats are subject to ecosystem-scale effects; biodiversity enhances ecosystem resiliency and productivity; global processes affect local populations; anthropogenic stressors can have cumulative effects; evolutionary processes must be protected. Additionally, we provide general recommendations for managing and protecting freshwater ecosystems and the fisheries they support providing examples of successful implementation for each management principle. Key general management recommendations for freshwater ecosystems include: engage stakeholders; provide agencies with sufficient capacity and legislative authority; measure success by defined metrics; identify and account for threats to ecosystem productivity; adopt a precautionary approach; embrace adaptive management; implement ecosystem-based management; account for all ecosystem services provided by aquatic ecosystems; protect habitat as the foundation for fisheries; protect biodiversity. Ecosystems are complex with many components that are spatiotemporally intertwined. Ignoring linkages and processes significantly reduces the probability of successful management efforts. The principles of ecosystem structures and functions must be considered when developing policy and identifying management options.

Oral CCFFR (General Session)

IMPACTS OF SUSTAINED LOW WATER LEVELS AND HUMAN SHORELINE DEVELOPMENT ON HISTORICAL MUSKELLNGE (*ESOX MASQUINONGY*) NURSERY HABITATS IN SOUTHEASTERN GEORGIAN BAY

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Georgian Bay, Lake Huron, has experienced sustained low water levels since 1999 that have structurally altered many coastal wetlands. Muskellunge (*Esox masquinongy*), an indicator of healthy aquatic ecosystems, are highly sensitive to alterations of their coastal wetland breeding habitats. This study examined the impacts of sustained low water levels and human shoreline development on historic muskellunge coastal wetland nursery habitats in southeastern Georgian Bay identified in 1981. These sites were resampled for fish and habitat parameters in 2012, with the same methodology used in 1981. No young-of-the-year (YOY) muskellunge were sampled in 2012. The lack of YOY muskellunge appeared associated with alterations to the coastal wetland's physical structure and associated flora and fauna communities. Substrate slope, measured to the 1.0 m depth contour, was significantly shallower in 2012 ($p < 0.001$) and differences in submergent and emergent aquatic vegetation stem densities showed structural and community homogenization compared to 1981. Additionally, round goby (*Neogobius melanostomus*), an invasive fish egg predator, was sampled at many of the sites in 2012, suggesting that this invasive fish is well established in the study area. These results suggest that the historical muskellunge coastal wetland nursery habitats are no longer productive, resulting from sustained low water levels, increase shoreline development and establishment of invasive species. It is currently unknown if muskellunge in southeastern Georgian Bay are experiencing reproductive dysfunction or are utilizing unidentified locations for reproduction. However, future work will focus on creating a conceptual model of suitable muskellunge reproductive habitat in eastern Georgian Bay.

Oral CSWS (Climate Change)

OUTBREEDING DEPRESSION: A MULTIGENERATIONAL ANALYSIS IN CHINOOK SALMON

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Outbreeding, the mating between genetically divergent individuals, may result in fitness consequences for offspring via outbreeding depression. Outbreeding has implications for salmonid aquaculture, conservation and risk assessment of farm-wild interbreeding, and theoretical importance, as outbreeding depression acts as a mechanism of reinforcement that contributes to local adaptation and population divergence, and eventually speciation. Outbreeding effects should be evaluated using a multigenerational approach, as heterosis may occur in the first generation; however, subsequent generations may experience outbreeding depression. We quantify outbreeding effects in first generation (F_1) hybrid and second generation (F_2) backcrossed hybrid Chinook salmon using purebred (inbred) lines. Captively reared parental lines were created by selectively breeding for differential performance for 3-4 generations. In 2009, parental lines were bred to create purebred and reciprocal hybrid crosses, and in 2010

parental and hybrid crosses were bred to create purebred and backcrossed hybrid crosses. Although we found significant phenotypic and genetic differences between parental line crosses, we found no negative consequences of outbreeding in either generation. Reciprocal F_1 hybrids showed no evidence of favorable heterosis or outbreeding depression (hybrid breakdown) for weight, length or survival. The F_2 reciprocally backcrossed hybrids showed no outbreeding depression for a suite of fitness related traits, including egg survival, morphology, growth, saltwater survival and stress response. Overall, we found no evidence of outbreeding depression in Chinook salmon, suggesting no negative implications of outbreeding for conservation and aquaculture breeding programs. We suggest that the lack of outbreeding depression in salmon may be a result of their tetraploid ancestry.

Oral CCFFR (General Session)

THE IMPORTANCE OF SEDIMENT RETURN IN SUBSIDIZING NITROGEN REQUIREMENTS FOR ALGAL PRODUCTION IN AN EXPERIMENTALLY EUTROPHIED LAKE (LAKE 227)

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Cultural eutrophication, triggered by the anthropogenic release of excessive quantities of nutrients to water bodies, can lead to massive algal blooms which have numerous negative effects on water quality, including the depletion of dissolved oxygen and the release of cyanotoxins, impacting human and wildlife health. An important question for the management of eutrophic lakes is whether primary production is ultimately (on an annual time-scale) limited by nitrogen, and therefore whether costly measures to control external nitrogen inputs are warranted. Lake 227 has been the subject of a long-term whole-lake phosphorus and nitrogen nutrient addition experiment. However, since 1990 the lake has been fertilized only with phosphorus, and the nitrogen requirements for primary production have been met through a combination of N_2-fixation, internal recycling, atmospheric deposition and runoff. It has been argued that fixation of atmospheric nitrogen may be insufficient to balance the nitrogen pool in Lake 227, however, the rapid recycling of nutrients in epilimnetic sediments and inputs from sub-thermocline waters during water column mixing may provide, over different time scales, an important subsidy of nitrogen to complement N_2-fixation and ensure that primary production is not nitrogen limited. To investigate these mechanisms we deployed benthic flux chambers, conducted sediment core incubations and regularly sampled the water column of Lake 227 during field campaigns in 2011 and 2012. We will present estimates of whole-lake sediment returns of nitrogen and attempt to place these in the context of other important processes in the N cycle, such as N_2-fixation and atmospheric deposition.

Poster SCL (Experimental Lakes Area Research)

INVESTIGATION OF ADAPTATION IN A DAPHNIA POPULATION TO RAPID ENVIRONMENTAL CHANGE

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Human induced environmental change is occurring at an unprecedented rate in aquatic ecosystems. One mechanism species may use to mitigate the impacts of this change is adaptation at the local scale. Examples of contemporary evolution to environmental stressors such as predation and eutrophication have been found many times in the zooplankton genus *Daphnia*. This study investigated if similar patterns of adaptation were present in a *Daphnia* population of Wapusk National Park exposed to a rapid increase in salinity. In the last 30 years Lesser Snow Goose (*Chen caerulescens caerulescens*) populations in the park have experienced a 16-fold increase in nesting area. These expanding goose populations forage by "grubbing", removing roots and rhizomes of vegetation. Ions from exposed soil are washed into surrounding water bodies, increasing salinity up to 100 times. This study collected sediment cores from an impacted pond and hatched *Daphnia magna* resting eggs from pre and post goose impact to investigate possible changes in salinity tolerance within this population over time. Egg bank densities for this pond indicate that the *Daphnia* community shifted from being composed of several species including *D. magna* and *D. tenebrosa* to a community dominated by *D. magna* after goose impact. No significant difference in EC50 or 48 hour survival was observed between the pre- and post-goose impact *D. magna* genotypes based on 32 clone lines (19 pre, 13 post). However, subtle differences in life history characteristics between genotypes may be responsible for the observed increase in abundance and will be investigated using long-term performance measures.

Oral SCL (Genetic Diversity and Adaptation)

ESTABLISHING THE LINK BETWEEN FISH BIODIVERSITY AND BIOMASS PRODUCTION ACROSS THE CANADIAN LANDSCAPE

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The generation of fish biomass in aquatic ecosystems is largely influenced by the efficacy with which the organisms which constitute its food web can convert primary and secondary food sources into fish biomass (trophic efficiency). Fish biodiversity plays a large role in trophic efficiency, as diverse communities are likely to host a variety of specialist feeders which create a food web with complex structure and high trophic efficiency. Homogeneous communities, on the other hand, are more likely to be dominated by few generalists, creating a food web with simple

structure and comparatively low trophic efficiency. It follows that fish biodiversity may then play a fundamental role when considering the productive capacity of fish habitat, at least in terms of biomass output. Here, we examine this relationship across a diversity of geographical regions in Canada, as well as across hydro-regulated and unregulated systems within those regions. We hypothesize that regions such as Newfoundland Island and the Cordilleran system will feature low biodiversity, resulting from limited "post-glaciation" colonization opportunities. As such, they will not be as productive as interior regions which we expect to feature high biodiversity as a result of zoogeographic factors. With respect to regulated and unregulated systems, we expect that where regulation limits the number of species present in a system, so too will it limit the potential for biomass output. This study is among the first to examine the relationship between biodiversity and productivity across entire food webs, and the first to do so on such a large spatial scale. We expect that it will provide valuable insight into both fisheries management and the broader ecology of food webs.

Poster CCFFR (General Session)

SUSTAINABLE EXPLOITATION RATES OF WALLEYE: THE ROLE OF CLIMATE AND DENSITY-DEPENDENT LIFE HISTORY TRAITS

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We present a model that describes how plasticity in life history traits dictates the ability of a population to sustain the additional mortality imposed by exploitation. We apply this model to estimate sustainable exploitation rates for walleye (*Sander vitreus*) populations spanning a climatic range of 1000 to 4000 ^{o}C growing degree days (GDD). Climate is responsible for much of the among-population variation in walleye life history traits (e.g., growth, natural mortality, maturation, and reproductive investment). Application of a thermal age concept (i.e., age x GDD) permits us to factor out the climate-driven differences among populations. We then use both among-population and within-population analyses to show that the remaining variation can be used to bound the density-dependent response ranges of life history parameters that support sustainable exploitation. Our results suggest density-dependent variation in walleye growth rate can be as large as 2-fold. Assuming that age of entry to the fishery equals age of maturity, this level of growth compensation will support fishing mortality that is approximately equal to the natural mortality rate. Because natural mortality increases with GDD, the model predicts sustainable rates of exploitation are higher in warmer climates.

Oral CCFFR (Climate Change)

THE RELATIVE INFLUENCE OF TOPOGRAPHY AND LAND-USE ON INORGANIC AND ORGANIC CARBON EXPORT FROM CATCHMENTS IN SOUTHERN QUEBEC, CANADA

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Export of terrestrial carbon to aquatic systems changes where and how carbon is processed, which has implications for local and global carbon budgets. In order to better understand what controls this export, we explored the relative influence of topography and land-use on the export of inorganic, organic, and total carbon in 83 catchments in southern Quebec, Canada. Topographical variables, such as catchment area, slope and elevation, along with land-use variables, such as percent vegetation and lakes in the catchments, were combined into multiple regression models that explain 50-60% of the variability in the measured dissolved inorganic carbon (DIC) and dissolved organic carbon (DOC) exported from these catchments in 2004 and 2005. An examination of variance partitioning in the models, reveals that topography and land-use variables are equally important in explaining the variance in DIC export (25% each), whereas land-use is much more important than topography in terms of DOC export (43% versus 17%). As for what explains the variance in total carbon export (TC), topography is more important than land-use (39% versus 19%) for these catchments. Our results also show that %vegetation, %lake, and elevation of the catchments are the most important individual variables for explaining DIC, DOC, and TC exports, respectively. This suggests that land-use changes that reduce vegetation (e.g. deforestation) would lead to modest increases in TC export, but large increases in the DIC/DOC export ratio. We conclude that both the topography as well as land-use, which can be anthropogenically altered, determine the quantity and form of terrestrial carbon exported from these temperate catchments. Whether the terrestrial carbon is exported to aquatic systems in an organic or inorganic form has implications for the fate of the terrestrial carbon and therefore for carbon budgets.

Oral SCL (Carbon Flux and Nutrient Cycling)

ADDRESSING INTERMIXING OF LAKE WHITEFISH POPULATIONS: COMPARING FISHERY MANAGEMENT AND ASSESSMENT PERFORMANCE BASED ON ALTERNATIVE ASSESSMENT APPROACHES

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Recent evidence suggests that lake whitefish populations in lakes Huron and Michigan intermix considerably during non-spawning periods, possibly from fish expanding foraging areas to meet nutritional needs. Simulations have shown that ignoring spatial structure can lead to unexpected risks of overexploitation, especially for low productivity populations. Currently, management of

lake whitefish in the 1836 Treaty ceded waters of the upper Great Lakes is based on separate assessments and harvest calculations for nominally distinct unit stocks that are assumed to not mix. In northern Lake Huron one of these assessment units was formed by combining several previously used units, in response to evidence of intermixing. We simulated four lake whitefish spawning populations with differing levels of productivity and intermixing rates during the fishing season, but which were assumed to be spatially segregated during spawning. We evaluated how alternative assessment methods performed with respect to supporting a thriving commercial fishery and ensuring long-term stock sustainability. Our first assessment approach treated each population and the region surrounding its spawning grounds as a unit stock ("separate populations"). The second approach lumped together the regions and populations into a "pooled population", so that all intermixed fish were treated as single unit stock occupying a larger area. Our preliminary results show that the choice between pooled and separate population assessments depends on mixing rates and productivity. While pooling can sometimes be advantageous, it can lead to substantial overfishing when actual mixing is low. A third assessment approach that incorporates actual mixing rates is presently being evaluated.

Oral CCFFR (Migration, Mixing and Dispersal)

APPLICATION OF COASTAL OCEANIC SENSOR ARRAYS IN THE GREAT LAKES DESIGNATED AREAS OF CONCERN

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The Bay of Quinte and Hamilton Harbour are designated Areas of Concerns within Lake Ontario. These eutrophic systems have been monitored for biological, physical and chemical changes for several decades. The Areas of Concern have experienced a multitude of changes as a result of urban development, phosphorus controls, species-shifts, and non-native species introductions, but monitoring has encountered the classic sampling trade-off between spatial and temporal representativeness. Currently sampling occurs bi-weekly at a small number of stations intending to be representative of a larger region, but the validity of this assumption is often left untested. Using the Laser Optical Plankton Counter (LOPC) in addition to Conductivity, Temperature, Depth, Turbidity and Chlorophyll sensors attached to an Acrobat towbody we can gather extensive spatial data on in-situ plankton size distributions and simultaneous physical/chemical measures using sawtooth epilimnetic transects to cover the entire Areas of Concern in a short period. The data variability is then compared to the long-term stations. The instrumentation setup, its application in other aquatic environments and in additional roles will be discussed.

Oral SCL (Disturbed Ecosystems, Threatened Species and Restoration)

MERCURY BIOACCUMULATION IN FISH OF THE LAKE ERIE FOOD WEB

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Long-term monitoring has revealed a recent increasing trend in mercury (Hg) levels in the top predatory fish of Lake Erie, despite the decline in regional atmospheric Hg emissions since the early 1970s. Although organismal concentrations of Hg are expected to decrease concurrently, the bioavailability of Hg in certain aquatic ecosystems is complicated by many factors beyond emission rates. Elemental Hg and its methylated form monomethylmercury (MeHg) elicit many adverse health effects in both humans and wildlife populations alike. This project aims to explore the role that recently introduced invasive species, such as the round goby, as well as zebra and quagga mussels, have played in the bioconcentration and bioaccumulation of Hg and MeHg throughout the lake-wide food web. $\delta^{15}N$ and $\delta^{13}C$ isotope ratios will be used to examine changes in trophic status, and this data will be coupled with Hg analysis of biotic and abiotic lake components. These procedures will be used to clarify the relationship between food chain lengthening and increasing complexity and the transfer of Hg through the food web to higher organisms, namely yellow perch and walleye. Spatial patterns of Hg, as well as temporal trophic changes associated with these introductions, may prove to be the key to understanding this unique increasing trend in fish Hg.

Oral CCFFR (Contaminants and Trophic Transfer)

BIOTIC AND ABIOTIC CHANGES IN AN END-PIT MINE LAKE AFTER LAKE FERTILIZATION TO REMEDIATE SELENIUM CONTAMINATION

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Selenium is a trace nutrient that at elevated concentrations leads to severe impacts on aquatic ecosystems. Selenium toxicity is of particular concern in end-pit mine lakes of the eastern slope Rockies, where it leaches out of waste rock from open-pit coalmines. We tested a potential whole lake method of reducing selenium concentration in end-pit lake water by stimulating the anaerobic, sulphur and selenium reducing, bacterial community present in the lakes' sediment. We fertilized a medium-sized end-pit lake with a retention time of >1yr in the spring of 2012 and monitored it over the ice-free season, while using an adjacent end-pit lake as a reference. Fertilization lead to elevated surface temperatures and a rise in the thermocline. A phytoplankton bloom established shortly after fertilization, increasing the dissolved oxygen concentration on the surface to super-saturation, while decreasing oxygen levels below surface to the metalimnion. However, anoxia did not establish below the metalimnion. The zooplankton community increased in abundance by 50-fold approximately two weeks after bloom establishment but was not able to control the phytoplankton. This made the bloom stable for approximately two months. Selenium concentrations did not change over the course of the experiment, likely due to strong

wind mixing and subsequent higher than usual dissolved oxygen concentrations in the hypolimnion. We suggest that maintaining highly eutrophic regimes while adding more organic matter intro the lake might increase anoxic habitat with higher bacterial growth and subsequent reduction of selenium from within the system over the long-term.

Oral SCL (Disturbed Ecosystems, Threatened Species and Restoration)

AVIAN-DRIVEN ALTERATIONS IN SEASONAL CARBON CYCLING OF AN ARCTIC TUNDRA POND IN WAPUSK NATIONAL PARK (MANITOBA, CANADA)

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Arctic ponds provide important habitat and resources to support abundant waterfowl populations. However, concerns have been mounting regarding the effects of increased waterfowl on eutrophication and biogeochemical cycling. Previous studies of waterfowl disturbance in arctic freshwater ecosystems have largely relied on conventional 'snapshot' limnological measurements but have yet to incorporate both multi-seasonal and biogeochemical measurements (e.g., carbon isotopes and carbon fluxes) that can potentially provide further insights. Over the last ~40 years, coastal regions of Wapusk National Park (Manitoba, Canada) have witnessed rapid increases in the density and nesting area of the Lesser Snow Goose population (LSG). In this study, we used a combination of limnological measurements and water and carbon isotope tracers to compare seasonal patterns of hydrolimnological and biogeochemical conditions between 15 shallow ponds (LDCF ponds) that currently have only low disturbance from the LSG population with one highly-disturbed pond (WAP 20). Using contemporary hydrolimnological measurements only small differences could be identified between the highly disturbed WAP 20 and the LDCF ponds. In contrast, carbon isotope biogeochemistry measurements reveal distinctive carbon dynamics in WAP 20. During mid-summer, a decrease in $\delta^{13}C_{DIC}$ values in WAP 20 may be a consequence of intense benthic algal carbon demand in the presence of high pH. In other studies, these conditions have been suggested to promote 'chemically-enhanced CO_2 invasion', which leads to strong kinetic carbon isotope fractionation and implies that WAP 20 acted as a carbon sink at this time. In contrast, the LDCF ponds exhibited typical seasonal carbon isotope behaviour under conditions of increasing productivity when carbon is in relatively low demand. Overall, results suggest that high levels of waterfowl disturbance have the potential to alter biogeochemical cycles in arctic ponds.

Poster SCL (Carbon Flux and Nutrient Cycling)

BIOASSESSMENT OF CUMULATIVE EFFECTS ON WATER QUALITY IN THE MUSKOKA RIVER WATERSHED

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The more than 2,000 lakes within the Muskoka River watershed (MRW) constitute a diversity of ecosystems. The natural allure of this landscape draws thousands of seasonal visitors. Consequently, lakes of the MRW receive substantial anthropogenic inputs that threaten water quality and ecological status. My research will develop regional biomonitoring methods, based on analysis of periphytic diatoms for detecting cumulative effects of multiple interacting stressors. A key component is to quantify baseline conditions and the range of natural variation in lakes throughout the watershed via analyses of lakes without known disturbances. Furthermore, I will evaluate how diatom communities respond to changes in nutrient loads and determine the relative importance of key stressors (e.g., development, agriculture, climate variations). Our study used a nested experimental design to strategically select 93 lakes for fieldwork conducted in 2013. Lakes were initially categorized as impacted or reference by their degree of disturbance using identified stressors within the catchment. Composite water chemistry and periphyton samples (HPLC, Chla and high taxonomic resolution of diatom algae) were created and analyzed from three random sites along lake shorelines, using established methods developed by the Hall lab. This poster will provide an overview of the study. The end-goal is to enhance the capacity of agencies tasked with environmental stewardship to maintain effective long-term monitoring programs and improve biomonitoring practices of watersheds across Canada.

