Abstracts

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SWS

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DISTRIBUTION OF METAL CONTAMINANTS IN THE SOUTHERN IRAQI MARSHES

Al-Malikey[*], R.N., and L. Campbell.
Environmental Sciences, Saint Mary's University, Halifax, NS (reyam80a@yahoo.com).

The freshwater marshes of southern Iraq have been impacted severely by drought and engineering processes between the years of 1970-2003. After a large-scale restoration process carried out by the Government of Iraq and United Nations Environmental Programmes, there were concerns about metal contamination throughout the marshes. A large-scale sampling and GIS mapping effort was carried out in the Al-Hammar region of the marshes (between Thi Qar and Basar provinces) to characterize the distribution of Cd ,Cr, Co,Cu, Fe Mn ,Pb, Ni, and Zn. Air filter samples (2.5 m), filtered water, sediment, soil, mussel shells, fish and macrophytes were collected from 40 stations. Water quality data were also collected. Samples were collected over two periods, the drier summer season (June 2008) and the wetter winter season (January 2009).Water quality results indicate highly basic pH (>7), with elevated conductivity (9.14 - 8.60 s/cm) and salinity (2.11- 1.88 g/L) exceeding drinking water standards, raising concerns about ocean water intrusions due to the drought. Air filters indicate that particulate metal concentrations do not exceed any regulatory guideline in the marshes. Water data also indicate elevated metal concentrations associated with waste discharges and populated sites, and tended to be highly correlated with sediment and fish metal concentrations. Soil metal concentrations were highly elevated at most sites, exceeding regulatory guidelines. There is much concern about metal contamination in Iraq and work is underway to better quantify wildlife and human contaminant exposure and uptake from various routes in the marshes.

Poster SCL (Impacts of multiple stressors)

THE INITIAL RECOVERY OF THE PETITCODIAC RIVER'S DIADROMOUS FISH POPULATIONS FOLLOWING 42 YEARS OF IMPAIRED FISH PASSAGE

Bagnall, J.F.
AMEC Earth and Infrastructure, 495 Prospect Street, Suite 1, Fredericton, NB E3B9M4
(john.bagnall@amec.com).

For 42 years, fish passage to and from the ocean was at least impaired, and in some cases prevented by the presence of a causeway that blocked tidal flow from reaching the 20 km of the Petitcodiac River estuary upstream of Moncton-Riverview, NB. At least 10 fish species were affected by the causeway barrier including the SARA-listed (Endangered) Inner Bay of Fundy Atlantic salmon, the COSEWIC-listed (Threatened) species the striped bass and the COSEWIC-listed (Special Concern) American eel. The Petitcodiac River drainage will be described and the special problems for fish passage related to the extremely high TSS loads of the huge tidal volumes of the upper Bay of Fundy will be emphasized. The state of the recovery of the diadromous fish populations of the Petitcodiac River system following the restoration of continuous tidal flow in April -2010 will be described. The process which resulted in the

opening of the gates and the uncertain future of the "Preferred Option" (a 280 m long bridge) for the project will be described.

Oral CCFFR (Species at risk)

COMPUTATIONAL FLUID DYNAMICS (CFD) MODELING OF FISH PASSAGE ENERGETICS IN A ROCKY RAMP TYPE NATURE-LIKE FISHWAY

Baki*, A.B.M., and D.Z. Zhu.
Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB, CANADA (baki@ualberta.ca).

Nature-like fishways have recently become of considerable interest throughout much of the world. Although they are gaining increased popularity as a means of providing for fish passage, systematic studies of nature-like fishways are still in an initial phase. The competency of hydrodynamic modeling of shallow near-wakes, however, is still inadequate. In this study, a three-dimensional (3D) computational fluid dynamics model (ANSYS-CFX) of a rock ramp type nature-like fishway was used to characterize fishway hydrodynamics. The model was initial calibrated with the experimental results and then simulated for desired flow conditions. Velocities and drag forces encountered by upstream migrating fish and energy expenditures in ascending the fishway are determined from the fishway hydrodynamics. Based on burst swimming speeds, the species of salmon *Oncorhynchus spp*. capable of migrating through the fishway were identified. Results from this study will increase our ability to predict and understand the possible effects of flows on fish passage in a nature-like fishway structure and have the potential to be a valuable fisheries management tool.