Poster SCL (Multiple Stressors)

MOVEMENT OF ARCTIC GRAYLING IN A CHANGING LANDSCAPE

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Arctic grayling (*Thymallus arcticus*) is an important circumpolar Arctic species that provides a model system for understanding the impacts of changing seasonality on Arctic ecosystem function. Climatic change that affects the seasonality of river hydrology could have a significant impact on grayling populations: grayling may leave overwintering lakes sooner in the spring and return later in the fall due to a longer open water season, but the migration could be disrupted by drought due to increased variability in discharge. For one component of a larger study, the FISHSCAPE project is assessing how the shifting seasonality of Arctic river hydrology alters key biotic linkages within and between lake and stream components of watersheds and may alter

the function of the Arctic system. To address these goals we undertook surveys of grayling migration dynamics for populations located on the North Slope of the Brooks Mountain Range, Alaska. In 2010 - 2012, we used Passive Integrated Transponder (PIT) tags, coupled with stream-side antenna units to monitor grayling migration dynamics in Arctic tundra watersheds under variable hydrologic conditions. Results indicate that grayling migration is intimately linked to hydrologic conditions. During seasonal migrations into overwintering lakes, grayling use flooding events and high water as the cue to move. However, if access to overwintering refuges is blocked by dry streams, as in 2011, migrants experience a heavy cost in duration of migration, condition, and overwintering survival. Stream and lake derived stable isotopes also indicate that lake trout rely on seasonally transported inputs of stream nutrients for growth. Thus, changes in the seasonality of river hydrology may have broader impacts throughout Arctic watersheds. Improved understanding of these processes will advance our general understanding of the role of animals in ecosystem dynamics, life-history evolution, and ecosystem management.

Oral CCFFR (Migration, Mixing and Dispersal)

THE INFLUENCE OF STRESSOR ORDER ON THE NET EFFFECT OF INVASIVE FISH AND WARMING ON ZOOPLANKTON COMMUNITIES

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Non-native sportfish and climate warming pose two of the greatest threats to lake ecosystems but their net effect is unknown. We hypothesized that these stressors would interact to affect zooplankton communities and moreover, that their net effect would depend on the order of exposure to the stressors. Specifically, we hypothesized that fish predation would shift communities towards small zooplankton that would be more metabolically adapted to subsequent warming, thereby dampening the net stressor effect. Conversely, we hypothesized that warming would stimulate predation by the top invertebrate predator, *Chaoborus* spp., and shift communities towards large zooplankton that would be more susceptible to subsequent fish predation, thereby amplifying the net stressor effect. To test these hypotheses, we performed a 42-day outdoor mesocosm (1000 L) experiment in which plankton communities from five fishless mountain lakes were each exposed to predation by non-native rainbow trout (F) and/or warming (W) in six treatment combinations: an unstressed control, two sequential exposures (F then W, W then F), two single-stressor exposures (F, W) and one simultaneous exposure (FW). Fish predation and warming synergistically amplified zooplankton biomass and simultaneous exposure to stressors, not stressor order, drove their net effect. Fish predation shifted communities towards small species, while warming had no independent effect but amplified the biomass of small zooplankton favoured by fish. Higher zooplankton biomass was supported by higher algal biomass in the presence of fish possibly due to increased nutrient recycling. These findings suggest that stressor order may be less important when stressors exert highly asymmetric impacts.

Oral SCL (Multiple Stressors)

ZOOPLANKTON IN THE FAR NORTH OF ONTARIO: REGIONAL CONTRASTS AND COMPARISONS

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Currently there is very little existing scientific knowledge about waters in the far north of Ontario, despite that this region contains the majority of lakes in Ontario (The Far North Science Advisory Panel, 2010). Given the particular interest in potential mining development in the "Ring of Fire" area of north-western Ontario, I plan to conduct three survey-based aquatic science projects in this general area. First, the water chemistry data from a 2011 geochemistry sampling survey carried out by the Geological Survey of Ontario will be used to characterize the relationships between landscape characteristics (geology, wetlands, soils, vegetation) and lake water chemistry in the Ring of Fire region. Secondly, in July 2012, I will conduct a basic limnological survey of ~20 lakes in the Ring of Fire area. The lakes will cover a gradient of lake types present on both the Boreal Shield and the Hudson Bay lowlands. This project will characterize the range of selected physical, chemical, and biological characteristics (zooplankton and phytoplankton) in lakes of the region. Thirdly, data from this survey will be compared to similar zooplankton surveys that have recently been completed, or are being conducted in other areas of the far north. By comparing regional patterns in zooplankton community composition as documented in different areas of Ontario, I will determine if we can transfer existing knowledge of zooplankton/environment/ stressor relationships from more southern lakes to assist with the management of lakes in the northern boreal region.

Oral SCL (Northern Ecosystems)

CHANGES IN THE LAKE MICHIGAN FOOD WEB FOLLOWING DREISSENID MUSSEL INVASIONS

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Dreissenid mussels became well established in Lake Michigan during the 1990s and early 2000s. Another invertebrate invader, *Bythotrephes longimanus*, became established in Lake Michigan

during the late 1980s. Abundance of the amphipod *Diporeia* dramatically decreased during the 1990s and 2000s, and this decline has been linked to the dreissenid mussel invasions. Spring total phosphorus (TP), an indicator of primary production, decreased by roughly 35% between the 1990s and the late 2000s. *Daphnia* and cyclopoid copepod biomass in the offshore declined during 1994-2008, but both groups have recently rebounded. Calanoid copepod biomass has been relatively stable since 1994. Similarly, total zooplankton biomass in the offshore waters has trended neither upward nor downward during 1994-2011. Total prey fish biomass available to the bottom trawl substantially declined between the 1990s and the 2000s, as the lowest biomasses on record were observed during 2007-2011. In contrast, piscivorous fish biomass has remained high during 1994-2011, with a significant increase during 1995-2000. Reductions in alewife (*Alosa pseudoharengus*) and lake whitefish (*Coregonus clupeaformis*) condition and growth during the 1990s have been attributed to the decreased *Diporeia* abundance. Unraveling the top-down and bottom-up influences on the Lake Michigan fish community will require additional years of fish abundance surveillance, intensive studies on food web structure, and continued across-lake comparisons. Fish habitat changes induced by the dreissenid mussel invasions also need to be considered in explaining apparent changes in prey fish abundance. Some effects of the dreissenid mussel invasions on the fish community may be difficult to discern.

Invited Oral CCFFR (Great Lakes Fisheries and Environmental Policies)

INVASIVE PHRAGMITES EFFECTS ON COASTAL WETLAND FISH COMMUNITIES OF THE GREAT LAKES BASIN

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Within the Great Lakes basin the remaining areas of coastal wetland are considered essential fish habitats, and are commonly vegetated with emergent species of *Schoenoplectis* and *Typha.* These plants are determining factors in structuring the near shore fish assemblages of these areas. However, the invasive reed *Phragmites australis* often displaces these plants creating dense mono-specific stands. Yet, little is known about the effects of this plant on fresh water fish communities. Using data collected in 2011 & 2012 by the Great Lakes Coastal Wetland Monitoring project, 131 sampled sites were classified according to the dominant adjacent emergent vegetation type (*Schoenoplectis, Typha, or Phragmites).* The abundance and species richness of fishes caught during overnight fyke net sets were compared across the plant zones, with one way ANOVA followed by Tukey's pairwise comparisons (n= 26,548 individuals belonging to 79 species). Zones dominated by *Phragmites* had significantly fewer species than those dominated by *Schoenoplectus* ($p = 0.016$, $F= 3.971$). No significant difference in richness was found between *Phragmites* and *Typha* zones ($p= 0.271$, $F= 3.971$) or *Schoenoplectus* and *Typha* zones ($p= 0.448$, $F= 3.971$). There were no significant differences in abundance among zones ($p =0.2175$, $F= 1.544$). Overall, *Phragmites* monocultures appear to support fish assemblages similar to those associated with Typha stands. These areas provide spawning and

maturing havens for many commercial and game fish species and alteration can have serious ecologic and economic repercussions.

Poster CSWS (Wetland and Land/Water Linkages)

SEASONAL USE OF CRITICAL HABITAT BY THE BLANDING'S TURTLE (*EMYDOIDEA BLANDINGII*) ON BEAUSOLEIL ISLAND, GEORIGAN BAY ISLANDS NATIONAL PARK

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The Blanding's turtle (*Emydoidea blandingii*) is a semi-aquatic species that requires a variety of aquatic and terrestrial habitat types and it is listed as a species at risk primarily because of habitat loss and degradation. A key step in generating effective recovery strategies is to identify critical habitat for Blanding's turtle populations under a variety of geographic settings. Since little information for this species exists for the many islands of Georgian Bay, we conducted an intensive study on the movements of 12 turtles (6 males, 6 females) on Beausoleil Island. We used a combination of radio-tracking and GPS loggers to determine habitat selection during the active seasons of 2011 and 2012. We used aerial imagery to quantify available habitat and used compositional analyses to determine habitat preferences. Both sexes exploited vernal pools and wet forest as movement corridors between habitat patches. Females used inland wetlands initially and moved uplands to use coastal wetlands during the nesting season, whereas males maintained extensive use of the inland wetlands during the entire active season. An effective conservation strategy for Blanding's turtles in Georgian Bay must include protection of inland and coastal wetlands, in addition to the surrounding upland matrix and connecting corridors.

Oral CSWS (Disturbed Ecosystems, Threatened Species and Restoration)

ENERGETIC STRATEGIES OF NATURALIZED AND AQUACULTURE STRAINS OF RAINBOW TROUT (*ONCOHYNCHUS MYKISS*) IN A WHOLE-ECOSYSTEM EXPERIMENT

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Aquaculture-reared rainbow trout (*Oncorhynchus mykiss)* are selectively bred for high growth rates. Escapes of domestic rainbow trout into the surrounding environment from commercial operations located in the Canadian Laurentian Great Lakes are a reoccurring and common phenomenon. Current understanding of the interactions between domestic and established, naturalized (wild) conspecifics in these systems is poorly understood. Here, we determined the

comparative energetic strategies of a domestic and wild stain as they relate to growth and competition in the wild, using a whole-ecosystem approach. We stocked replicate lakes at the Experimental Lakes Area (ELA) in northwestern Ontario with equal numbers of size-matched domestic and wild rainbow trout. Differences in seasonal growth were quantified between strains and supported by analysis from stomach contents, stable isotopes and bioenergetics modeling. The results from this study suggest that domestic rainbow trout have the potential to more efficiently access and utilize energy sources, leading to growth rates as high as 3 times that of wild conspecifics. Additionally, domestic rainbow trout growth in the wild can be attributed to maximizing the ratio of energy acquisition to routine metabolic costs.

Oral CCFFR (Experimental Lakes Area Research)

TEMPORO-SPATIAL LIFE HISTORY SHFTS IN INVASIVE ROUND GOBY (*NEOGOBIUS MELANOSTOMUS*) DURING RANGE EXPANSION IN THE TRENT-SEVERN WATERWAY (CENTRAL ONTARIO)

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Invasive species have been shown to undergo life history shifts during range expansion that facilitate their establishment and spread in exotic environments, but the spatial and temporal scales over which these life history traits are modified have not been examined. To assess life history shifts during active range expansion, we examined male and female Round Goby (*Neogobius melanostomus*) in the Trent-Severn Waterway (central Ontario), a system that has had this species since 2003. Gonadosomatic Index, seasonal reproductive allocation, fecundity and oocyte size in females captured from newly colonised areas were compared with those taken from an adjacent area that had been colonised for about a year. The increase in reproductive output exhibited by the female Round Goby over such a small temporo-spatial scale suggests high levels of life-history plasticity. Higher reproductive allocation by females at the expansion front indicates a change in reproduction strategy, with females producing either more oocytes, larger oocytes or both. Higher reproduction allocation toward the expansion front was associated with lower population density. Seasonal somatic growth rate, body mass and body condition were also evaluated to determine whether those characteristics could be factors explaining shifts in reproductive output.

Oral CCFFR (Invasive Species)

A HIGH-RESOLUTION INVESTIGATION OF GROUNDWATER/SURFACE WATER INTERACTION AND ITS CORRELATION TO SALMONID REDD SITE SELECTION

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A high resolution network apparatus has been developed to measure temperature and conductivity of upwelling groundwater into stream channels in wadable flow depth conditions. The purpose of the apparatus is to assess the spatial distribution of groundwater upwelling at high (30 cm grid spacing) resolution conjunctively with a spatial inventory of salmonid redds (brown, rainbow and bull trout) to correlate fish spawning selection preferences with groundwater discharge in the hyporheic zone. The spatial inventory of redds includes approximately 200 geodetic locations of salmonid redds from 10 different rivers in southern Ontario and British Columbia. Spatial correlation of the redd locations has identified that brown trout (fall spawners) and rainbow trout (spring spawners) construct redds in nearly identical locations. Initial network results from 6000-7000 discrete temperature and conductivity measurements per riffle (morphological features averaging 14m wide by 72m in length) on a historic and current spawning riffle of Whiteman's Creek in Brantford, Ontario indicate that redds are infrequently located immediately above groundwater discharge locations where low conductance and decreased temperature are observed. A greater proportion of the redds appear to be located immediately downstream of emerging groundwater discharge locations within the vertical and transverse mixing zone of groundwater and surface flow. Additional channel morphologies and spawning locations are being inventoried to determine if the result is a consistent observation or specific to each depositional region. Additional observations will allow for re-interpretation of redd spatial distribution, and will better relate salmonid redd selection preference to the utilization of the river bed.

Oral CCFFR (General Session)

USING ECOSYSTEM MODELS FOR A LARGE LAKE ECOSYSTEM TO EXAMINE DYNAMIC RELATIONSHIPS BETWEEN WALLEYE, CORMORANTS, AND YELLOW PERCH

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Increased population sizes of double-crested cormorants (*Phalacrocorax auritus*) and small-bodied yellow perch (*Perca flavescens*) have occurred at Lac la Biche, Alberta, Canada since fisheries collapsed the walleye (*Sander vitreus*) population. A walleye restoration program was introduced in 2005 but uncertainty around the ecosystem's response (global stability or alternate stable state) to management masks the interpretability of program success. This study used forty variations of Ecopath with Ecosim models representing ecosystem conditions over 200 years to test the potential for multiple attractors in a large lake ecosystem. Results suggest that alternate stable states, defined by walleye-dominated and cormorant-dominated equilibriums, existed in historical models (1800, 1900) while contemporary models (1965, 2005) had a single cormorant-dominated attractor. ASSs were triggered by smaller perturbations in 1900 than in 1800, and

model responses were more intense in 1900, suggesting a decline in system resilience between model periods. Total prey biomass consumed by walleye was up to four times greater than the biomass consumed by cormorants in historical models, but dropped to 10% of cormorant consumption in 2005 models. Differential size-selection pressures of cormorants and walleye on yellow perch provide a strong feedback that stabilizes each state. These results provide important theoretical support for alternate stable states as well as practical insights for restoration of large lake ecosystems affected by human-induced overharvest of top-level fish predators.

Oral CCFFR (General Session)

SEA LAMPREY (*PETROMYZON MARINUS*) EXPLOIT HYDRODYNAMIC CONDITIONS TO APPROACH AND PASS AN IN-STREAM BARRIER

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We conducted experiments in a laboratory flume to investigate the responses of sea lamprey (*Petromyzon marinus*) to hydrodynamic conditions near and at a barrier to upstream migration. Such responses could assist with designs of instream barriers and traps used to control invasive fishes. A Y-maze design assessed whether sea lamprey responded to flow while approaching a barrier where alternative configurations of holes differing in their degree of hydrodynamic challenge were presented on either side of a center divider. Behaviour at the barrier was used to assess whether sea lamprey distinguished among individual openings. Upon release, sea lamprey displayed a preference for the side of the flume where velocities were highest. At the barrier, the sea lamprey selected openings in the lower and upper corners of the barrier over an opening in its center. Selection of holes was due to sea lamprey approaching the baffle along the walls of the flume and the reduced hydrodynamic challenge presented by openings at the corners versus the center of the barrier. Sea lamprey exploit subtle hydrodynamic structure when swimming up to, and at, barriers to movement. Openings at the corners of barriers and traps could be more attractive to sea lamprey than openings in the center.

Invited Oral CCFFR (Migration, Mixing and Dispersal)

CATCH ME IF YOU CAN: SEA LAMPREY (*PETROMYZON MARINUS)* BEHAVIOUR AT THE ENTRANCE OF TRAPS IN THE ST. MARY'S RIVER

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We tested five hypotheses for lower than desired trapping success of sea lamprey (*Petromyzon marinus*) in the St. Mary's River connecting Lakes Huron and Superior. The sea lamprey is an invasive species in the Great Lakes and the target of a binational control program. Trapping could be a valuable form of sea lamprey control in large rivers if trapping success could be increased. We used video surveillance at traps to assess sea lamprey behaviour as part of an experiment investigating how trapping success changed in response to alterations of nightly discharge through a power plant where sea lamprey are trapped. Consistent with earlier research, many sea lamprey that encountered traps did not enter. We hypothesized that entrance rates were low because sea lamprey (i) could not reach the trap opening either because high discharge made it difficult to swim to (H1) or because they failed to detect the opening due to complex flows (H2), (ii) had to compete with other sea lamprey for access to the trap opening (H3), or (iii) reached the trap opening, but "decided" not to enter because of either individual differences in behaviour (H4) or responses to environmental conditions at the time of their arrival (H5). Sea lamprey encountered trap entrances with high probability regardless of discharge, contrary to H1 and H2. They were often at the trap opening alone, contrary to H3. Our findings demonstrate how understanding behaviour can be crucial to improving the trapping success of invasive species.

Oral CCFFR (General Session)

SPECIATION REVERSAL IN FISHES INHABITING HYDROELECTRIC RESERVOIRS IN THE KANANASKIS REGION OF ALBERTA

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Disturbed environments are associated with the breakdown of barriers to hybridization (i.e., speciation reversal). By studying hybrid populations of suckers (*Catostomus commersonii* x *Ca. catostomus*) and cyprinids (*Couesius plumbeus* x *Rhinichthys cataractae*) that occur in hydroelectric reservoirs in the Kananaskis region of Alberta, we are able to infer the genetic basis of adaptive differences between these species, and the genetic basis of reproductive isolation. Restriction-site associated DNA sequencing allows sampling of many genetic loci in many hybrid and non-hybrid individuals to quantify associations between the loci implicated in reproductive isolation and the loci implicated in adaptive divergence. Genetic loci with lower than expected heterozygosity in hybrids are implicated in reproductive isolation. Genetic loci that are divergent between each pair of species are implicated in adaptive divergence. We are also able to infer selection against hybrids by sampling multiple age classes and measuring the decline in hybrid proportion with increasing age. With a clearer understanding of the

relationship between the genetic basis of speciation and the genetic basis of adaptation, we will be able to make predictions about the role of genetic architecture in both promoting adaptive divergence and facilitating species collapse. "Genetic architecture" refers to the number of genes underlying adaptation and/or speciation, their distribution across the genome, and the linkage among these genes and neutral loci throughout the genome.

Invited Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

THINGS TO CONSIDER WHEN CREATING AN AQUATIC ECOSYSTEM CLASSIFICATION

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Aquatic ecosystem classifications are management tools that can serve an impressive number of land-water management goals, including: to describe what is known (where and what is there); to communicate and report on ecosystem status; and to represent hypotheses about how we think ecosystems behave. As such they are often considered a first and necessary step towards evaluating ecosystem services and expected ecosystem response(s) to stressors. The process of classification involves grouping objects (i.e., ecological units) together on the basis of known similarities or relationships between the objects of interest. Aquatic classifications, however, differ in a number of fundamental ways from their land-based counterparts, and it is important that these differences are understood. This talk will cover the principle aspects to consider during the creation of aquatic ecosystem classifications. 1) How will boundaries between ecosystem units (e.g., aquatic segments) be identified? Will river-lake-wetland systems be segmented into separate components or will small ecosystems be identified by aggregating sections of water together? 2) What will be the smallest unit of classification? 3) Is there a defined spatial relationship between up and downstream sections of the network? 4) How will changes in spatial scale be addressed? 4) What is the mapping resolution and how does this affect classification metrics such as fragmentation metrics that capture river fragmentation by dams? 5) What statistical clustering methods will be used? How will number of classes be determined? Will land-based attributes of upstream contributing areas influence class outcome?

Oral CCFFR (General Session)

STOICHIOMETRY OF *MOUGEOTIA:* HOMEOSTATIC RESPONSES TO VARIABLE NUTRIENT SUPPLY?

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Filamentous green algae (FGA) are widespread and abundant across much of the Kawartha Lakes in southern Ontario. Despite their prevalence, little is known about the environmental controls on their growth and spread. We examined growth rates and cellular stoichiometry of *Mougeotia* grown under variable supply rates and ratios of nitrogen and phosphorus in a laboratory experiment. In short, *Mougeotia* was purified from samples obtained from the Kawartha Lakes and exposed varying concentrations of dissolved N and P in an environmental chamber for 17 days. In terms of cellular N:P ratios, *Mougeotia* was relatively homeostatic (H=0.25) compared to other commonly studied green alga such as *Scenedesmus*, in response to increasing water N:P ratios. *Mougeotia* mass-specific growth rates varied between 0.22 and 0.32 day-1 with maximum growth rates occurring in media N:P ratios of 12. Our results demonstrate that the elemental composition of *Mougetia* is variable, albeit less than expected, to changed in external nutrient supply. Consequently, use of Mougetia stoichiometry to diagnose the type and severity of nutrient limitation of FGA in the Kawartha Lakes should be taken with care.

Oral SCL (Carbon Flux and Nutrient Cycling)

INFLUENCE OF EXPERIMENTAL CORTISOL MANIPULATION ON OUTMIGRATION BEHAVIOUR, SURVIVAL AND GROWTH OF SEA TROUT SMOLTS

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For out-migrating sea trout (*Salmo trutta*) smolts, the transition from life in freshwater to the marine environment is an inherently challenging and dangerous period characterized by high levels of mortality. As such, smoltification is a relevant life-history phase to examine how physiological state, in particular, glucocorticoids, influences fitness-oriented endpoints such as migration timing and survival. By combining passive integrated transponder (PIT) tagging with exogenous cortisol manipulation (i.e., intra-coelomic injection) we experimentally assessed the outmigration behaviour (timing and speed), survival, and growth of anadromous brown trout smolts. Backpack electroshocking was used to capture smolts in five reaches of the Gudsø Møllebæk River in eastern Jutland, Denmark. PIT tags were inserted into all trout before they were allocated to one of four treatment categories: Control (CO), Sham (SH), and Low- (LW; ~0.025 mg/g) and High-dose (HI; ~0.1 mg/g) cortisol. In total, 771 trout were PIT tagged, with approximately equal numbers in each treatment. Two PIT-tag reading stations located downstream of the tagging site monitored outmigration into Kolding Fjord. Once outmigration was complete, the system was electroshocked again to contrast growth of trout that remained in the system. We found no difference in the timing of outmigration among treatments, but recaptured individuals tended to be smaller for the cortisol treatments. Future long-term monitoring of this population may demonstrate the long-term repercussions of chronic stress as trout return from the ocean and further contribute to our understanding of the relationship between organismal condition and fitness.

Oral CCFFR (Migration, Mixing and Dispersal)

IDENTIFICATION OF THERMAL HABITAT USE BY 1SW ATLANTIC SALMON (*SALMO SALAR*) OF NORTH AMERICAN ORIGIN DURING SUMMERS AT SEA, USING OXYGEN STABLE ISOTOPES

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Otolith-derived thermal habitat estimates of male and female 1SW Atlantic salmon (*Salmo salar*) of North American origin were generated for fish caught by the collaborative Salmon-at-Sea (SALSEA) sampling program off West Greenland in 2009 and 2010. Two summers of otolith growth were sub-sampled via micro-milling from each of 40 fish and analysed by mass spectrometry to produce $\delta^{18}O$ values. A salmonid-based fractionation equation was used to convert obtained oxygen isotope values to temperature, producing estimates of the summer-specific marine thermal habitat experienced by each fish. Sex-specific and summer-specific (age-related) temperatures did not show significant differences, but pooled data produced significant differences in the mean occupied thermal habitats between fish caught in 2009 and 2010. Sea surface temperature (SST) data were obtained from the NOAA Extended Reconstructed SST V3b Database for the Labrador Sea and West Greenland coast to determine whether differences in salmon thermal habitat reflect changes in SST conditions in the years from 2008 to 2010. Otolith-derived temperature estimates were also correlated with the measured width of the respective otolith summer growth zones to determine the extent to which temperature is a predictor of Atlantic salmon growth at sea. Relationships between $\delta^{18}O$ and $\delta^{13}C$ otolith values did not show significant correlation, indicating the absence of metabolic influence on oxygen stable isotope fractionation in otoliths of 1SW Atlantic salmon of North American origin.

Poster CCFFR (Salmonids as Sentinel Species)

CYANOBACTERIA RESEARCH AT ELA

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Forty years of continuous nutrient additions to Lake 227 have clearly shown that elevated nutrient loading leads to increased primary productivity and formation of cyanobacterial blooms. While phosphorus is a strong risk factor for bloom formation, the mechanism which causes

cyanobacteria to displace eukaryotic phytoplankton as the dominant phytoplankton taxa in enriched waters was not known until recently. Using whole-lake, mesocosm and laboratory studies, this presentation explores how phosphorus, nitrogen and iron interact to promote blooms of cyanobacteria fixers and non-fixers.

Invited Oral SCL (Experimental Lakes Area Research)

DESCRIBING THE DISPERSAL BEHAVIOUR OF BAFFIN ISLAND ANADROMOUS ARCTIC CHAR USING A GENETIC ASSIGNMENT APPROACH

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Anadromous Arctic char (*Salvelinus alpinus*) is subject to a commercial fishery in Cumberland Sound, Baffin Island, Nunavut. The fishery is currently managed on a river-by-river basis, assuming that most individuals home to their river of origin. Tagging data from other regions, however, suggest that straying (dispersal) is more common in this species than in other salmonids. We use data from 14 microsatellite loci to quantify dispersal in Arctic char from 15 rivers around Cumberland Sound, Nunavut. Due to low genetic differentiation among rivers, we obtained different estimates of dispersal depending on the genetic assignment method used. All estimates of numbers of dispersers, however, are fairly high and range between 16% and 45%. We also find evidence that individuals in reproductive condition are more likely to home than individuals not in reproductive condition. This higher propensity to disperse in years where they forego reproduction has interesting implications for the evolution of local adaptation in this system. Other biological traits (sex, age, fork length, weight, gonad weight, and condition factor) were not good predictors of dispersal propensity. Understanding the dispersal behavior of Arctic char will be crucial as the commercial fishery for this species intensifies. Our study demonstrates the usefulness, but also highlights limitations, of using genetic markers for the study of dispersal in Arctic fisheries.

Oral CCFFR (Northern Ecosystems)

THE FATE OF DEAD FISH IN AN URBAN STREAM: INSIGHTS FOR TRACKING STUDIES AND FISH KILL INVESTIGATIONS

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Mortality is a key factor in understanding the population dynamics of fish. For studies using biotelemetry, missing individuals pose a challenge since the ultimate fate of both the animal and

the tag are unknown. While there have been many studies on the mortality of fish associated with fisheries interactions and migration, there has been little research on the fate of fish that die. Furthermore, even though fish may be subject to high mortality rates, rarely are dead fish evident in the field except following a major fish kill. In lotic systems, there is the potential for carcasses to be dispersed great distances before decomposing. In contrast, during low water conditions or extreme drought, dead fish may end up on shore, where they are subject to scavengers and decomposition. In this study, we document a simulated small-scale fish kill of PIT- and radio-tagged fish to determine both the fate of deceased fish in a small stream and the radio and PIT tags with which they were tagged. In addition, we contrast the decomposition rates of deceased fish instream with those on the riverbank. By examining the role of scavengers, dispersal and decomposition, it is possible to understand the fate of dead fish in order to improve our understanding of fish kills and the impact of mortality in tagging experiments.

Poster CCFFR (General Session)

HYDRAULIC IMPLICATIONS OF HYDROELECTRIC DAM DISCHARGE PRACTICES ON CRITICAL FISH SPAWNING HABITAT IN THE RAINY RIVER, ONTARIO

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River regulation for the purposes of flood control and hydropower generation causes major deviations in the flow regime from natural hydrologic conditions, altering the nature of river hydraulics. Success and stability of river ecosystems are often dependent on specific hydraulic conditions occurring on certain spatial and temporal scales. In 2001, the International Joint Commission (IJC) issued an Order specifying water level and discharge ranges on the Rainy River watershed, subject to review in 2015. As part of priority studies for said review, simultaneous biological and hydraulic river surveys were performed from April – August, 2012 on a 22 km stretch of the Rainy River directly downstream of the International Falls Dam. Lake Sturgeon, Walleye, and Logperch surveys identified crucial spawning locations at specific river stages. Hydraulic conditions on the river were measured at 7 – 10 increments over a 3 m range in river stage using differential GPS-enabled Acoustic Doppler Profiler (ADP) technology at 47 standard cross section locations, in addition to identified fish spawning locations. Statistical characterization of hydraulic parameters over the range of surveyed discharges will be analyzed in concert with observations of fish spawning locations, providing linkages between the physical hydraulic processes and preferred biological habitat conditions. The identified hydro-ecologic relationships will be applied to develop weighted usable spawning area over the flow regime range, thereby identifying the range of discharges which optimize the spawning/nursery for the species of interest on the Rainy River.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

REDUCING GANGION BREAKING STRENGTH OF GREENLAND HALIBUT LONGLINE GEAR TO REDUCE GREENLAND SHARK BYCATCH IN THE CUMBERLAND SOUND

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Due to deteriorating sea ice conditions caused by climate change, turbot (*Reinhardtius hippoglossoides*) longline fishing through the ice during the winter months in the Cumberland Sound has experienced all time lows in the last number of years. To increase fishing opportunities for turbot, a summer vessel-based fishery has been proposed for the Cumberland Sound area.
A challenge to developing a successful summer fishery is the higher incidental bycatch of Greenland shark (*Somniosus microcephalus*), causing problems for fishers and posing a threat to sensitive Greenland shark populations. To develop an efficient and sustainable summer turbot fishery, finding a way to reduce shark capture and entanglement rates without affecting turbot catch rates is imperative.
Due to the large size difference between the bycatch and target species, modifying the gear by reducing gangion breaking strength was proposed as a method to reduce Greenland shark capture rates. To test if this gear modification has an effect on targeted and non-targeted species capture rates, three experimental breaking strength gangions were fished with a control on longline sets of 400 hooks. I hypothesized that with decreasing breaking strength shark catch rate would decrease without effecting turbot catch. If the hypotheses hold true then efforts to incorporate gangions with reduced breaking strength into commercial turbot fisheries within coastal waters of Nunavut will be pursued. This poster will present the results to date.

Poster CCFFR (Carbon Flux and Nutrient Cycling)

COMPARATIVE FISHING TO DETERMINE THE COMMERCIAL VIABILITY OF A NEW BOTTOM FRIENDLY SHRIMP TRAWL

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Newfoundland and Labrador supports the largest northern shrimp fishery in the world. The fishery is an economic driver for the region and provides the primary source of employment for many rural communities. The only viable method to harvest shrimp in this region is by the use of bottom trawls which can have negative ecological effects including destruction of habitat. In accordance with the Ecosystem Approach to fisheries management, reducing negative impact on

habitat is an important step towards sustainability. There is a need to develop fishing gears with reduced habitat impacts.
In this study we conducted a comparative fishing experiment in which a novel bottom trawl with reduced sea bed impacts was evaluated against a traditional bottom trawl. Using the alternate haul method (DFO, 1998), a total of 20 paired tows of 15 minute duration were conducted using a commercial vessel in the Gulf of St. Lawrence near Port au Choix, NL. Total catch weight and size distribution for shrimp and all bycatch species was measured for each tow.
I hypothesize that the experimental and traditional trawls are not statistically different in their catch weights and size distributions. This presentation will discuss our results to date. If successful, it is expected the innovations will be commercialized and implemented into the inshore shrimp trawling fleet.

Oral CCFFR (General Session)

MODIFYING BAITED COD POTS TO CAPTURE FLATFISH SPECIES WHILE EXCLUDING SNOW CRAB

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In the current study, the Newfoundland baited cod pot was modified to capture flatfish species while in the process attempting to reduce the incidental capture of snow crab (*Chionoecetes opilio*). Baited fish pots are an environmentally friendly fishing alternative to other fixed fishing gears such as gill nets and long lines. Pots generally have low start-up costs, minimal seabed impacts, greater quality of catch that can be sold at a higher price, and bycatch or undersized fish can be released alive and unharmed. In this study, 16 treatments were tested to determine which treatment or combinations of treatments were optimal at catching commercial quantities of flatfish while reducing bycatch of non-targeted species. Modifications to the existing Newfoundland cod pot design included entrance shape, type of fish retention device (FRD), FRD trigger spacings, and finally presence/absence of a light lure inside the pot. Originally Greenland halibut (*Reinhardtius hippoglossoides*) was the primary target species for this experiment due to a long standing voluntary closure for gill netting this species by small boat (<35') fisherman to reduce the incidence of snow crab bycatch. However, few Greenland halibut were captured. Instead some interesting information was obtained on the use of lights in baited and non-baited pots to capture American plaice (*Hippoglossoides platessoides*) which will open up further research into using light as a possible replacement for bait when targeting this species.

Poster CCFFR (General Session)

GEAR MODIFICATIONS TO A SHRIMP TRAWL TO REDUCE SEABED IMPACTS AND PRESERVE CATCH RATES IN THE ATLANTIC CANADA INSHORE SHRIMP FISHERY

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Bottom trawling is a common fishing method that involves the towing of a large net by a fishing vessel on the seabed to catch fish, shrimp or other target species that are on or near the seabed. The ground gear of trawls can have detrimental impacts to structurally complex seabed ecosystems. Digging and scraping by the ground gear when towed over mud bottom can damage or kill many marine organisms that inhabit the seabed. Bottom trawling fisheries are facing increasing restrictions, area closures, and bans in many regions around the world which all proves very challenging to the fishing industry. The shrimp fishing industry which takes place on soft muddy bottom is very important to Canada. Canada is one of the world's leading producers of coldwater shrimp, particularly Northern Shrimp (*Pandalus borealis*) and bottom trawling is currently the only economical means to harvest this species. If restrictions or bans were placed on this fishing method this industry would suffer greatly along with other bottom trawl fisheries in Atlantic Canada. In the current study, ground gear modifications were made to a shrimp trawl designed to reduce mechanical stress and contact area on the seabed by up to 50% while maintaining commercial quantities of shrimp. Variables such as catch rates, length of shrimp, breakage of shrimp, and bycatch of non-target species for this seabed friendly trawl were compared to a shrimp trawl with the traditional style ground gear which is commonly used in the shrimp fishery today.

Poster CCFFR (General Session)

IMPACTS OF ELECTROMAGNETIC FIELDS FROM WOLFE ISLAND SUBMARINE CABLE ON NEARSHORE FISH DIVERSITY AND DISTRIBUTION

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A recent review of the impacts of offshore wind power projects to Great Lakes fishes and their habitats identified that effects related to electromagnetic fields represent one of the most significant knowledge gaps. The limited amount of research undertaken to date indicates that electromagnetic fields may alter migratory behaviour and habitat use by fishes, and in particular electromagnetic-sensitive fishes such as American Eel, Lake Sturgeon, and salmonids. We assessed the impacts of an 8 km high-voltage (245 kV) transmission cable that runs across the lake-bed of eastern Lake Ontario between Wolfe Island and Kingston, Ontario. The objective of our study was to determine whether the spatial pattern and composition of nearshore fishes is influence by proximity to the cable and its associated electromagnetic fields. Spatially intensive point electrofishing surveys were used to characterize patterns of nearshore fish communities relative to the location of the transmission cable. We compared number of fish and species richness between study and reference transects, determined the influence of habitat and

proximity to cable on fish community structure and completed analysis to detect boundaries in fish assemblage composition. There was no significant difference in the structure of nearshore communities between the communities in close proximity to the cable and the reference transects. Fish community composition was found to be strongly correlated with water depth, substrate size, amount of complex aquatic vegetation but not with distance from transmission cable.

Poster CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

AMERICAN EEL HABITAT USE AND MOVEMENT IN THE LAC DES CHATS SECTION OF THE OTTAWA RIVER

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Hydroelectric dams are a major contributing factor to the decline of American eel, *Anguilla rostrata*, populations. The lac des Chats section of the Ottawa River continues to support American eel despite the presence of three hydroelectric dams downstream of the river section. The objective of this study was to characterize the habitat use and movement of American eel within the reach. Adult eels over 800g in weight were captured in the spring annually between 2008 and 2012 and surgically implanted with a radio transmitter. Eel positions were determined on a daily or weekly basis using a combination of aerial and boat tracking between June and October. In total, 36 eels were implanted with radio transmitters. Seven eel moved downstream of the Chats dam and died in the process. Movement data revealed that eels occupied a small range of the available river, and preferred a rocky, highly reticulate portion of the shoreline. Average home range size was 0.67 km^2 and maximum total range was 28 km. Eel movement was greatest in the month of August corresponding to the timing of peak mortality rates observed in tailrace surveys on the Ottawa River. Results of this study will help inform conservation and mitigation measures that may be taken to recover American eel in the Ottawa River and its tributaries.

Poster CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

AVIAN SPECIES-AREA RELATIONSHIPS IN THE NATURAL AND CONSTRUCTED WETLANDS OF NORTHEASTEN ALBERTA

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Wetland habitats are in decline due to changing weather and impacts of human development. They are home to many avian species including a disproportionate number that are rare or at

risk. Thus, effective wetland conservation is essential. It has been documented that species diversity increases with habitat area; larger wetlands support greater avian diversity as well as individual species abundance. We attempt to make associations of habitat characteristics to avian diversity to determine if constructed wetlands are able to support avian communities comparable to those wetlands found in natural boreal forest. Additionally, because colonization of high trophic level species is dependent on colonization of their lower trophic level food sources, we hypothesized that plant and bird species-area relationships should have positive correlations. We performed point counts in constructed and natural wetlands in northeastern Alberta; an area experiencing disturbance due to open-pit oil sand mining. Preliminary results for 2011 suggest that constructed wetlands have greater avian species richness than natural wetlands and that plant and avian species richness correlates with increasing wetland area, however, a small sample sizes limits our ability to detect a significant trend. This research will be used to produce a multitaxon comparative assessment of the relationship between area and biodiversity in reclaimed and natural wetlands of the oil sands landscape. Research on the relationship between wetland size and species richness and between plant and avian diversity will provide a better understanding of the habitat requirements needed to build and conserve sustainable wetlands comparable to those found naturally.

Poster CSWS (Disturbed Ecosystems, Threatened Species and Restoration)

USING GAME CAMERAS TO REMOTELY MEASURE ANGLING EFFORT ON SMALL LAKES: A CASE STUDY FROM BRITISH COLUMBIA

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Quantification of angling effort using traditional methods (creel surveys, aerial counts) typically involves long hours and high costs. In an era of tight budgets and diminishing human resources, fisheries managers are seeking low cost alternatives. One such method is the use of commercially available wildlife cameras. We have been developing methods to measure effort using wildlife cameras on approximately 50 small lakes (less than 100 ha) in British Columbia since 2007. Cameras were programmed to take hourly pictures of the lake, and when combined with periodic ground-based counts, hourly counts can be extrapolated into estimates of daily and seasonal angling effort. We discuss the use, effectiveness and limitations of using time-lapse cameras to measure effort on small lakes.

Poster CCFFR (General Session)

SNOW CRAB-SHRIMP TRAWLING INTERACTIONS: A CASE STUDY USING TRAWL MOUNTED CAMERA OBSERVATIONS IN NAFO DIV 3K

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Catch rates of snow crab in NAFO Division 3K on the northeast coast of Newfoundland have been lower than expected recently. While multiple potential factors, including poor recruitment, changing environmental conditions have been suspected for this situation, there has been increasing concern by both industry members and scientists about whether shrimp trawl activity negatively affects snow crab population and/or habitat. To clarify this concern, we conducted trawl mounted camera observations in NAFO Div 3K aboard Clyde Noble's vessel (*F/V Lynette Marine II*) during June 2012. A self-contained underwater camera system (e.g. low-light standard definition -SD) and secondary lighting unit developed by JT Electric were attached to a traditional shrimp trawl to collect video footage of crab/trawl interaction. Altogether, a total of 15 tows were conducted yielding more than 9 hours of video. The video footage was analyzed using Observer XT software as an innovative solution for behavioural research developed by Noldus Information Technology B.V. to investigate the behaviour of snow crab in response to the footgear components. This study provides insight into how individual crab interact with the (rockhopper) footgear components of a shrimp trawl, including likelihood of reaction, orientation, reaction behaviour (e.g. avoidance/moving behaviour), reaction distance, and nature of collision. The results are expected to inform discussions about the impacts of trawling and assist the development of new policies and/or alternative gear designs.

Oral CCFFR (General Session)

STANDARD METABOLIC RATE RESPONSE OF ATLANTIC SALMON PARR (*SALMO SALAR*) TO DAILY THERMAL FLUCTUATIONS IS INFLUENCED BY TEMPERATURE ACCLIMATIZATION AND THERMAL HISTORY

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Water temperature is considered one of the most important environmental factors for fishes as it directly controls their feeding, growth and metabolic rates. Many studies have evaluated the impacts of different water temperatures on fish metabolic rates when temperatures were held constant. Results from these studies may not be representative of what is found in nature since, in rivers for instance, the water temperatures usually fluctuate on a daily basis. Previous results by Beauregard *et al.* (Submitted) showed that salmon parr from River Ouelle held under a constant temperature regime (20°C) had Standard Metabolic Rates (SMR) up to 32% lower than parr held under a fluctuating regime (20±2,5°C). Temperature of acclimatization, river of origin and thermal history may influence fish metabolic response. The objective of this study is to compare SMR of Atlantic salmon parr collected from two rivers (Ouelle and Cascapedia Rivers, Quebec) and acclimatized in laboratory to four thermal regimes (constant (15°C, 20°C) or fluctuating daily (15±2,5°C, 20±2,5°C)). These regimes are based on observed natural regimes in both

rivers; average summer water temperature for the Ouelle River (20°C) is higher than for the Cascapedia River (15°C). SMR were measured using intermittent-flow respirometry on 24-hour time periods. Results show that the impact of a fluctuating regime compared to a constant regime depends on the average temperature at which the parr are acclimatized and is influenced by the thermal history of the fish. SMR values also differ according to the parr's river of origin.

Oral CCFFR (Climate Change)

MANAGING GREAT LAKES FISHERIES IN TIMES OF UNPRECEDENTED UNCERTAINTY: THE ROLE OF OBSERVING AND DATA SYSTEMS

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The Laurentian Great Lakes fishery represents an economically, socially, culturally, and ecologically valuable resource. The sheer size of the lakes, however, has hindered our understanding of the complex interactions of the fish community and created a hurdle for managers charged with protection and rehabilitation of this fishery. Advancing regional observing capacity and utilizing the latest technologies available for data management are key to providing the foundation for information managers need to adapt to the changing environment. The Great Lakes Observing System (GLOS) is a bi-national organization established to connect data users with data providers in ways that are supportive of policy and decision making. GLOS coordinates the advancement of observations, information technology, data delivery products, and related services in partnership with a broad network of members.
Through its role as a data management facilitator, GLOS makes a broader suite of interoperable data available to resource managers, decision-makers, researchers and other data users, allowing them to develop a more complete characterization of our Great Lakes by collecting and bringing information together to be used with other data sets, in models, and in data visualization products. For instance, GLOS worked with the Great Lakes Fisheries Commission to initiate ways to use data management to support coordination of the Great Lakes Acoustic Telemetry Observing System (GLATOS). There is tremendous potential to continue to build from this work and identify more opportunities to improve informed management and decision-making of Great Lakes fisheries. This presentation will explore the role for GLOS is supporting fisheries management.

Invited Oral CCFFR (Great Lakes Fisheries and Environmental Policies)

COMPLEX INTERACTIONS AMONG STRESSORS CAUSE REGIONAL CHANGE

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A majority of ecosystems are threatened by multiple stressors, yet we are only beginning to understand their cumulative risks and impacts. Knowledge of how stressors interact and the resultant ecological consequences are needed to inform efforts to restore and conserve valued ecosystems. Lakes in south-central Ontario are subject to numerous anthropogenic stressors including climate change, lakeshore development and acid deposition. These stressors have altered the physico-chemical environments of lakes across the region. We used a large-scale, replicated field survey to investigate how these changes, as well as the spread of the invasive predator *Bythotrephes*, have impacted zooplankton communities in lakes on the Canadian Shield over a 25-year period. We found that zooplankton total abundance, species richness, diversity and the relative abundances of prominent taxonomic orders of zooplankton changed in response to changes in water quality, lake thermal regime and predator composition. Stressor interactions were common and caused complex community shifts over time. This work provides the first quantitative, multi-decade assessment of the cumulative impacts of multiple physical, chemical and biological stressors and their interactions at a regional scale. Our findings indicate that the interactive effect of stressors must be considered when assessing human impacts in systems subject to multiple stressors.

Poster SCL (Multiple Stressors)

ESTUARINE WATER QUALITY FROM RELATIVELY UNIMPACTED WATERSHEDS DEPENDS AS MUCH ON NATURAL LAND FEATURES THAN ON ANTHROPIC ONES

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Land transformations can adversely impact estuarine water quality, as has been shown in the case of heavily impacted coastal watersheds. In such cases, intensive agricultural activities that dominate the catchment area can represent extra sources of nutrients to aquatic systems. Paradoxically, we know little about the strength of land-water connections in relatively unimpacted coastal systems. Coastal watersheds from Northeastern New Brunswick are still forested on 80% of their areas, but it remains unclear if anthropic land features influence water quality. We characterized four coastal watersheds in terms of their natural and anthropic terrestrial attributes and examined how water quality varied among estuaries (n=4), between hydrological positions (upstream freshwater, downstream saline), among years (dry 2010, wet 2012, 2013) and between seasons (spring, summer).Preliminary results indicate that about 60% of the variability in total organic carbon (TOC) concentration was associated with watershed. In contrast, other water quality parameters (phosphorus, ammonia, temperature, oxygen, conductivity, pH, turbidity, chl-a) generally had less than 20% of their variability associated with watershed, hydrological position (except conductivity: 68%), season (expect temperature: 65%),

or year (except pH: 61%). TOC was as strongly correlated to natural land features (drainage ratio) than to anthropic ones (percent wetland cover). Algal biomass showed a stronger (negative) correlation with (coloured) TOC, than with inorganic nutrients, suggesting that light may limit primary productivity more than nutrients. As wetlands in Northeastern NB are often exploited peat lands, more work is needed to assess the importance of peat land area and management on estuarine biological productivity.

Oral SCL (Wetland and Land/Water Linkages)

TEMPORAL AND SPATIAL VARIATION IN PEATLAND BIOGEOCHEMISTRY IN THE SMELTER AFFECTED AREA OF SUDBURY, ONTARIO

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The impact of acid and metal deposition on aquatic (lake) and terrestrial (forest) ecosystems in the Sudbury (ON) region is well documented. In contrast, despite their abundance in the region, there has been relatively little work on wetland functioning and no studies have investigated biogeochemical functions and relationships within wetlands in terms of regulating allochthonous material, nutrients and metals received from terrestrial and atmospheric sources and exported to aquatic environments. The objective of this study was to characterize the spatial and temporal variability in peat and pore water chemistry in 18 wetlands (poor fens) in the Sudbury area. Surface (0-30 cm) peat samples were sampled in the fall 2011 and summer 2012 campaigns and pore water chemistry was sampled in the fall 2011, spring and summer 2012 using wells installed at 0-30 cm depth. Metal (Cu, Ni Co) concentrations in peat exhibit a clear spatial pattern of decreasing concentration with increasing distance from the Copper Cliff smelter. However, most peat and pore water parameters exhibit both spatial and temporal variation among the peatlands. For example, sulphate (SO_4) concentrations were 10 fold lower in spring compared with fall and summer, and pore-water pH was more than 1pH unit higher in the spring. Wetlands with higher peat carbon contents and a lower groundwater influence had porewater with higher DOC and humification index (HIX) values. Nevertheless, metal partitioning (K_d) could be reasonably predicted by pH. Overall, these data demonstrate that peat and pore-water chemistry is influenced by a combination of temporal (seasonal), anthropogenic (metal and acid deposition) and natural (groundwater, peatland type) factors, which have important implications for future restoration projects.

Poster CSWS (Wetland and Land/Water Linkages)

CAN WE FORECAST THE OCCURRENCE OF CYANOBACTERIA BLOOMS IN MUSKOKA LAKES?

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Identification of factors that favour the development of epilimnetic cyanobacterial blooms in lakes is of vital importance for the effective management of our limited freshwater resources. However it is unclear what the important factors are for temperate lakes in the Muskoka region of Ontario. Hence the goal of our research is to assess the importance of several chemical, physical and meteorological variables for the cyanobacteria community. Here we use detailed data collected bi-weekly from two Muskoka lakes, Brandy and Three Mile, in 2002-2003 and 2006-2007, respectively. Cross-correlation time series analyses indicate that blooms are preceded (i.e. a 14 day positive lag period) by the following meteorological conditions: low winds, warm temperatures and low precipitation, and the chemical and physical conditions: low hypolimnetic oxygen, warm surface temperature, stable water column, high phosphorus concentrations and low TN:TP ratio. In general the chemical and physical parameters are more strongly correlated at a positive lag period of 14 days to % cyanobacteria in the phytoplankton community compared to meteorological factors. These results indicate that managers should be able to forecast bloom occurrence in a lake using the lake characteristics and, to a lesser extent, meteorological information.

Oral SCL (Multiple Stressors)

EFFECTS OF HYBRIDIZATION ON THE REINTRODUCTION OF ATLANTIC SALMON TO LAKE ONTARIO

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Atlantic salmon (*Salmo salar*) has historically been one of the most important salmonids in Lake Ontario for its role in commercial and sport fisheries and as a top predator. Although Atlantic salmon played a key role in Lake Ontario they were extirpated, partly owing to habitat loss due to human activities. Over the last two decades efforts have gone into revitalizing the lake's habitat and studies suggest that the Lake Ontario basin is now in appropriate condition for Atlantic salmon reintroduction. Three strains (LaHave, Sebago, and Lac St-Jean) of Atlantic salmon have been approved for reintroduction into Lake Ontario. However, little is known about the viability of hybrids from crosses created between strains. Hybrids can exhibit hybrid vigour or hybrid breakdown resulting from the effects of new genes being introduced into a population. We collected gametes from eight females and eight males (4 of each sex from each strain) and performed a full-factorial breeding design producing 64 families consisting of non-hybrid and hybrid offspring. Survival metrics were measured to assess whether hybrid vigour or breakdown occurs. Preliminary data show that there was no difference in early survivorship in hybrids as compared to non-hybrids, providing no support for the hybrid breakdown or vigour hypotheses.

Invited Oral CCFFR (Genetic Diversity and Adaptation)

EXAMINING ECOSYSTEM IMPACTS OF NON-NATIVE SPECIES IN AQUATIC SYSTEMS: THE ROUND GOBY IN GREAT LAKES TRIBUTARIES

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After habitat alteration, the introduction of non-native species is the dominant threat to aquatic biodiversity worldwide. As species invade novel habitats, they often face limited biotic resistance from native species, allowing for rapid spread. One example of such expansion has been the invasion of the Round Goby (Neogobius melanostomus) in the Great Lakes. Within five years of its original invasion in 1990, the Round Goby quickly spread to all the Great Lakes, with populations now estimated in the billions. However, despite nearly two decades of potential invasion, the secondary invasion of Round Goby into neighboring rivers was only recently documented, allowing for renewed interests in understanding the impacts to native communities, especially from an ecosystem perspective. I will discuss the results of several studies which compared native fish communities pre/post the secondary invasion of Round Goby, describe the magnitude of impacts of round goby invasion for the lotic fish community, and outline the potential implications for the management of Great Lakes tributaries. In particular, I will highlight the importance of indirect effects of species invasion, including how the invasion of Round Goby can facilitate the collapse of other aquatic species via disruptions in food web dynamics and host/parasite relationships. Results of simulations demonstrate that indeed indirect effects of species invasion may facilitate ecosystem collapse, supporting the invasional meltdown hypothesis. The results of these studies should emphasize the old adage that for the introduction of non-native species, an ounce of prevention is worth a pound of a cure.

Oral CCFFR (Invasive Species)

CONSUMER-RESOURCE SPATIAL ASSOCIATIONS AND PRODUCTIVE CAPACITY IN A MANITOBA RESERVOIR: A HYDROACOUSTICS APPROACH

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Fish productivity in aquatic ecosystems is dependent on the availability of food sources, particularly small forage fish and zooplankton, at multiple spatial scales. Anthropogenic activities such as hydropower production can drastically alter the structure and function of aquatic food webs and thus the productive capacity of fish habitat. We used a BioSonics DTX echosounder with multiple-frequency transducers at 200, 430 and 1000 kHz mounted on a five-

metre Boston whaler, to quantify multiple trophic levels in the Lac du Bonnet reservoir in Manitoba. Acoustic signals were verified using gillnetting and vertical plankton tows. The objective was to assess the degree and scale of spatial association between fish and lower trophic levels. Preliminary results suggest that spatial associations are size-dependent and vary over spatial scale, being strong at intermediate scales and weak at very small and large scales, relative to the size of the reservoir. Such methods have potential to enhance long-term ecological monitoring of hydro projects in Manitoba and elsewhere.

Poster CCFFR (Aquatic Ecosystem Services)

BODY STOICHIOMETRY AND GROWTH RATE OF *DAPHNIA:* ASSESSING WITHING AND AMONG POPULATION RESPONSES TO VARIABLE FOOD QUALITY

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Consumers are known to exhibit variable responses to food quality. Determining the source of this variation is essential for understanding how food quality effects on consumer traits and life history strategies alter ecosystem level processes. Here we examined within and among lake variation in body nutrient composition and growth rate of the generalist keystone consumer, *Daphnia spp.*. Consumer body elemental composition, food stoichiometry, and water column nutrients were surveyed from ten lakes in southern Ontario across a trophic gradient. We further examined differences in growth rate and body stoichiometry of five clones collected from each lake using common garden experiments where animals were fed variable food quality under controlled laboratory conditions. Variation in resource quality and elemental composition of *Daphnia* was found across and within field sites. We also found significant differences in growth rate and body stoichiometry responses to food quality among clones raised in the same laboratory environmental conditions. The variation in elemental composition and life history strategies could potentially alter zooplankton population dynamics and ecosystem nutrient cycling in lakes. As nutrient cycling models generally rely on mean variable information, consideration of the variation around mean trait values will lead to more ecologically realistic predictions.

Poster SCL (General Session)

BYCATCH OF ENDANGERED COHO SALMON IN AN ABOROGINAL FISHERY: MEASURING IMPACTS AND EVALUATING SOLUTIONS

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Following a population decline in the 1990s, the "nationally significant" coho salmon of the upper Fraser River watershed (British Columbia) was listed as endangered (COSEWIC). To improve prospects of recovery, regulations require that all wild coho salmon captured by Fraser River fisheries be released, while DFO restrict gillnetting and angling during the peak run-timing of the population to reduce incidental mortality. However, aboriginal (First Nations) fisheries are permitted to target co-migrating pink and sockeye salmon using beach seines, with an un-validated assumption of 95% post-release survival for coho salmon bycatch. From 2009 to 2011, we attended these fisheries in an effort to: 1) using radio telemetry, estimate post-release mortality of coho salmon bycatch, 2) develop tools to manage and reduce bycatch mortality, and 3) understand perspectives of the aboriginal fishing community. We gastrically implanted radio transmitters in 182 wild coho salmon over the three study years and tracked their migration success to DNA-identified natal subwatersheds. In doing so, we completed a validation of reflex action mortality predictors (RAMP), and evaluated the utility of pre-release facilitated recovery in a flow-through fish-holding bag. The data also provide a first glimpse into stock-specific migration behaviour for endangered Fraser River coho salmon. Our study demonstrates that integrating social science surveys into fisheries research provides interdisciplinary value to research findings and relevance to stakeholders.

Oral CCFFR (General Session)

THE ECOLOGICAL AND SOCIOLOGICAL FACTORS IN DECIDING ENDPOINTS FOR ECOSYSTEM RECOVERY

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Examples of ecosystems damaged by industry and other human activity are certainly not hard to find. But when these ecosystems are improved either through intervention or natural processes, an important question is when we might consider them "recovered". The recovery threshold may have sociological and legal, as well as ecological implications. One problem with recovery thresholds is that they may be difficult to define and, although rarely specified, are usually based on some idea of return of the ecosystem to a normative species complement. Unfortunately, the assumption that the trajectory of recovery would approach the condition of unaffected reference areas is often not the case in multiple-stressor environments. Broadscale effects such as urbanization, calcium decline, nitrogen pollution, and climate change all make the recovery threshold a moving target. Another problem with species-based recovery thresholds is that they ignore both ecosystem function and ecosystem value services. If a recovering lake can be shown to have food web dynamics similar to reference systems, does it matter that the species complements of the two systems are different? If people find recreational value in angling in a recovering lake, does it matter that the fish community is different from reference lakes? In this

paper, I use examples from long-term data sets on phytoplankton, benthos, zooplankton, and fish in recovering Sudbury lakes to illustrate some of the issues with recovery thresholds.

Oral SCL (Disturbed Ecosystems, Threatened Species and Restoration)

DO *DAPHNIA PULEX* GROW AND REPRODUCE BETTER IN PATCHY THAN UNIFORM ALGAL DISTRIBUTIONS?

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The heterogeneity of prey distributions is a well-documented phenomenon, yet many models of aquatic predator foraging assume homogeneous prey distributions. Previous modeling work has shown that the spatial distribution of prey should have a substantial impact on the foraging success of predators, though this theory has rarely been tested empirically. A series of homogeneous and heterogeneous distributions of the algal prey *Ankistrodesmus sp.* were created in 1L glass chambers in the lab using a combination of temperature and salinity gradients. The individual growth and fecundity of grazing *Daphnia pulex* were measured to test the assertion that growth and reproduction are greater in patchy prey. Results will be discussed in the context of spatial processes and trophic interactions.

Poster SCL (General Session)

STOCK ASSESSMENT AND MANAGEMENT OF LAKE NIPIGON LAKE WHITEFISH (*COREGONUS CLUPEAFORMIS*): A VALUE OF INFORMATION APPROACH

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A series of alternative hierarchical and uniform Bayesian surplus production models were used to estimate biological reference points, i.e., F_{MSY} and B_{MSY} and their uncertainty. We estimated the historic and current status of the Lake Nipigon lake whitefish fishery and showed that both the reference point estimates and stock status were highly uncertain. The results were highly sensitive to the priors and the catch and CUE time series used for parameter estimation. Using data from 1999-2010 resulted in much higher estimates for r and smaller estimates for K than when data from 1917-2010 was used, but the 1999-2010 times series generated bimodal posterior estimates of r and K, and depletion. DIC was used to rank the models. According to the best model, the probability of overfishing in 2010, i.e., $P(F_{2010}>F_{MSY})$, was very low at 0.005, while

the probability that the population was overfished in 2010, i.e., $P(B_{2010}<B_{MSY})$ was 0.544 due to high uncertainty about both B_{2010} and B_{MSY}. A Bayesian decision network model of the fishery was used to determine and rank the value of information associated with r, K, catchability, biomass and BRPs. The implications of the VOI analysis for decisions about assessment, harvest policy, and options to reduce stock status uncertainty to more acceptable levels, are discussed.

Oral CCFFR (Great Lakes Fisheries and Environmental Policies)

ARCTIC GRAYLING (THYMALLUS ARCTICUS) POPULATION STRUCTURE AND DIVERSITY IN A DISTURBED LANDSCAPE

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Arctic grayling (*Thymallus arcticus*) are cold-water, salt-water intolerant salmonids with a holarctic distribution including most of northern Canada. In Alberta, the abundance of Arctic grayling has been steadily declining since the 1950s and the species is now provincially classified as Sensitive. Although the suspected factors behind the Arctic grayling decline (e.g., overharvest, reduced habitat quality) have been documented, no genetic studies of Alberta Arctic grayling have been completed. To investigate population structure and genetic diversity, tissue has been collected from approximately 750 Arctic grayling from 24 rivers in the Hay River, Peace River and Athabasca River watersheds. We will develop and use microsatellite markers to investigate broad and fine scale population structure. It is expected that populations will be distinct between watersheds, and that structure within subwatersheds will represent a spatially nested hierarchy of sub-populations linked by infrequent gene flow. Subpopulations are likely because of varying degrees of isolation resulting from barriers, distance between subpopulations, and spawning site fidelity. We also expect genetic diversity in Arctic grayling populations to decrease in a south-eastern direction because these populations are the furthest from putative, northern refugia. In the future, we plan to use these data to investigate correlations between contemporary landscape features and genetic diversity of Arctic grayling subpopulations.

Poster CCFFR (Genetic Diversity and Adaption)

INVESTIGATING EFFECTS OF CLIMATE CHANGE ON WARMWATER FISHES

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To address concern regarding the potential effects of climate change on Canadian fisheries, many studies apply forecasts of climate warming applied to aquatic systems to estimate effects on fish

and fish habitat. However, regions of Canada have already demonstrated significant warming during the past four decades. At the Experimental Lakes Area (ELA) in Northwestern Ontario, mean annual air temperatures have increased by more than 1.5°C on average since 1969. Similarly, the ice-free period on Rawson Lake has increased by 17 days on average. Throughout this period, significant annual variation has also occurred, with mean annual temperature ranging nearly 5°C and ice free days by 47 days. Epilimnetic young-of-year (YOY) fish are likely susceptible to environmental conditions in the year they are born. We evaluated the role of annual weather patterns and temporal trends in the growth rate of young-of-year (YOY) minnows and yellow perch in reference lakes at the ELA. Preliminary analyses for Rawson Lake yellow perch showed that fall YOY size was greater in years with higher mean annual air temperature, cumulative growing degree days (>5°C, GDD) and an index of zooplankton prey abundance. Fall YOY size, GDD did not trend significantly with time, though our prey abundance index declined over time. Analyses of minnow YOY size will also be discussed.

Oral SCL (Experimental Lakes Area Research)

STATUS OF THE CHANGING LAKE HURON ECOSYSTEM

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The native offshore fish community in Lake Huron was disrupted by introductions of sea lamprey, alewife and rainbow smelt and was dominated by invasive species by the 1950s. More recently, introductions of dreissenid mussels, predatory zooplankters, and round gobies have further affected this community. The offshore waters of Lake Huron have recently shown signs of increasing oligotrophy, including reductions in phosphorus levels, changes in the concentration and seasonality of chlorophyll, and shifts in zooplankton abundance and community structure. The estimated lakewide biomass of offshore prey fishes in Lake Huron remains at unprecedented low levels, and the offshore demersal fish community had collapsed by 2006. Invasive alewife populations crashed in 2003 and estimated biomass of this species has remained very low, while native bloater abundance is beginning to rebound. Thiamine levels in lake trout eggs have increased in recent years, and natural reproduction of lake trout is occurring lakewide. Changes in offshore fish habitat use suggest that large-scale changes may be occurring in the offshore benthic environment. It is currently difficult to assess prey fish biomass estimates in the context of primary production and predator demand, as these are currently highly variable, poorly understood, and dependent on ongoing food web changes. The recent increased occurrence of *Cladophora* events and botulism outbreaks may also be related to recent foodweb changes. It has been suggested that Lake Huron may be undergoing a regime shift, and the consequences for future ecosystem services from the lake are uncertain.

Invited Oral CCFFR (Great Lakes Fisheries and Environmental Policies)

PARALLEL TRAIT RESPONSES IN FRESHWATER ZOOPLANKTON POPULATIONS AND COMMUNITIES TO INCREASED DISSOLVED ORGANIC CARBON?

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The interplay between evolution and ecology has increasingly been recognized as a significant factor that can alter trait variation and production in both populations and communities. To understand possible links between evolution in populations and the ecology of associated communities, it is necessary to test whether responses at each of these biological levels occurs in parallel or opposite directions. My study question is: do crustacean zooplankton populations and communities from clear (< 3.0mg/L DOC) versus dark (> 8.0 mg/L DOC) circum-neutral lakes differ similarly in their response to DOC addition? Specifically, I am interested in whether population-level traits (body-size, fecundity) differ between clear and dark lakes in a similar manner as related community-level parameters (secondary production and size-structured community biomass). To investigate possible links between population- and community-level trait variation, I conducted a common garden field mesocosm transplant experiment using three replicate communities from two different lake source types (dark or clear).My prediction was that dark-source zooplankton would show no affect associated with DOC addition, but that clear-source zooplankton would have reduced body size, fecundity, secondary production, and biomass under DOC-enriched conditions. Preliminary results suggest reductions of zooplankton abundance and secondary production irrespective of lake source in a high DOC environment. Testing for more subtle effects of lake origin on population-level traits and community size structure are underway. Quantifying landscape-level variation in zooplankton populations and communities along DOC gradients is a first step for informing us of potential eco-evolutionary responses to DOC enrichment of northern lakes associated with climate change.

Oral SCL (Multiple Stressors)

OVERWINTER SURVIVAL, LIPID, AND REPRODUCTIVE ALLOCATION OF NON-NATIVE FISHES INTRODUCED INTO NOVEL CLIMATES

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To be successful, non-native species must deal with the climate of their introduced range. In particular, the energetic demands of winter can vary dramatically between native and non-native ranges. Here, we consider overwinter survival in two non-native species: a Ponto-Caspian invader introduced into the colder climate of central Ontario (Round Goby; *Neogobius melanostomus*), and a North American species introduced into the milder climate of the Iberian Peninsula (Pumpkinseed; *Lepomis gibbosus*).

Round Goby sampled from a central Ontario river showed remarkably high survival (96%) after 142 days under simulated winter conditions without food. Autumn lipid content was higher in areas of recent range expansion compared with the area of original establishment. This appeared to influence reproductive allocation of these starved fish, which began to mature under laboratory conditions. The energetic demand of surviving winter does not appear to limit survival or early spring reproductive effort of adult invasive Round Goby and is unlikely to curb its northward range expansion.
In a common environment experiment, adult Pumpkinseed from Ontario and Spain were used to establish pond colonies in central Ontario. The progeny of Spanish individuals overwintering in these ponds experienced substantially lower survival (31% and 49%) compared with Ontario populations (68% and 78%). Juvenile Spanish Pumpkinseed lost lipid more rapidly and had higher susceptibility to fungal infection at cold temperatures. The relatively short exposure (~ 100 years) to the milder climates of Spain appears to have resulted in a reduced capacity to tolerate the winter conditions typically experienced by northern native populations.

Poster CCFFR (Invasive Species)

EXAMINING RELATIONSHIPS (OR LACK THEREOF) BETWEEN NITROUS OXIDE AND NITRATE IN RIVERS: IS THE IPCC ENTIRELY WRONG?

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Nitrous oxide (N_2O) is a strong greenhouse gas (GHG), primarily produced by denitrification (nitrate reduction) of nitrogen fertilizers. A significant portion of global N_2O production occurs in streams, rivers and estuaries, and is generally assumed to increase linearly with nitrate (NO_3^-) loading. However, evidence is sparse and conflicting. We examine the N_2O:NO3- relationship in the Grand River, southern Ontario, Canada on instantaneous and annual scales. No significant linear relationships between N_2O and NO_3^- were found, although N_2O correlated to dissolved oxygen (DO) levels, presumably because anaerobic denitrifying microbes are oxygen-limited. Using non-linear regression tree analysis, we show that N_2O emissions are predicted by different variables (temperature, NO_3^-, DO) in reaches of the river dominated by different land-use and geomorphology. The upper watershed is primarily agricultural and NO_3^- concentrations and N_2O emissions are low. N_2O is best predicted by temperature and NO_3^-. The central watershed is urban-dominated, experiences hypoxia at night in summer, and has high N_2O fluxes best predicted by DO. In the lower, lake-like, agricultural reach of the river, temperature is the best predictor of N_2O emissions. NO_3^- only predicts N_2O emissions where emissions are low. Overall, DO-limited and temperature-limited N_2O emissions dominate annual N_2O emissions from the Grand River. Non-linear statistical methods predict N_2O emissions much better than linear regressions, and can indicate limiting factors for N_2O production. They can therefore suggest management strategies for GHG mitigation in rivers and a new paradigm for IPCC and global N budgets.

Poster SCL (Carbon Flux and Nutrient Cycling)

DEVELOPING A LONG-TERM MONITORING PROGRAM TO ASSESS THE EFFICACY OF SPAWNING HABITAT CREATION IN THE ST. CLAIR-DETROIT RIVERS SYSTEM

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The St. Clair-Detroit River System (SCDRS) is composed of the St. Clair River, Lake St. Clair, and the Detroit River connecting lakes Huron and Erie in the densely populated Detroit, MI and Windsor, ON metropolitan areas. The waterway is a major navigational and recreational resource of the Great Lakes basin over which more than $80 billion in trade takes place annually. While vibrant and lucrative sport fisheries currently exist for several species, the SCDRS was a renowned commercial fishery until about 1910 when channelization for navigation destroyed a large amount of fish spawning habitat. Losses of fish spawning habitat and other environmental perturbations resulted in the designation of the SCDRS as Great Lakes Areas of Concern with losses and degradation of fish habitat designated as a Beneficial Use Impairment (BUI). Efforts to remediate and delist this BUI have focused on restoring functional spawning habitat for native fishes and three spawning reefs were constructed. To date, scientific investigations focused only on site-specific effectiveness of constructed habitats. While these investigations have done well to provide validation of individual spawning habitat restoration project success, they do not provide a credible measure of fish population and community trajectory as a response to improvements in habitat. Herein, we discuss the need for and desirable attributes of a long-term monitoring program that assesses the effectiveness of fish habitat restoration efforts toward rebuilding fish populations in the SCDRS and how this system serves as an epicenter for restoration of native fishes in the central Great Lakes.

Invited Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

RELATIONSHIPS BETWEEN GROWTH, THE COST OF TISSUE SYNTHESIS, AND STANDARD METABOLIC RATE: IMPLICATIONS FOR HABITAT USE AND LIFE-HISTORY ADAPTATION IN SALMONIDS

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Variation in standard metabolic rate (SMR) among individuals may be considerable, and is often attributed to genetic differences in metabolism. However, SMR in juveniles is also sensitive to variation in food consumption and growth. We review the role of resource-driven variation in growth for variation in SMR, with the goals of better understanding i) the contribution of growth (consumption) to variation in SMR through ontogeny, and ii) the contributions of tissue

maintenance vs. tissue synthesis costs to SMR. Empirical estimates of SMR in starved and satiated juvenile salmon and trout demonstrate that up to 40% of SMR variation is attributable to variation in ration and growth for 2 to 5 g fish. Growth simulations for resident vs. anadromous fish indicate that fixed (i.e. genetic) differences in maximum body length would lead to differences in SMR on the order of ~15% among individuals in a population, and ~ 25% between resident vs. anadromous juveniles at satiation. These results suggest that a substantial component of any intrinsic (genetic) variation in SMR among juvenile salmonids may be associated with variation in maximum body size and associated juvenile growth among individuals or life-history types. We speculate that selection for differences in adult body size and associated juvenile growth among resident and anadromous forms may also contribute to habitat segregation in freshwater, where anadromous juveniles with higher growth may be constrained to foraging in higher velocity habitats to meet their greater consumption needs.

Oral CCFFR (General Session)

THE BEHAVIOURAL BASIS OF TRAPPING AN INVASIVE SPECIES: LESSONS LEARNED FROM THE SEA LAMPREY

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We tested whether manipulations of discharge influenced the behaviour of spawning-run sea lamprey (*Petromyzon marinus*), an invasive species in the Laurentian Great Lakes, in a manner that increased their susceptibility to trapping near the Clergue Generating Station on the St. Marys River. Invasive animals are becoming the focus of management concern in many ecosystems across the globe. Trapping is a potentially valuable form of control. For sea lamprey, increased trap success in large rivers is desired to meet the management objectives of a binational control program. One hundred and sixteen sea lamprey were tagged with passive integrated transponder tags and released downstream of the generating station. Antennas at two traps monitored when sea lamprey approached, and left or entered, a trap. Multi-state Markov models quantified how transition rates between being unavailable and available to be trapped, and between entering and leaving a trap, differed with nightly manipulations of discharge. Sea lamprey altered their behaviour in response to discharge, but trapping success was relatively unchanged. Sea lamprey were approximately two times more likely to approach a trap when discharge was high than when it was low, but they were approximately five times more likely to leave the trap rather than enter. Results suggest that the behavioural responses of sea lamprey to changes in discharge are complex and additional stimuli are likely needed to encourage sea lamprey to enter a trap. Understanding the behaviour through the trapping process can help resource managers improve trapping for invasive species control.

Oral CCFFR (Invasive Species)

NUNAVUT ARCTIC CHARR FISHERIES: MANAGING FOOD SECURITY AND SUSTAINABLE FISHERY DEVELOPMENT IN A CHANGING ARCTIC

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The Arctic charr (*Salvelinus alpinus*) is an abundant and predictable food source in Canada's Arctic region and retains a high value as food security currency in rapidly changing Arctic communities. The development of commercial fisheries for arctic charr plays an important role in the subsistence and market economies of Nunavut and is considered key to poverty reduction and economic growth in many communities. Arctic charr fisheries are developed on relatively small scales permitting to minimize problems of cost, transportation and infrastructure that usually impede on remote, northern enterprises. The conservation and optimization of arctic charr resources in Nunavut remain complicated by data paucity; by the widespread distribution and biological complexity of arctic charr stocks; by growing uncertainties related to climate change impacts on Arctic freshwater fish and ecosystems; and by the lack of adapted stock assessment tools and co-management framework linking Inuit traditional knowledge with scientific expertise. We briefly review the current state of arctic charr fisheries in Nunavut and present science alternatives for the evaluation of arctic charr stocks using intra-specific life history diversity as a basis for risk and quantitative assessments. The implementation of a community-based fishery monitoring program permitting to test management options, refine stock assessment tools and foster knowledge co-production on the species and its habitat is also discussed. Small-scale arctic charr fisheries underline the importance of alternative, flexible and integrated co-management strategies to ensure conservation and sustainable use of fishery resources in Arctic regions.

Oral CCFFR (Climate Change)

INDIVIDUAL VARIABILITY IN THE MOVEMENT BEHAVIOUR OF JUVENILE ATLANTIC SALMON

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Stream-dwelling salmonid populations are generally thought to be composed of both relatively mobile and sedentary individuals, but this conclusion is primarily based on results obtained from recapture methods with low temporal resolution. In this study, the mobility of 50 juvenile Atlantic salmon was monitored using a large array of passive integrated transponder antennas buried in the bed of a natural stream. Fish locations were recorded at a high frequency for a period of three months in a 65 m reach. Four types of daily behaviour were identified: stationary (detected primarily at one location), sedentary (limited movement between a few locations), floater (frequent movements in a restricted home range) and wanderer (movements across the reach). Most individuals exhibited low mobility on most days, but also showed occasional bouts of high mobility. Between-individual variability accounted for only 12-17% of the variability in the mobility data. High mobility was more frequent at low flow, but no difference was observed between the summer (12-18^{o}C) and the autumn (4-12^{o}C). Individual variation on a daily basis suggested that movement behaviour is a response to changing environmental conditions rather than an individual behavioural trait.

Oral CCFFR (Migration, Mixing and Dispersal)

EXPLAINING PATTERNS IN THE MEAN AND VARIANCE OF FLUORESCENCE-BASED MEASURES OF PHYTOPLANKTON BIOMASS: A GLOBAL ANALYSIS

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The automated, high-resolution measurement of in-situ chlorophyll fluorescence via relatively inexpensive submersible fluorometers is rapidly gaining popularity as a tool used in research and monitoring of phytoplankton physiology and biomass in aquatic ecosystems. This technique generates chlorophyll data at temporal scales (minutes to hours) that few have examined, but that may have considerable explanatory power in understanding many aspects of variation in algal dynamics. Despite its increasing application, relatively little is known of how variation in

fluorescence measurements scales in space and time and what environmental variables predict these patterns. We employ a large dataset of chlorophyll fluorescence measurements from 18 Global Lake Ecological Observatory Network (GLEON) lakes around the world and corresponding temporal (wind, temperature, PAR and stability metrics) and spatial (area, depth, tropic status, etc.) variables to 1) determine the environmental drivers of daily measures of phytoplankton biomass and physiology, and 2) quantify how variation is apportioned at hourly, daily and monthly scales within lakes and test at what scale variance-environment relationships are strongest among lakes. We show that wind speed is a strong correlate of changes in both the mean and variance of daily chlorophyll fluorescence, but that patterns of variation at hourly and monthly scales are not as strongly correlated with many of the variables often thought to influence more traditional measures of algal dynamics. As a result, changes in wind speed and the frequency of wind events under altered climate regimes may have important implications for lake productivity at a global scale.

Poster SCL (General Session)

THE ROLE OF STREAM MICROBIAL COMMUNITIES IN THE RECOVERY OF AQUATIC ECOSYSTEMS FROM NATURAL AND INDUSTRIAL DAMAGE

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Microbial communities living in streams have an active role in the health of aquatic ecosystems through their participation in the decomposition and processing of organic matter and nutrients. This study will investigate the role of microbial community abundance and activity in the processes promoting aquatic ecosystem recovery following natural and industrial watershed disturbance. The approach aims to assess the ecological integrity and state of recovery across a gradient of disturbance (old/recent logging, fire, industrial acidification and metal deposition) by linking catchment characteristics (i.e. catchment delineation, upland and riparian vegetation surveys) with stream habitat characteristics (i.e. particulate organic matter, sedimentation rate, woody debris) and biotic measures (i.e. leaf litter decomposition and microbial community structure). Spectral analysis will track alterations to the structure of dissolved organic matter by distinguishing between what is terrestrially and aquatically derived. Organic matter characteristics will be further supported by enzyme assays (i.e. fungal ergosterol and bacterial hydrolases and lignases) that will identify the specific activity of microbial metabolism in the processing of nutrients and organic matter within the streams. An understanding of the specific microbial contributions to recovery of aquatic systems from watershed disturbance will help characterize the patterns and processes important in promoting overall ecosystem integrity and will inform restoration management strategies.

Poster SCL (Wetland and Land/Water Linkages)

THE TYRANNY OF SMALL DECISIONS: CUMULATIVE EFFECTS IN THE GEORGIAN BAY SYSTEM

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The "tyranny of small decisions" or cumulative effects, is one of the most highly discussed areas of Environmental Assessment and is an issue that scientists, planners, practitioners and policy makers continue to grapple with. While many have long sought to identify means of assessing cumulative effects, present government supported frameworks are deemed ineffective. The literature supports a regional level scale for Cumulative Effects Assessments; however there is an absence of effective regional methodologies that provide information on cumulative environmental change at appropriate spatial scales. The development of novel metrics is one potential solution to this problem. Our study examines food webs within Georgian Bay and how their structure can be used as a metric for cumulative effects. Aquatic food webs are structured such that top predators derive energy from two energy channels (pelagic and littoral), and this food web configuration is quite stabilizing. Therefore it is hypothesized that if the littoral channel is negatively impacted by anthropogenic activities it would destabilize the food web structure and will have an inordinate negative effect on biodiversity. Here we begin to show how food web structure responds to anthropogenic cumulative effects along the Georgian Bay shoreline.

Poster CCFFR (Multiple Stressors)

DIETARY ENRICHMENT OF MARINE-DERIVED LIPIDS IN JUVENILE ATLANTIC SALMON: HIGHLY CONSERVED OR QUICKLY METABOLIZED?

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Spawning anadromous fish (i.e. salmon, smelt, alewife, sea lamprey) can enhance stream productivity by depositing marine-derived nutrients (MDN), which stimulate the production and growth of algae, aquatic invertebrates and fish. Marine-derived nutrients can also increase the *quality* of the food resources by making available essential fatty acids (EFA) that are required for optimal physiological performance, but cannot be synthesized by freshwater organisms at sufficient rates to meet their basic biochemical requirements. Certain fatty acids are only synthesized in a marine environment or from a marine source (e.g. Omega 3 fatty acids) and can be used to track trophic pathways in freshwater systems. This is possible because, unlike other dietary nutrients, fatty acids are not generally degraded and retain their basic form in consumer tissues. Similarly, fatty acid profiles identify the relationships among nutrient sources and whether they are essential nutrients, making these organisms of greater nutritional value to

feeding juvenile salmon. Incorporation of marine-derived nutrients was assessed using fatty acid analysis. Aquatic invertebrates and juvenile salmon were reared in experimental streams, using adult spawning Atlantic salmon as the marine nutrient source. Juvenile salmon muscle, brain, and gonadal tissues where analyzed to trace lipid incorporation and whether EFA are conserved or metabolized into these specialized tissues. Preliminary analysis showed that incorporation of MDN led to increased lipid content in some tissues, suggesting that the EFA are both conserved and metabolized depending on metabolic function. These results indicate that marine-derived lipids from anadromous fishes are an important source of metabolic subsidies.

Oral CCFFR (General Session)

DISSOLVED ORGANIC MATTER IN LAKES AND STREAMS AT ELA: QUANTITY, QUALITY AND ISOTOPES

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At ELA, extensive research has been conducted on Dissolved Organic Matter (DOM) due to the importance of DOM in lake heat budgets and stratification, light regimes, mercury cycling, trace metal complexation and toxicity, stable isotope signatures of organisms and sediments, drinking water treatment, carbon cycling and greenhouse gas production. These important roles of DOM are related both to DOM quantity but also to quality. Natural DOM is a mixture of thousands of compounds with different reactivities that changes spatially and temporally even at very small scales. Important questions about the roles and fate of DOM in both ELA streams and lakes have arisen as a result of this extensive research. In addition, the balance of terrestrial carbon accumulation in the sediments versus loss to the atmosphere, the relative importance of autochthonous DOM and the role of DOM in nutrient supply and foodweb studies are still uncertain. A new technique, LC-OCD, is available for studies of DOM quality andQuantity. classifies DOM into 6 fractions based on molecular size and hydrophilicity. We probed the use of this new tool in lakes, streams and wetlands at ELA. We also followed changes in $\delta^{13}C$ and DOM quality during a series of incubations of stream and lake waters performed under natural sunlight and in the dark, with and without microbial inoculation. These two approaches along with the wealth of research conducted on DOM at ELA lead to new insight into the continuum of organic matter decomposition and the associated changes in DOM quality and quantity on the boreal landscape.

Invited Oral SCL (Experimental Lakes Area Research)

DISSOLVED ORGANIC MATTER AT ELA: EFFECTS OF PHOTOLYSIS ON DOM AND CO_2 ISOTOPES AND DOM QUALITY

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Dissolved Organic Matter (DOM) plays an important role in lake heat budgets and stratification, light regimes, trace metal complexation and toxicity, mercury cycling, acid buffer capacity, drinking water treatment, carbon cycling and greenhouse gas production. Lake mass budgets show significant net DOM retention in boreal lakes and in small wetland ponds but the relative rates of autochthonous DOM production, photolysis, microbial decomposition and flocculation/sedimentation are unknown. We conducted a series of incubations with DOM from lakes and upland and wetland streams at ELA under natural sunlight and in the dark, with and without microbial inoculation. A new technique, LC-OCD, that classifies DOM into 6 fractions based on molecular size and hydrophilicity was used to follow changes in DOM quality. We also followed changes in $\delta^{13}C$ of both the DOM and in the CO_2 that was produced. Photolysis of DOM resulted in a decrease in size and proportion of humic substances, an increase in $\delta^{13}C$-DOM and production of $\delta^{13}C$-CO_2 that was more negative than the DOM source. These results have implications for stable isotope analysis of food webs, the interpretation of stable isotopes in sediment cores and the changing nature of DOM quality with landscape position and hydrology.

Poster SCL (Experimental Lakes Area Research)

A CLASSIFICATION OF RIVER HABITAT TYPES ACROSS CANADA

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Rivers are often seen as a mosaic, where several habitat patches define the structure of the river. For instance, riffles, runs and pools are frequently used to describe river habitat types; however the environmental features and the boundaries defining those habitat types are not clearly identified in the literature, neither are they recognized by biologists. Therefore, an accurate classification of these patches into habitat types may facilitate communication among scientists, and ease comparisons across systems, as well as statistical analyses. The objectives of this study were three fold: 1) to establish a classification for a set of Canadian river habitat types; 2) to assess the regional structure of habitat types across Canada; and 3) to evaluate if habitat types were influenced by the presence of a hydroelectric dam. This was done by sampling 761 sites of 300 m^2 in 43 rivers distributed across Canada (BC, AB, ON, QC and NFL). About half of the rivers were regulated by a hydroelectric dam, while the others had a non-regulated flow. For each of these sites, substrate size, velocity, macrophyte, tree branches, and depth were recorded. A K-means partitioning analysis showed that the sites could be associated into 8 habitat types based on their environmental features. Chi-square tests were used to contrast habitat types among Canadian physiographic regions and types of rivers, namely regulated and non-regulated. Chi-square tests demonstrated that habitat types were not evenly distributed across Canada, and that the presence of a hydroelectric dam affected the structure of habitat types in a river.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

CAN STORMWATER PONDS SUPPORT RECREATIONAL FISHERIES IN SOUTHERN ALBERTA?

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Limited fishing opportunities exist in southern Alberta causing an overexploitation of natural watercourses in surrounding areas. To lessen the fishing pressure on natural watercourses and to create additional fishing opportunities, it has been suggested that urban stormwater ponds be stocked with rainbow trout. To determine the suitability of southern Alberta stormwater ponds to support put-and-take recreational fisheries, 400 rainbow trout were stocked into six stormwater ponds and studied from May to October. Stocking success was determined by quantifying i) the ability of ponds to support fish stocks, ii) fish health, and iii) toxicant levels in fish tissues. Very few ponds met the physical, biological and water quality parameters necessary for trout survival. Catch per unit effort rates indicated that rainbow trout survival varied widely between ponds and was related to predation, angling pressure and water temperatures. Invertebrate biomass estimates suggested that the majority of ponds had ample food sources, which is supported by bioelectrical impedance analysis evaluations of fish body condition. Despite the low proportion of suitable stormwater stocking locations, stormwater ponds are very abundant on the urban landscape. Pending toxicological results, numerous viable recreational fishing opportunities could be created from under exploited stormwater ponds.

Oral CCFFR (General Session)

RELAX OR RELOCATE: DISPERSAL AND HOME RANGE OF AGE 1 GREENLAND COD IN NEWMAN SOUND, NEWFOUNDLAND

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We documented movement of 82 tagged age 1 Greenland cod (*Gadus ogac*) in Newman Sound, Newfoundland, October 2010 to June 2012. Individuals captured from two coves were released in a single (2010) and reciprocal (2011) transplant design. We used a network of 26-34 hydrophones to track the movement of fish at our release sites and calculate seasonal home range areas within the study area. Mean seasonal home range during both tagging periods exceeded those documented for age 2 Atlantic cod, suggesting a less localized residency for age 1

individuals of Greenland cod. Many of our tagged fish, particularly transplanted individuals, moved greater distances than reported in previous studies, particularly during late fall/early winter and early spring. We observed a behavioural dichotomy in both years, with some fish (49% and 29% in years 1 and 2 respectively) remaining in their cove of release, and others moving away to surrounding areas. Factors affecting dispersal tendency and home range area likely include predation, habitat, homing tendencies, spatial cognition, metabolism, and abiotic factors such as temperature, but these factors likely differ in importance across individuals given the large variability in movement and home range size. The stability of populations relies on the dispersal dynamics of juveniles. Our study indicates the dispersal range of age 1 Greenland cod is far greater than expected, suggesting a greater contribution to dispersal and population connectivity than previously realized.

Oral CCFFR (Migration, Mixing and Dispersal)

INFLUENCES OF CLIMATE CHANGE, LOCAL WEATHER, LARGE-SCALE CLIMATIC DRIVERS, AND THE SOLAR CYCLE ON LAKE ICE BREAKUP DATES

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We investigated the temporal patterns in inter-annual variability in ice breakup dates for Lakes Mendota and Monona, Wisconsin, between 1905 and 2004. We analyzed the contributions of long-term trends attributed to climate change, local weather, indices of sunspots, and large-scale climatic drivers, such as the North Atlantic Oscillation (NAO) and El Niño Southern Ocean Index (ENSO) on time series of lake-ice breakup. The relative importance of the aforementioned explanatory variables was assessed using linear regression and variation partitioning models accounting for cyclic temporal dynamics as represented by Moran Eigenvector Maps (MEM). Model results explained an average of 58% of the variation in ice breakup dates. A combination of the long-term linear trends, rain and snowfall in the month prior to breakup, air temperature in the winter prior to breakup, cyclic dynamics associated with sunspot numbers, ENSO, and for Lake Mendota, NAO, all significantly influenced the timing of ice breakup. Increased precipitation in the month prior to ice breakup delayed ice breakup, suggesting that cloudiness with its reduction in sunlight reaching the lake's surface was an important process. Our results indicate that lake ice dynamics are complex in both lakes and multiple interacting processes explain the residuals around the linear warming trends that characterize lake ice records.

Oral CCFFR (Climate Change)

BEHAVIORAL AND GENETIC DIVERSITY AMONG ECOTYPES OF LAKE SUPERIOR BROOK TROUT (*SALVELINUS FONTINALIS*)

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We used crosses between migrant and stream resident brook trout caught from tributaries along the north shore of Lake Superior to test for genetic variation in behavioural traits believed to be tied to migratory behaviour, including risk taking, general activity, and sociability. Two ecotypes of brook trout (*Salvelius fontinalis)* originate from tributaries in this part of Lake Superior: a large ecotype that migrates to lake and a small ecotype that remains stream resident. The abundance and distribution of the migrant ecotype has declined in range and abundance, and is the focus of conservation concern. In 2011, migrant and non-migrant adult brook trout were captured in the field and crossed to generate 26 families. In spring and summer of 2012, ten fish from each of family were put through three behavioral experiments to assess risk taking, activity, and sociability. Results of these tests will be used to test for quantitative genetic variation in the behavioural measures made in the lab. This research will help understand whether the life history variation observed among brook trout populations in Lake Superior is due to genetic polymorphism or phenotypic plasticity, and will assist managers with efforts to conserve and restore these populations.

Oral CCFFR (Genetic Diversity and Adaptation)

COMBINED EFFECTS OF ZEBRA MUSSEL (*DREISSENA POLYMORPHA*) INVASION AND NUTRIENT LOADING ON ZOOPLANKTON

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Zebra mussels (*Dreissena polymorpha*) can filter vast amounts of suspended particles, phytoplankton, and zooplankton, potentially changing water clarity, plankton communities, and nutrient cycling. However, invaded systems are often subjected to more than one stressor, and little is known about how additional stressors can alter the effects of zebra mussel invasion. Nutrient loading is one of the most common anthropogenic stressors on lake systems. Its effects on water clarity, phytoplankton, and zooplankton show an obvious potential for interactions with zebra mussels. Of particular concern are the combined effects of these two stressors on zooplankton communities, as the impacts of zebra mussels on zooplankton are not well understood, and can be dependent on external nutrient input. The objective of this experiment was to study the separate impacts of zebra mussels and nutrient loading on zooplankton communities, and how the effects of these stressors on zooplankton are altered when they occur together. To do this, mesocosms containing a regional pool of zooplankton from uninvaded lakes

were constructed. A phosphorus gradient progressing from ambient to highly eutrophic was established in the mesocosms, followed by the addition of varying densities (none, low, medium and high) of zebra mussels. The mesocosms with no zebra mussels will then be compared to the invaded mesocosms to disentangle the individual and combined effects of zebra mussel invasion and nutrient loading.

Oral SCL (Multiple Stressors)

CHARACTERIZATION OF FOOD WEB STRUCTURE IN THE RAINY RIVER, ONATRIO UNDER REGULATED DISCHARGE PRACTICES

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There is growing awareness of the pivotal role of the flow regime as a key driver of the ecology of rivers. Stable isotope analyses (SIA) has been successfully applied to decipher some of the complexity of food web structure in lentic systems, but has not been as widely applied to the study of flow perturbation effects on lotic food webs. Recently, SIA has been shown to be capable of determining the importance of flow variation as a key structural influence on the food webs of regulated rivers. The International Joint Commission (IJC) issued an Order prescribing the method of regulating the water levels of Rainy and Namakan lakes. As a part of the 15 year review, the IJC identified the need for characterization of the Rainy River food web using SIA. Characterization of the Rainy River food web will be used to determine the possible effects of the flow regime on food web structure through collection of baseline vegetation, primary consumers (snails, mussels), aquatic invertebrates and fish in a variety of identified habitat types specific to key fish species. Specifically, the goals will be to identify possible differences in baseline $\delta^{13}C$ signatures in relation to water velocity. Comparisons of food chain length with previously studied regulated and unregulated rivers in the Lake Superior basin will be used to determine possible impacts of the flow regime on food web structure. The intent being to provide data useful for a scientific evaluation of the existing discharge practices on the Rainy River.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

RESTORATION OF WATERSHED PROCESSES AT CFB GAGETOWN, NEW BRUNSWICK

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CFB Gagetown is 1100 km2 in size and contains over 3270 km of watercourses and 156 water-bodies. Fish species of management interest include brook trout and the COSEWIC assessed Atlantic salmon, striped bass and American eel, The base is home to the Army's Combat Training Centre and several military units. Over 50 years of military training activities and associated development such as land clearing, roads, trails, fords and water-crossings have significantly impacted watershed processes and the associated biota. Watershed restoration at CFB Gagetown is focussed on the rehabilitation of habitat connectivity, watershed hydrology, erosion and sedimentation, riparian zones and in-stream habitat. This is being accomplished by improving and decommissioning roads, water-crossings and fords; reforestation of riparian zones; re-vegetation of cleared areas; wetland construction; and in-stream habitat creation.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

THE INFLUENCE OF STAKEHOLDER VALUES IN ENVIRONMENTAL DECISION MAKING

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This study investigated how variation in stakeholder values can complicate management decisions. Environmental decision making is a complex process where scientific tools and evidence are integrated with stakeholder values. Ecologists have advanced the scientific tools of environmental decision making by incorporating mathematical models and uncertainty into structured decision making approaches, such as decision analysis. Decision analysis is used to model the potential outcomes of management actions under uncertainty and incorporate empirical representations of stakeholder values to identify management actions that are likely to meet management objectives that satisfy stakeholders. Sensitivity analysis is a key step for exploring models representing the scientific aspects of decision analysis. It can also be used to explore how projected outcomes of management actions are influenced by stakeholder inputs. We used the tension surrounding the removal of the dam on the Black Sturgeon River on the north shore of Lake Superior as an opportunity to assess how projected recommendations from decision analysis can be influenced by variation in stakeholder values. Our assessment entailed sensitivity analyses examining the consequences of altering the weight (value) placed on different management objectives and stakeholder risk behaviour (risk averse versus risk prone). We found that the weighting of management objectives was most influential for the final decision. Our analysis demonstrates that if a decision maker is able to determine an appropriate weighting for each management objective, a balanced decision could be reached without extensive stakeholder workshops and interviews.

Invited Oral CCFFR (General Session)

FROM ONE GENERATION TO THE NEXT: EFFECTS OF PARENTAL STRESS ON SOCKEYE SALMON OFFSPRING

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Stress jeopardizes reproduction, and thus can have resonating effects on offspring quality. Fish are susceptible to the ramifications of parental stress given that aquatic ecosystems are now subjected to a barrage of environmental and anthropogenic stressors. Of particular concern are the declining populations of sockeye salmon (*Oncorhynchus nerka*) that migrate within British Columbia's Fraser River watershed. Exposure of adult sockeye salmon to stressors alters reproductive hormones and behaviours, however, little is known about how offspring are influenced by stress experienced by the previous generation. Here we investigate the intergenerational effects of stress in an ecologically and economically relevant model species, sockeye salmon. Migrating adults were captured six weeks prior to spawning from the Harrison River, a major tributary of the Fraser River. Fish were held in captivity and either chased daily or left undisturbed (as captive control fish) until maturation. Eggs were collected and fertilized from chased and control fish, in addition to eggs from adults that naturally migrated to spawning areas in the Harrison River. Offspring development, survival and swim performance were examined among all offspring reared. Eggs and subsequent emergent offspring of captive fish were smaller than those reared from fish caught on spawning grounds. Survival to critical life stages was notably reduced in offspring from chased females. Interestingly, surviving offspring from chased females demonstrated superior swim performance. The results support the predicted consequences of parental stress, but also the idea that stressed parents may be able to prime offspring to cope with a stressful environment.

Oral CCFFR (General Session)

MARINE DISTRIBUTION OF ATLANTIC SALMON REVEALED BY STABLE ISOTOPES

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The marine feeding locations for regional populations of Atlantic salmon (*Salmo salar*) in the North Atlantic Ocean are not well known, and may be changing. Geographical gradients of stable isotope values, or isoscapes, of oxygen in seawater may be used to track migratory movements of individual Atlantic salmon. The oxygen stable isotope ($\delta^{18}O$) values in otoliths vary with the baseline isotopic composition of seawater and known associated fractionation processes. The aim of our study is to identify feeding areas in the North Atlantic Ocean used by

adult salmon that have subsequently returned to their spawning rivers by using $\delta^{18}O$ in otolith bands representing at-sea growth. Saggital otoliths were sampled from >200 adult salmon (1SW and MSW) from North American and European populations. This study will provide novel information on the marine ecology of Atlantic salmon, a wide-ranging species of significant commercial value, and should contribute to better management and conservation efforts.

Oral CCFFR (Migration, Mixing and Dispersal)

IS MACROINVERTEBRATE RICHNESS AND COMMUNITY COMPOSITION DETERMINED BY HABITAT COMPLEXITY OR VARIATION IN COMPLEXITY?

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Many studies have reported a positive relationship between habitat structural complexity and species abundance and diversity. However, it is still unclear what mechanisms support greater species richness in more complex areas. Theoretical work suggests that both heterogeneity (i.e., variation in complexity) and complexity itself may mediate functional relationships among organisms, which may be the mechanism behind increase in richness. We tested the postulates that variation in complexity is more important than overall complexity in explaining macroinvertebrate richness and community composition. We used a stovepipe sampler to collect epiphytic and planktonic invertebrates associated with several species of macrophytes covering a wide complexity gradient from two wetlands in eastern Lake Huron. Plant complexity was quantified by vertical and horizontal interstitial distances. Multiple regression was used to relate genus richness and the diversity of invertebrate functional groups to plant species identity, complexity, and variance of interstitial distance. Results of this experiment will contribute to our understanding of the mechanisms by which habitat complexity affects richness and species composition in aquatic ecosystems. This has implications for the selection of protected areas and habitat restoration by the enhancement of habitat structures.

Poster CSWS (Wetland and Land/Water Linkages)

TRENDS IN WATER QUALITY IN ONTARIO STREAMS OVER A 30 YEAR PERIOD

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Streams in Ontario have been subjected to many changes in recent decades, including agricultural intensification, urbanization, climate variations, and changes to management practices. However, the effects of these changes on water quality are poorly understood. The objective of this study is to determine long term trends (1979-2010) in nutrient (TP, SRP, total

nitrates) concentrations in a variety of streams with different land use types (urban, forested and agricultural) throughout the province. Sampling locations were selected from stations used in the Provincial Water Quality Monitoring Network, which collects water quality data approximately 8 times each year from April to November. Interestingly, Mann-Kendall trend tests show a similar pattern of decline in median annual TP concentrations in most streams across all land use types. Several hypotheses have been developed to explain this trend, including changes in discharge and land use.
Additional data have been collected from other long term datasets to explore these hypotheses, including the Water Survey of Canada, which provides a record of daily discharge in gauged streams and the Census of Agriculture, which provides information on agriculture land use. This research will lend insight into how Ontario's stream water quality is responding to many natural and anthropogenic changes.

Poster SCL (General Session)

ENVIRONMENTAL INFLUENCES ON NICHE OVERLAP BETWEEN WALLEYE AND SMALLMOUTH BASS, WITH SPECIAL EMPHASIS ON WATER CLARITY

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The distribution of smallmouth bass (*Micropterus dolomieu*) in Ontario has expanded northwards over the past century, with adverse consequences for native salmonid and cyprinid populations. The effect on walleye (*Sander vitreus*) is less understood. We used stable isotopes of nitrogen (^{15}N / ^{14}N) and carbon (^{13}C / ^{12}C) in fish muscle tissue to investigate how resource partitioning between walleye and smallmouth bass is related to water clarity and other habitat variables in 34 small (100-200 ha) Boreal Shield lakes. Total isotopic niche space of smallmouth bass decreased significantly with increasing water clarity thorugh greater use of pelagic resources and a narrower range of trophic levels. In contrast, walleye trophic niche dimensions did not respond significantly to differences in water clarity. Niche overlap ranged from 0 to 65%, but was not significantly related to water clarity. Both species fed on more similar carbon sources in shallow lakes, had more similar niche size with increasing DOC, and occupied more similar food web positions when yellow perch (*Perca flavescens*) abundance was high. There were no effects of the relative abundance of either species on trophic interactions. This research indicates that walleye may be resilient against smallmouth bass invasions in boreal lakes across a relatively wide gradients of water clarity conditions.

Oral CCFFR (Climate Change)

SHARING THE TOP OF THE BOTTOM: INFLUENCES ON ISOTOPIC NICHE DIMENSIONS AND OVERLAP OF LARGE BENTHIVORES

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Studies on the trophic ecology of large-bodied benthivorous fishes in boreal lakes are relatively rare, despite the abundance of these species and their interesting position as terminal nodes in aquatic food webs (i.e., adults of these species are not commonly preyed upon by piscivores). We used stable isotopes of nitrogen (^{15}N / ^{14}N) and carbon (^{13}C / ^{12}C) in fish muscle tissue to investigate how resource and habitat partitioning between lake whitefish (*Coregonus clupeaformis*) and common white sucker (*Catostomus commersoni*) was related to sympatry and habitat variables in > 45 Boreal Shield lakes. Lake whitefish occupied a significantly higher trophic position (inferred from $\delta^{15}N$) than white sucker, however there were no significant differences in dietary carbon source (inferred from $\delta^{13}C$) between them. Where the two species occurred in sympatry, white sucker had significantly larger niche dimensions (inferred from variance ellipses in $\delta^{13}C$ - $\delta^{15}N$ space), but there was no evidence that larger white sucker niches were associated with greater niche overlap with lake whitefish. Niche overlap between species was relatively uncommon, but white sucker niche dimensions were larger in lakes where overlap did occur compared to white sucker niche dimensions in lakes with no overlap and lakes without lake whitefish. The results of a secondary analysis exploring how niche dimensions and overlap vary with habitat variables will also be presented. This research will shed light on how benthivorous fishes partition habitats and resources, thus addressing a knowledge gap in our understanding of boreal food webs.

Poster CCFFR (General Session)

BIOLOGICAL EFFECTIVENESS OF AN INEXPENSIVE NATURE-LIKE FISHWAY CONSTRUCTED BY VOLUNTEER LABOUR FOR PASSAGE OF WARMWATER FISH ON A SMALL ONTARIO STREAM

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Few studies have been conducted to evaluate the effectiveness of nature-like fishways, particularly in low-gradient warmwater streams with diverse fish communities. We evaluated a nature-like fishway that was installed to facilitate upstream passage at a low-head dam on Indian Creek near Spencerville, Ontario. A passive integrated transponder (PIT) array was used to quantify attraction and passage efficiency for 391 PIT tagged warmwater fish, represented by seven species. Attraction efficiency for the three most common species, common shiner, creek chub, and white sucker, was 63.3%, 83.7%, and 65.6%, respectively and passage efficiencies were 5.1%, 38.4%, and 25%, respectively. Creek chub were able to locate the fishway in less time than white sucker and common shiner, however, took longer to successfully pass. Manipulation of creek chub release locations was used to separate issues of attraction and passage and revealed that passage efficiency was highest (76.2%) for those released within the fishway and intermediate for those released at the entrance (42.1%). This multi-species fishway constructed by volunteers improved stream connectivity, but additional work is needed to fine tune its configuration. Similar projects that engage stakeholders in nature-like fishway construction are a promising approach for the thousands of small dams that occur on low-gradient streams around the globe, but those studies should incorporate a biological evaluation to ensure that attraction and passage efficiency are optimized.

Poster CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

EFFECTS OF TEMPERATURE ON ROUND GOBY (*NEOGOBIUS MELANOSTOMUS*) LARVAL DEVELOPMENT

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Round goby (*Neogobius melanostomus*) is an invasive fish known to have detrimental effects on native species within the Great Lakes basin. Thus, understanding features of round goby larval development could assist with management of the species. Our study objective was to examine the influence of temperature on larval development. Round goby embryos were retrieved from artificial nests deployed at Erieau, Lake Erie, during June and July, 2012 and transferred to a fish hatchery. Larvae were reared from embryos to yolk sac absorption at 15˚C, 20˚C and 25˚C, reflecting the range of water temperatures at Erieau. The rate of yolk sac absorption of round goby varied significantly among temperature ($P = 0.009$). As expected, larvae reared at higher temperatures experienced faster rates of yolk absorption. Larvae subjected to 25˚C and 20˚C completed yolk absorption by days 7 and 9, respectively. In contrast, larvae at 15˚C retained their yolks for a longer period (still apparent on Day 30). Larval mortality varied significantly among temperature ($P<0.001$). Higher mortality was observed in larvae reared at 15˚C than those at 20˚C. Round goby larvae exhibited different swimming behaviours between day and night; there was a greater propensity for larvae to enter the water column at night. Temperature played a key role in round goby larval development and survival.

Poster CCFFR (Invasive Species)

POST-RELEASE BEHAVIOUR OF IMPERILLED FRESHWATER TURTLES IN A SMALL-SCALE COMMERCIAL FYKE NET FISHERY IN EASTERN ONTARIO

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Bycatch is the capture of non-targeted species and can occur in commercial fisheries in both marine and freshwater systems. Captured individuals are exposed to a wide range of potential stressors and injuries, which may affect the survival of released animals. Although bycatch may not be immediately lethal, physiological disturbances and injury may impair the ability of animals to forage or avoid predators post-release. Freshwater turtles are encountered as bycatch in fyke-net fisheries in eastern Ontario. Turtle mortality associated with bycatch is a conservation concern due to their at-risk status and life-history characteristics including delayed maturation and high adult survivorship, that make turtle populations susceptible to decline in response to increase in adult mortality. The purpose of the current study was to determine the post-release behaviour and fate of freshwater turtles caught as bycatch in commercial fishing nets. We chose two ecologically different freshwater turtle species (i.e., midland painted turtles (*Chrysemys picta marginata*) and eastern musk turtle (*Sternotherus odoratus*) and exposed them to simulated capture stressors. We observed the fine-scale behaviour of individuals using tri-axial accelerometers, which also measured depth and temperature to assess post release behaviour. Collectively, this work will clarify the sub-lethal consequences of fisheries interactions on freshwater turtles.

Oral CCFFR (General Session)

MORPHOMETRIC AND GENETIC ANALYSIS OF CISCO (*COREGONUS ARTEDI*) FROM THE GREAT LAKES

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Deepwater coregonines like cisco (*Coregonus artedi*) were largely extirpated by the 1970s from the Great Lakes. The recent decline of non-native forage species such as alewife and rainbow smelt have opened niches that could be (re)occupied by native ciscoes. Information on the

current and historical status of deepwater cisco populations is required to evaluate existing resources and develop rehabilitation strategies. Prior to their collapse, studies of *Coregonus spp.* (formerly *Leucichthys spp.)* in the Great Lakes described three cisco morphotypes; a "slim terete" morphotype (*L. artedi artedi*), a "deep compressed" morphotype (*L. artedi albus*), and a deep-bodied form (*L. artedi manitoulinus*). We used discriminant function analysis (DFA) of body measurements of to discriminate historic morphotypes and used DFA and genetic analysis to discriminate contemporary cisco from sites on lakes Superior, Ontario, and Michigan. Shapes of historic morphotypes were found to vary significantly. Contemporary cisco from lakes Superior, Ontario, and Michigan sites were predominantly classified as *artedi*, while the most common classifications from northern Lake Huron were *albus* and *manitoulinus*. Genetic differentiation was observed among all three lakes. Consistent with previous analyses, samples from Lake Superior were the most distinct genetically. We conclude that contemporary cisco having shapes matching the missing historic morphotypes in the lower lakes warrant special consideration as potential donor populations in reestablishment efforts.

Invited Oral (General Session)

LIFE AND TIMES OF ANADROMOUS LAKE TROUT (*SALVELINUS NAMAYCUSH*) IN THE CANADIAN ARCTIC

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Populations of partially anadromous (sea-run) Lake trout (*Salvelinus namaycush*) were recently discovered in the Canadian Arctic. Anadromous Lake trout are in better condition, have more lipid stores, and have lower mercury concentrations than sympatric freshwater individuals. To investigate geographic extent and subsistence harvest of anadromous Lake trout in the coastal Canadian Arctic, microchemistry analyses were conducted on archived collections of otoliths, and traditional knowledge interviews were conducted with subsistence fishers. Preliminary results indicate that the anadromous life history type of Lake trout extends from the Mackenzie Delta to the east coast of Hudson Bay. The freshwater life history type is much more common than the anadromous life history type, however. Anadromous Lake trout are captured by subsistence fishers, but are not targeted. Unlike anadromous Arctic char, stable isotope ratios (Bayesian mixing models) indicate that anadromous Lake trout continue to feed on freshwater prey even after onset of annual marine migrations. These results, as well as differences between life history types in egg size and egg lipid content, will be discussed in the broader context of conditional life history strategies.

Oral CCFFR (Migration, Mixing and Dispersal)

SEASONAL CHANGES IN DOM QUALITY IN BOREAL PEATLANDS AND IMPLICATIONS FOR TRACE METAL TRANSPORT AND AVAILABILITY IN LAKES

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The highly coloured and recalcitrant DOM that originates from peatlands plays several important roles within aquatic systems, including the regulation of trace metal transport and availability. The quantity of dissolved organic matter (DOM) in a lake has been shown to be correlated to the area of peatland within its watershed; however the quality of this DOM that is exported from a peatland may be quite variable both within and between sites. The objectives of this study were to investigate spatial variation in DOM quality in streamwater from disturbed peatlands, and compare this variation to temporal variation. We chose 6 peatlands of varying peat and vegetation profiles, and investigated the export of DOM, nutrients, and metals. DOM was analysed using fluorescence spectrophotometry, with scans across a range of excitation from 220 nm to 450 nm, reading emissions from 300 nm to 600 nm. The resulting excitation emission matrices (EEMs) allowed us to characterize specific DOM structures (protein-like and humic-like) and calculate several common metrics, including the Fluorescence Index and the Humification Index. Seasonal patterns, and differences between peatlands are investigated, and implications to the export of metals is discussed. This research will help to understand seasonal variation in metal exports, which is becoming particularly important with the increased frequency of extreme weather events. This study will also contribute in understanding the mechanisms of lake recovery in areas with a history of trace metal deposition.

Oral SCL (Carbon Flux and Nutrient Cycling)

DATA LIMITED ASSESSMENT OF SELECTED NORTH AMERICAN ANADROMOUS ARCTIC CHARR, *SALVELINUS ALPINUS,* STOCKS

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Arctic Charr, *Salvelinus alpinus,* populations are particularly susceptible to change, either from the application of harvest or environmental conditions such as climate variation. As an alternative to conventional fishery analysis, we analyze the sustainability and viability of selected North American charr stocks using a number of approaches. We compare several methods for data limited situations to determine the allowable harvest of the Ekalluk River, Paliryauk River, Halovik River, Jayco Lake and Lauchlan River Arctic Charr including

Cadima's Maximum Sustainable Production Method, Hierarchical Bayesian Surplus Production Models, a Status Quo Total Allowable Harvest method, Long-term Average Catch methods and the Depletion-Corrected Average Catch method. Each method provided a similar outcome in terms of the relative importance of stocks to the fishery. The predicted sustainable harvest of larger stocks such as the Ekalluk and Jayco varied more according to the method applied than the other stocks studied. While not a replacement for more comprehensive fishery models these methods can be useful in data poor situations.

Oral CCFFR (Northern Ecosystems)

HISTORICAL AND CONTEMPORARY DRIVERS CYANOBACTERIA DYNAMICS; A REGIONAL AND GLOBAL PERSPECTIVE

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There is growing concern that harmful cyanobacterial blooms are increasing in frequency and occurrence around the world. Although nutrient enrichment is commonly identified as a key driver of cyanobacterial blooms, recent work has shown that climate change may also be an important driver. Using a regional monitoring dataset from Canadian prairie lakes, we identified important interactions among nutrients and climate-related variables in cyanobacterial models, which were strongest in thermally-stratified basins. To evaluate whether the strength of these relationships has changed over a longer time period, we analyzed the paleolimnological records of this lake set. Preliminary results based on our most highly-resolved record demonstrates that although rising abundance corresponds to elevated nutrient concentrations, the contribution of nutrients to this rise has been unprecedented in the last decade when temperatures have been their warmest. Finally, to provide a global context, we conducted a meta-analysis of published sedimentary pigment records. Preliminary results show that cyanobacterial pigments have increased over the past ~200 years, that this increase has been more pronounced than that of pigments of equal stability, and that cyanobacterial trends vary among regions due to differences in elevation, agricultural land-cover, lake morphometry, and trophic status. Overall, results presented here show that cyanobacterial abundance is increasing globally and through time, and that this is due in part to cultural eutrophication and climate change.

Rob Peters Memorial Award for best student paper
Oral SCL (Multiple Stressors)

LONG TERM EFFECTS OF IMPOUNDMENT OF GEORGIAN BAY WETLANDS

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Wye Marsh, located in Midland, Ontario, is an approximately 430 ha provincially significant and ecologically important wetland in Georgian Bay. Prior to 1930, the St. Marie Dam was built at the northern end of the marsh to raise and control water levels. Through a series of aerial images spanning 1930 to 2008, we demonstrate potential long term effects of the impoundment. Constant water levels have led to infilling of the marsh by dominant emergent vegetation (e.g. *Typha spp.*). Through a variety of field studies, we demonstrate that although the avian community is similar to a non-impounded wetland of similar size and geographic location, the fish community diversity has suffered. Migratory fish species dependant on wetlands for spawning and access to the bay were absent from our assessment above the impoundment. On the other hand, various wetland dependent species were present in the similar but non-impounded wetland. In general we show that the long term effects of impounding Georgian Bay wetlands are negative for overall biodiversity.

Oral CSWS (Wetland and Land/Water Linkages)

MANAGING AN UNCERTAIN LAKE ONTARIO - TOWARDS MULTIPLE FUTURES

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The future of Lake Ontario's fish community and fisheries can be seen as a number of possible futures, some desirable and some not so. However, fisheries managers are taught to define a specific vision, establish clear goals and objectives and develop strategies and plans to realize that vision. Restoration of the Great Lakes has been associated with rapid and often abrupt changes in ecosystem structure and function, challenging the one vision approach to management. In Lake Ontario, attempting to manage for restored native species and ecosystem function while sustaining human benefits is particularly challenging. In this paper, we make the case for the concept of multiple futures to the management of Lake Ontario fish community and fisheries and make recommendations for a renewed management approach.

Invited Oral CCFFR (Great Lakes Fisheries and Environmental Policies)

EFFECTS OF STOCKED TROUT AND AERATION ON NATIVE COMMUNITIES OF BOREAL FOOTHILLS LAKES

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Stocking non-native trout is a widespread fisheries management technique that can create new angling opportunities but can also negatively affect native fauna in stocked lakes. To reconcile conservation and fisheries management objectives, lake managers need to understand the characteristics of lake ecosystems and their native fauna that make them vulnerable or resistant to non-native species. We have integrated multi-lake comparative studies with a whole-lake manipulation and mechanistic mesocosm experiment to investigate impacts of trout stocking on the native fauna and explore mechanisms that limit its effects in a set of small, productive boreal lakes in Alberta, Canada. Overall, effects of trout on native animals were limited and primarily indirect. Altered habitat/behavior in lakes and results of mesocosm experiments indicated that abundant macrophytes provide effective structural refuge for forage fish, while relatively warm epilimnia may limit trout foraging in littoral areas. As well, abundant alternative prey for generalist-feeding trout may diffuse and weaken impacts on fish and macroinvertebrates. Overwinter surface aeration used by managers to increase survival of trout likely also increases survival of fish and invertebrates, further mitigating direct negative effects of trout. Finally, comparisons with naturally fishless lakes indicate that the presence of native fish have "pre-shaped" native assemblages of amphibians and zooplankton such that trout have limited additional effects. Our project demonstrates that negative outcomes of trout stocking are not universal and identifies ecological factors that can buffer native assemblages against effects of trout.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

SPATIALLY VARYING POPULATION DEMOGRAPHICS AND FISHERY CHARACTERISTICS OF LAKE ERIE WALLEYE (*SANDER VITREUS*) INFERRED FROM A LONG-TERM TAG-RECOVERY STUDY

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Since 1990, Lake Erie walleyes *Sander vitreus* have been tagged annually with jaw tags to improve understanding of population dynamics and ecological characteristics of spawning populations. Using this tagging data, we developed a spatially explicit tag recovery models to estimate region-specific mortality rates and inter-region movement rates. The model parameterized with region and age-specific natural mortality rates was the best performing model among the set of evaluated models. Region-specific movement rates estimated from the spatially explicit model were similar to those estimated in other movement studies; western basin walleye migrated to the central and eastern basins of Lake Erie as well as northward into the Huron-Erie Corridor and Lake Huron. Eastern basin walleye were more sedentary than western basin fish with a high proportion of tagged fish remaining in the eastern basin after taggin. Natural

mortality rates were higher for younger fish (< age 5: range 0.31-0.43) than older fish (≥ age 5: range 0.15-0.26). Fishing mortality rates ranged from 0.13 and 0.55 for the commercial fishery and 0.05 and 0.16 for the recreational fishery. Model results were insensitive to movement rates assumed for those regions where no walleyes were tagged and release. Presently, the assessment model used as part of the Lake Erie walleye quota management system assumes a homogenous and well mixed population, which may result in biased abundance and mortality estimates. The information from this study should assist fishery managers develop a spatially explicit assessment model as part of an updated Lake Erie walleye quota management system.

Oral CCFFR (Migration, Mixing and Dispersal)

THE IMPORTANCE OF THE NEED FOR CALIBRATION OF DEPTH SENSORS ON TELEMTRY TRANSMITTERS

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Acoustic transmitters are widely used to gain information on fish habitat use. Some transmitters contain pressure sensors, which are factory-calibrated before being sold; however, the values obtained from these sensors have a certain range of error. Our goal is to assess the accuracy of these pressure sensors and to evaluate the need for additional calibrations. To evaluate error, we conducted calibrations on acoustic transmitters with pressure sensors from VEMCO either in lab (air-pressure-based calibrators) or the field (water calibrations). The slopes and intercepts of calibrated sensors were compared to the factory-calibrated slopes and intercepts to compare calibration methods and identify directional biases. In addition, we evaluated the relevance to ecological data of using researcher- versus factory-calibrated pressure sensors. Using the two forms of calibrated data from the same transmitters, we compared basic summaries of depth selection (e.g., diel patterns, small vs. large fish) for tagged fishes. Finally, we evaluated external effects (e.g., time, temperature, salinity, altitude) on sensor output. To estimate changes in sensor output over time, we re-calibrated sensors from transmitters returned to Great Lakes Fishery Commission after being deployed in Lake Trout (*Salvelinus namaycush*) for 1-2 years, and compared the slopes and intercepts obtained to values from the original calibrations. To determine the effects of temperature, we calibrated the same sensors at varying temperatures and compared slopes and intercepts. These results will guide researchers on the necessity of undertaking independent calibrations.

Poster CCFFR (General Session)

A COMPARISON OF OXYGEN CONSUMPTION AND ISOTOPIC FRACTIONATION IN SUB-BOREAL LAKES

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Northern temperate and boreal lakes are generally net heterotrophic ecosystems, fuelled by input of organic matter from their surrounding catchments. On the Canadian Shield, these lakes are typically oligotrophic to mesotrophic, phosphorus-limited and, when deep enough to stratify, exhibit a hypolimnetic O_2 concentration decline during summer stratification. Cool hypolimnetic water is a refuge for cold-water organisms biota. Hypolimnetic O_2 concentrations decline during the stratified season and in some lakes declines significantly. To study hypolimnetic respiration (and O_2 decline) and its associated isotopic fractionation, we sampled the summer-stratified hypolimnion of several lakes, in profile, over 4 to 5 months. Additionally, to assess the role of O_2 consumption rate and temperature on isotopic fractionation, we incubated epilimnetic and hypolimnetic water at various temperatures.

Poster SCL (Experimental Lakes Area Research)

EFFECTS OF INTERNAL CARBON SUPPORT ON THE ^{13}C OF ORGANIC CARBON IN AN EXPERIMENTALLY EUTROPHIED LAKE

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Nutrient loading to lakes increases aquatic primary production. Large amounts of algal biomass can lead to several problems such as unpleasant scums, taste and odour problems, and anoxia from the decomposition of the biomass. Eutrophication changes the biogeochemistry of lakes and can induce positive feedback mechanisms whereby nutrients for continued algal growth are released from epilimnetic sediments. Recovery from eutrophication will depend on how long inputs from lake sediments fuel water column algal production; during this recovery period the molar and isotopic ratio of the algal biomass is expected the change. One expectation in eutrophied lakes is that chemically enhanced CO_2 flux, induced by high pH values associated with high rates of primary production, coupled with low algal isotopic fractionation will be evident in the ^{13}C values of particulate carbon and thus in the sediments. We use water column POM, sediment trap and surficial sediment samples and DIC in benthic flux chambers from the experimentally eutrophied Lake 227 at the Experimental Lakes Area to assess how the rapid return of inorganic carbon from epilimnetic sediments reduces the effects of chemically enhanced CO_2 flux on the ^{13}C values of particulate organic carbon.

Poster SCL (Experimental Lakes Area Research)

PROCESSES AFFECTING GREENHOUSE GAS PRODUCTION IN EXPERIMENTAL BOREAL RESERVOIRS

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Flooding land for water reservoir creation has many environmental impacts including the production of the greenhouse gases (GHG) carbon dioxide (CO_2) and methane (CH_4). To assess processes governing GHG emissions from the flooding of terrestrial carbon, three experimental reservoirs were constructed in upland boreal forest areas of differing carbon stores as part of the Flooded Upland Dynamics Experiment (FLUDEX). We calculated process-based GHG budgets for these reservoirs over five years following the onset of flooding. Stable isotopic budgets of carbon were necessary to separate community respiration (CR), which produces CO_2, from net primary production (NPP), which consumes CO_2, and to separate CH_4 production from oxidation. NPP removed up to 44% of the CO_2 produced from CR. CR and NPP exhibited different year-after-year trends. CH_4 flux to the atmosphere increased about 2-fold over three years, yet isotopic budgets showed CH_4 production in flooded soils increased nearly 10-fold. CH_4 oxidation near the flooded soil–water interface greatly decreased the CH_4 flux from the water column to the atmosphere. Ebullition was the most important conduit of CH_4 to the atmosphere after three years. Although CH_4 production increased with time, the total GHG flux, in CO_2 equivalents, declined. Contrary to expectations, neither CR nor total GHG fluxes were directly related to the quantity of organic carbon flooded. Instead, these reservoirs produced a strikingly similar amount of CO_2 equivalents over five years.

Poster SCL (Experimental Lakes Area Research)

MULTIPLE ECOLOGICAL STRESSORS IN THE CONTEXT OF THE SPECIES CO-TOLERANCE AND NICHE CONCEPTS

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The species co-tolerance concept is an important way of viewing the potential cumulative impacts of multiple stressors on aquatic communities. However, other ecological traits as captured by species niches are also key determinants of stress responses by communities. Here, we combine the species co-tolerance and niche concepts to illustrate contrasting multiple-stressor scenarios in which species diversity and community function respond differently due to trade-offs involving competitiveness, productivity, and stress-tolerance. Hypothetically, if a community displays the trade-off between realized niche height (i.e. competitive potential) and

positive co-tolerance, then dual stressors impair function greater than diversity. In contrast, a trade-off between realized niche height and negative co-tolerance is expected to cause greater loss of biodiversity than function. Three-dimensional community-response surfaces will be used to illustrate these different scenarios. Finally, we also propose a revision of the species niche concept to better reflect the contingency (i.e. co-tolerance) that often exists between species responses to presumed "orthogonal" environmental changes.

Invited Oral SCL (Multiple Stressors)

EFFECTS OF CLIMATE, HYDROLOGY, AND LAKE PHYSICO-CHEMISTRY ON WATER QUALITY IN THE NORTHERN GREAT PLAINS (QU'APPELLE LTER)

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The Qu'Appelle River catchment drains ~52,000 km^2 of mixed grassland and provides water to a third of the population of the Canadian Great Plains. Degradation of water quality from excess algal growth and toxicity represents a significant threat to regional water security, but identifying risk factors depends on resolving complex interactions between broad scale climatic patterns with more localized effects of regional hydrology and agricultural nutrient run-off. We estimated the relative effects of large-scale climate drivers, weather , hydrology, and lake physico-chemistry on indicators of water quality, including algal production and water clarity using 19 years of data collected from six limnologically diverse lakes (Qu'Appelle LTER). Multivariate models incorporating the full suite of environmental variables, in addition to considerations of time and space, accounted for between 60-90% of the variation in water quality parameters. Physico-chemical variables such as water temperature and nutrients were identified as stronger determinants of water clarity and algal production than climatic or meteorological factors. These insights will contribute to the development of a provincial 25-year plan for ensuring water security in Saskatchewan, Canada.

Oral SCL (Multiple Stressors)

METABOLOMIC DIFFERNTIATION OF NUTRITIONAL STRESS IN AN AQUATIC INVERTEBRATE

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Poor diet quality frequently constrains the growth and reproduction of secondary consumers, which can alter their population dynamics, interactions within food webs, and contributions to ecosystem services such as nutrient cycling. The identification and measurement of an animal's nutritional state is thus central to studying the connections between diet and an animal's ecological interactions. Here we show how the nutritional state of a freshwater invertebrate, *Daphnia magna*, can be determined by analysis of its metabolome using a ^{1}H NMR-based approach. With a multidimensional analysis, we found complete differentiation of the metabolite composition of animals grown under control conditions (good food conditions and no environmental stress), raised on different diets (low quantity, nitrogen-limited, and phosphorus-limited), and exposed to two common environmental stressors (bacterial infection and salt stress). We identified sixteen individual metabolites that were significantly different between control animals and at least one limiting food type or environmental stressor. The unique metabolite responses of animals that we document here to inadequate nutrition and environmental stress are reflective of the dramatic and distinctive effects that each stressor has on animal metabolism. Our results thus suggest that dietary-specific induced changes in metabolite
composition of animal consumers hold considerable promise as an indicator of nutritional stress and will be invaluable to future studies of animal nutrition and its ecological importance.

Oral SCL (General Session)

MASSIVE RETICULATE EVOLUTION AMONG BULLHEADS (*AMEIURUS*) IN THE LOWER GREAT LAKES

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Introgressive hybridization among Brown Bullhead (*Ameiurus nebulosus*) and Black Bullhead (*Ameiurus melas*) is known to occur within the Lake Erie watershed. Hybridization among these species has the potential to call into question analyses of population genetic structure, regional biogeography and evolutionary history. Furthermore, the interspecific admixture of hybrid fishes may potentially preclude the use of appropriate bullhead species as toxicological bioindicators of ecosystem health. Here, we use genetic data from nuclear and mitochondrial single nucleotide polymorphisms (SNPs) to demonstrate the widespread, and likely historical, capture of Black Bullhead mitochondrial haplotypes by Brown Bullhead sampled from multiple sites in Lake St. Clair, the Detroit River, Lake Erie, the Niagara River, and Lake Ontario. Our data provides novel insights into the regional colonization, genetic structure, and divergence among bullhead within the Lower Great Lakes.

Oral CCFFR (Genetic Diversity and Adaptation)

EFFECTS OF SAMPLE SIZE AND DETECTION LIMIT ON THE PERFORMANCE OF DIFFERENT SPECIES DISTRIBUTION MODELS: A SIMULATION STUDY

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Species distribution models (SDMs) are increasingly used in fisheries research. The sample size and detection limit of data used for SDMs vary among taxa and regions because of logistic constraints. To determine the effects of sample size and detection limit on SDMs is critical for making reliable predictions. It is difficult to evaluate SDMs using sampling data because the true situation is unknown. SDMs should be able to approximate the true relationship if ecologists want to use them as reliable tools. We used generalized beta function to describe different species response shapes (symmetrical and asymmetrical) and simulate the true datasets. Data with different sample sizes (n = 50, 100, 200, 400, 600, 800) were randomly drawn from the true datasets under different detection limits (0, 0.2, 0.4, 0.6, 0.8). Linear discriminant analysis (LDA), multiple logistic regression (MLR), random forests (RF) and artificial neural networks (ANN) were developed on the sampled datasets, and assessed using accuracy, sensitivity, specificity, phi, AUC and Pearson's correlation. With increasing sample size, model accuracy increased and variability decreased across species response shapes and among models. The performance of LDA and MLR decreased significantly when detection limit > 0.2, whereas the performance of RF and ANN decreased significantly when detection limit > 0.6. Although RF and ANN had better overall performance at different sample sizes and detection limits, LDA and MLR exhibited good sensitivity at smaller sample size. Random forests performed more consistently across different sample sizes and detection limits and often had among the best performance.

Oral CCFFR (General Session)

BEHAVIOURAL AND MORPHOLOGICAL INDICATORS OF NEST HOLDING MALE ROUND GOBIES

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Determination of male reproductive status in the round goby (*Neogobius melanostomus*) can be challenging because current metrics require the fish to be sacrificed. Fanning behaviour is common in fish species that exhibit male parental care as it is important for egg development. Because male fanning begins before spawning, it also may play a role in pheromone dispersal and courtship. Initially, we examined which morphological metrics best delineated groups of reproductive and non-reproductive male gobies (determined using the gonadosomatic index, GSI). Surface areas of fused pelvic fins ($F = 9.37$, $p = 0.0028$) and caudal fins ($F = 8.81$, $p = 0.0037$) best separated these groups of males. Using video recordings of nest-holding male

gobies, we characterized both pectoral and caudal fanning behaviour. Rates of maximum caudal and pectoral fanning were correlated (r=0.40, p = 0.052). Subsequently, we determined if fanning metrics were related to 11 ketotestosterone (11KT), a measure of secondary sexual traits, GSI and morphological traits. No relationship was found between any of the fanning or morphological metrics and GSI values. However, there was a significant relationship between the maximum pectoral fanning rate and plasma 11-KT levels (r=0.42, p=0.041). Also, there was a significant relationship between the maximum pectoral fanning rate and both condition factor (r = -0.428, p = 0.016) and the surface area of the 1st dorsal fin (r = 0.392, p = 0.029) of males. These findings suggest that males may fan to disperse odours (pheromones) out of the nest, advertising their quality to prospective females.

Oral CCFFR (Invasive Species)

A MECHANISTIC UNDERSTANDING OF DENSITY-DEPENDENT CATCHABILITY IN A MULTI-STOCK RAINBOW TROUT RECREATIONAL FISHERY

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Mechanisms resulting in density-dependent catchability in recreational fisheries are poorly understood due to a lack of empirical data. We collected data on angler catch per unit effort and assessed fished populations in two unique situations to assess the mechanistic cause of density-dependent catchability for the multi-stock spatially structured rainbow trout (*Oncorhynchus mykiss*) lake fishery: we had a single expert angler fish a set of experimental lakes closed to fishing and we interviewed anglers at lakes open to recreational fishing. We found that catchability was approximately constant across fish density in the experimental angling lakes and density-dependent in the recreational fishing lakes. Furthermore, angler expertise varied substantially across the interviewed anglers and catchability was positively related to angler expertise. The observed results of density-dependent catchability did not appear to be sensitive to angler effort effects (or in-season depletion of fish) as the parameter estimates were similar between spring-only data and seasonal-averaged data. Therefore, we determine that variation in angler skill level among lakes is the driving factor contributing to density-dependent catchability for this fishery.

Oral CCFFR (Disturbed Ecosystems, Threatened Species and Restoration)

MERCURY EXPOSURE OF SMALL-BODIED FISH IN LOTIC SYSTEMS IN THE HUDSON BAY LOWLANDS

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There is considerable interest in the mercury dynamics of the peatland-dominated watersheds of Canada's Hudson Bay Lowlands in light of current and future climate and land-use changes. Little data exist on total mercury (THg) and methylmercury (MeHg) concentrated in the various abiotic and biotic components of the lotic ecosystems of the region making assessments of future changes to Hg cycling difficult. Small-bodied fish are a useful tool for monitoring changes in Hg exposure in aquatic ecosystems because their tissue Hg concentrations reflect juvenile (short-term) exposure that is not masked by cumulative bioaccumulation as in larger fish. This research, conducted at the De Beers Victor Mine near Attawapiskat, Ontario, focuses on the use of small-bodied fish as sentinels of spatiotemporal variability in far north aquatic ecosystem Hg exposure. Hg concentrations of fish and abiotic and biotic food web compartments, age structure analysis, water quality (dissolved organic carbon [DOC], THg, and MeHg), and (sub)watershed hydrogeomorphic information will be examined. Analysis of these data suggest that there is within-site and within-species variability in fish Hg body burden that can be explained by differences in age and food web structure, confounding previous understanding of accumulation in northern aquatic ecosystems. This research addresses the relative importance of biogeochemical, ecosystem, and trophic controls on Hg bioaccumulation and spatiotemporal variability of Hg in these fish. This unprecedented dataset provides a framework for determining whether climate and land-use changes influence Hg dynamics and generating a baseline for ongoing monitoring of Hg in Ontario's far north.

Oral CCFFR (Contaminants and Trophic Transfer)

CHEMOSENSORY CUES FROM SPAWNING SUBSTRATE ATTRACT LAKE TROUT, AND EGG PREDATORS

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Lake trout (*Salvelinus namaycush*) return to the same spawning locations annually, despite the availability of local sites that are structurally similar. A field experiment was conducted at the Experimental Lakes Area to determine whether chemosensory cues emanating from lake trout spawning substrate attract breeding fish as well as their egg predators. Substrates from either a spawning site or a control site were randomly placed in trap nets around an isolated spawning shoal. Nets that contained spawning substrate caught significantly more lake trout, as well as a greater proportion of lake trout in breeding condition, than nets with control substrate. White sucker (*Catostomus commersoni*) were a major predator of lake trout eggs and were also captured in greater numbers in nets with spawning substrate.

Oral CCFFR (Experimental Lakes Area Research)

DOCUMENTING BIOSTRUCTURE AND BIODIVERSITY IN THE ARCHIPELAGO OF GEORGIAN BAY

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Current documentation of the biodiversity of Georgian Bay is limited. As an example, there are approximately only 50 species from this region registered in iBOLD (International Barcode Of Life Database). It seems likely that this area is grossly under-represented in terms of documented biodiversity. Efforts to monitor ecosystem changes over time as well as for more immediate management purposes requires a more thorough understanding of what currently exists. Towards resolving this information gap, we begin to characterize the diversity of life within this highly impacted ecosystem. This project is intended to provide a snapshot across time and space of the diversity, from benthic invertebrates to top predators as well as aquatic vegetation. Spatial gradients are being chosen to reflect the different levels of development and human impact found within the archipelago, as a first step towards using modern DNA-techniques to monitor this iconic Canadian ecosystem.

Poster CCFFR (General Session)

TRANSCRIPTION AND ENVIRONMENT INTERACTIONS: EVIDENCE FOR LOCAL ADAPTATION OF BABINE LAKE RAINBOW TROUT

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Adaptation of salmonid populations to their local environment is believed to explain the vast diversity of life history strategies demonstrated by this group. Gene transcription has been implicated as a mechanism facilitating rapid evolution of salmonid populations and may form the basis of many local adaptations. While transcriptional differences among populations have been described there is little information about the environmental forces driving local adaptation of transcriptional traits. Here we assay gene transcription, at resting state and in response to metabolic and immune challenges using a custom microarray, for six populations of juvenile rainbow trout rearing in tributaries of Babine Lake. We also characterized both the thermal regime of the tributaries using data loggers and the bacterial communities of the tributaries using massively parallel pyrosequencing. We examine the interactions among environmental parameters and assess their relevance for determining transcriptional profiles of fish rearing in those environments. The results of this study provide insight into mechanisms facilitating local adaptation of salmonids and have implications for the management of salmonid populations.

Oral CCFFR (Genetic Diversity and Adaptation)

ACOUSTIC SIZE SPECTRA: ASSESSING DIFFERENCES AMONG FISH HABITATS IN A HYDROPOWER RESERVOIR

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Hydroacoustics were used to assess summer habitat use and production by fishes in a hydropower reservoir in eastern Manitoba (Lac du Bonnet). A splitbeam Biosonics DTX scientific echosounder, operating at multiple frequencies, was used to conduct full systematic surveys and near-shore tracks that circumscribed the reservoir. Acoustic data were used to map bathymetry and develop classification criteria for bottom types. A combination of physical sampling and underwater video footage was used to assist habitat classification according to depth, bottom substrate (bedrock/boulder; gravel/cobble; sand; mud) and the presence or absence of submerged aquatic vegetation. A size-based analysis of the fish population relative to habitat is employed in this analysis; trends in acoustic size-frequency spectra may be used to assess the condition and production of aquatic ecosystems. This method negates the limitations associated with species identification of acoustic signals in systems with high biodiversity. Variation in size-frequency spectra among habitat types is used as an indicator of the relative importance and productivity of different habitat types for fishes during the summer months. These methods have potential to play an important role in the monitoring of net changes in aquatic ecosystems, especially those associated with hydropower development.

Poster CCFFR (General Session)

AQUATIC AND RIPARIAN HABITAT USE BY EMERGING ADULT INSECTS IN BOREAL FEN AND MARSH VEGETATION

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Habitat selection is an important evolutionary adaptation determining the conditions under which organisms will survive and reproduce. Arthropod assemblages are best predicted by plant community characteristics at the biome level. However, factors attracting riparian insect assemblages to colonize distinct wetland ecosystems remain unclear.
Structurally complex habitats are thought to support greater insect diversity and biomass due to increased niche space, microhabitats, and refugia for prey species. Structural complexity in wetlands arises from the diversity of abiotic characteristics, littoral vegetation, and riparian

vegetation. My research assesses how structural complexity in wetland plants, their zonation, and their vertical structure affects community composition and biomass of emergent adult insects in boreal fens and marshes in northeastern Alberta. To determine the use of vertical zonation by emergent insects, sticky traps were placed at 4 heights ranging from ground level to 1.5 m above ground in 20 x 20 m wetland plots containing either fen vegetation and soil or recently colonizing cattail and sedge species (marsh vegetation and soils). Insects settling on Tanglefoot-coated acetate sheets over 72 h at each height in August 2011 and May 2012 were enumerated and identified to family. No significant differences in abundance were found among vertical zones in fen vegetation plots. However, wetland resident insects (those whose larvae use a wetland substrate) tended to be associated with traps in the center of tall, emergent marsh vegetation. No differences in either abundance or community composition were found between fen and marsh vegetation plots; this may reflect the small plot size.

Poster CSWS (Disturbed Ecosystems, Threatened Species and Restoration)

TRACKING ADULT PACIFIC SALMON ENERGY USE FROM OCEAN TO SPAWNING GROUNDS WITH ACOUSTIC ACCELEROMETER TRANSMITTERS

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Migrating adult Fraser River sockeye salmon face a myriad of anthropogenic (e.g., fishing) and environmental (e.g., high water flows, increased water temperatures) challenges as they migrate from coastal waters and up the Fraser river to their natal stream to spawn. Because sockeye salmon cease feeding in the ocean, they are entirely reliant on endogenous energy stores to successfully complete their migration and spawn. Increased water temperatures results in increased energy demands on migrating sockeye salmon, and may cause an energy deficit which results in death before reaching the spawning grounds. Current energy estimates have been determined using radio telemetry and are limited to freshwater. Development of acoustic tri-axial accelerometer transmitters has facilitated the fine scale study of sockeye salmon energy use in both freshwater and marine environments. We collected physiological samples and tagged 55 sockeye salmon in the ocean and 25 salmon in the Harrison River, with accelerometer transmitters. Previously developed models were used to convert accelerometer output to swim speed and energy use. We examined swimming activity across a variety of environments, to examine how energy use changes based on environmental and physiological variables. For the first time we provide empirical data on the swimming activity and energy use of adult Pacific salmon from the ocean to spawning grounds.

Oral CCFFR Migration, Mixing and Dispersal

OXIDATIVE STRESS AND SENESCENCE THROUGHOUT MIGRATION OF PINK SALMON (*ONCORHYNCHUS GORBUSCHA)*

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A previously unidentified cost of migration in Pacific salmon (*Oncorhynchus* spp.) may be oxidative stress. Oxidative stress is caused by an imbalance between free radical production and absorption, leading to irreparable cellular damage that accumulates over time and contributes to senescence. The objective of this study was to determine if oxidative stress represents a significant cost of migration between river entrance and spawning of maturing pink salmon (*Oncorhynchus gorbuscha)*. Pink salmon tissues (plasma, heart, brain, red and white muscle, and liver) were collected from individuals at different stages of migration in the British Columbia Fraser river watershed. Each tissue was assayed for resistance to oxidative stress using the oxygen radical absorbing capacity (ORAC) assay, as well as for oxidative DNA damage using an 8-hydroxy-2-deoxy Guanosine (8-OH-dG) EIA kit. Results demonstrate that oxidative stress may be experienced differentially between tissues and may be dependent on antioxidant availability and mobility. A decrease in resistance to oxidative stress occurs across migration indicating oxidative stress may correlate with the rapid senescence associated with a semelparous reproductive strategy.

Poster CCFFR (General Session)

CHANGES IN LAKE ERIE PHYTOPLANKTON DENSITY AFTER DREISSENID MUSSEL INVASION

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The objective of our intakes monitoring programme is to monitor and assess the water quality of the Laurentian Great Lakes nearshore areas and connecting channels, using municipal water treatment plant intakes as collection points. To date we've found that annual average chlorophyll *a* concentrations and phytoplankton densities decreased significantly ($P < 0.05$) at stations in Lakes Erie and Ontario in relation to nutrient load reductions during the early 1980s. There were further notable decreases following the invasion of the lakes by dreissenid mussels during the late 1980s to mid-1990s. The greatest rates of decrease were in diatom abundance. Abundances appear to have increased somewhat since 1999 however, particularly at the intakes in the western and central basins of Lake Erie. In this presentation, we focus on 3 of the intakes on Lake Erie (one in each basin) to assess annual and seasonal trends in water quality and phytoplankton abundance in more detail, emphasizing the period post-dreissenid mussel invasion. We will explore our hypothesis that spring diatom peaks in particular have decreased. We will also investigate any changes in winter diatom peaks, and determine whether they have become relatively more important seasonally during the post-dreissenid period.

Oral SCL (Invasive Species)

MORPHOLOGICAL RESPONSES TO TROPHIC LEVELS IN NATIVE AND NON-NATIVE FISH

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Non–indigenous species that exhibit a high degree of morphological plasticity are more likely to successfully spread through novel environments. The pumpkinseed (*Lepomis gibbosus*) is a North American centrarchid, first introduced to Europe over a century ago, and has since been reported in over 28 countries. In the Iberian Peninsula, the species is continuing to spread through the region's complex network of reservoirs and tributaries. We hypothesized that internal and external morphological traits, functionally significant for feeding and locomotion, will differ in pumpkinseed by habitat (river or lake) and population origin (native or non–native). We reared F1 juveniles from two Spanish and two Ontario populations for 80 days in enclosures that restricted fish to either the littoral or pelagic zone of an artificial pond. While differences in phenotypic plasticity between North American and European populations appeared to be minimal, fish held under pelagic conditions exhibited significantly longer dorsal and ventral caudal peduncle lengths, and wider caudal fin bases, regardless of geographic origin. Under pelagic conditions, all populations exhibited narrower and shorter lower jaws, and longer gill rakers. Surprisingly, the distance between gill rakers increased in all fish held under pelagic conditions. Spanish fish exhibited longer median fins and wider bodies, which is consistent with the findings of previous morphological comparisons. Native and non–native pumpkinseeds held under pelagic conditions appear to exhibit similar morphological changes geared towards enhancing their ability to cruise through open–water habitat.

Oral CCFFR (Invasive Species)

THE EFFECTS OF MULTIPLE STRESSORS ON THE ZOOPLANKTON COMMUNITY OF LAKE SIMCOE FROM 1986 TO 2010

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The zooplankton community of Lake Simcoe, Ontario, Canada, has been subjected to many changes in the past decades, including changes in dissolved oxygen concentration and warm- and cold-water fish abundances, invasive species introductions, and climate change. We performed multivariate analyses to determine whether these multiple stressors affected ice-free zooplankton community composition, using zooplankton samples that have been collected through the ice-free season in Lake Simcoe since 1986. Many changes were observed within the zooplankton community over the past 24 years, with the greatest shifts occurring after 1994 and 2000. The community shift in 1994 coincided with the establishment of the zooplanktivore *Bythotrephes longimanus* (spiny water flea), and observed changes in species abundance were typical of *Bythotrephes* effects for most zooplankton species. The zooplankton community shift in 2000, as well as atypical changes in the abundance of some zooplankton species, could have been caused by changes in the fish community, and/or gradual increases in dissolved oxygen and water temperature. Multiple stressor impacts on the zooplankton community in Lake Simcoe will be explored further in this presentation.

Oral SCL (Multiple Stressors)

EFFECTS OF AGE STRUCTURE OF SPAWNING STOCK ON THE STOCK-RECRUITMENT RELATIONSHIP OF LAKE ERIE YELLOW PERCH (*PERCA FLAVESCENS*)

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Maternal effects have been detected for many fish species. Typically, old and large females tend to reproduce more eggs with higher quality than young and small ones. Thus, changes in the age structure of the spawning stock may affect the subsequent recruitment dynamics. We are studying the effects of variation in age structure of the spawning stock on the stock-recruitment relationship of Lake Erie Yellow Perch (*Perca flavescens*). Model selection will be used to compare fits of an extended Ricker model with an index variable for spawning stock age structure and a neutral Ricker model without this index variable to observed stock-recruitment data collected between 1990 and 2010. Implications with respect to gear selectivity for managing Lake Erie Yellow Perch will be discussed.

Oral CCFFR (Great Lakes Fisheries and Environmental Policies)