Poster CCFFR (Use of new technology).

CYANOBACTERIA BIOMASS IN THE UNITED STATES: DEVELOPING GENERAL AND TRAIT-SPECIFIC PREDICTIVE MODELS

Beaulieu*, M.[1], F. Pick[2], and I. Gregory-Eaves[1].
[1]*Dept. of Biological Sciences, McGill University W6/5 Stewart Biology Building, 1205 Docteur Penfield, Montréal, Québec H3A 1B1.* [2]*Department of Biology, University of Ottawa, 30 Marie Curie, Ottawa, Ontario K1N 6N5* (marieke.beaulieu@mail.mcgill.ca)

Cyanobacteria blooms can negatively impact water quality and recreational use of water bodies. Nutrients have most often been identified as the main predictor of cyanobacteria biomass based on empirical modelling. More recently, climate-related variables such as water temperature and water column stability have be considered as predictor variables, especially in light of the traits of cyanobacteria that allow them to dominate in warmer and more stable water columns. To quantify the relative importance of climate-related variables as predictors of cyanobacteria biomass we conducted analyses of the 2007 US National Lake Assessment (NLA); a program that surveyed over 1000 lakes across the United States. As part of the NLA, phytoplankton taxa

were identified from euphotic zone samples that were collected mid-summer. We converted the cell density counts (conducted to the lowest taxonomic level) into cyanobacteria biomass (ug/L) using size ranges and shapes from the literature. Genera-specific traits such as the propensity to form water blooms and produce toxins were used to estimate the response of these specific groups. Preliminary results show that nutrients remain the best predictors of total cyanobacteria biomass. However, surface water temperature is also a significant predictor, capable of explaining a third of the variability which nutrients explain. For specific cyanobacteria trait groups, the relative and absolute importance of these factors varies. Overall, the goal of this research is to untangle the relative important of nutrient and climate variables as drivers of cyanobacteria biomass and identify which trait groups are most sensitive to climate change.

Oral SCL (Impacts of climate change)

CONSEQUENCES OF DIFFERENT THERMAL REGIME ON THE STANDARD METABOLIC RATE OF ATLANTIC SALMON PARRS (*SALMO SALAR*)

Beauregard*, D[1], E. Enders[2], and D. Boisclair[1].
[1]*Département des sciences biologiques, Université de Montréal, Québec.* [2]*DFO Freshwater Institue Science Laboratory, Winnipeg, Manitoba* (david.beauregard.2@umontreal.ca).

This study investigates the effects of daily temperature fluctuations on the standard metabolic rate (SMR) of Atlantic salmon parr. Fifty wild salmon parrs collected from the Ouelle River were acclimated to three treatments, for a total of 150 salmons. Temperature treatments were determined to represent some aspects of the natural conditions found in the Ouelle River in August 2009. Treatments were: constant (20 ^{o}C), mean daily fluctuations (20 ^{o}C ±1.5 ^{o}C) and maximum daily fluctuations (20 ^{o}C ±2.5 ^{o}C). The SMR were calculated by determining oxygen consumption rates in an intermittent-flow respirometer. Oxygen consumption rates for each salmon were calculated using time intervals of 15 minutes for 24h. Our results shows that salmon acclimated to fluctuation treatments have higher SMR than salmon acclimated to constant temperature. The SMR between maximum and mean fluctuations does not significantly differ. The effects of daily fluctuations are more important for smaller salmon. The ratio of the SMR mean fluctuations treatment/SMR constant treatment is between 1.83 for a fish with a weight of 5 g and 1.46 for a salmon with a weight of 25 g. Our study suggests that the SMR calculated with fish kept at constant temperature underestimate the SMR of fish living under natural conditions.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

NICHE PARTITIONING AND DIVERSITY IN LAKE PHYTOPLANKTON

Beisner*, B.E., and M.L. Longhi.
Department of Biological Sciences, University of Quebec at Montreal, Montréal, QC, H3C 3P8, Canada (beisner.beatrix@uqam.ca)

A variety of vertical habitats are available in stratified lakes because of opposing gradients of light and nutrients, as well as the limited mobility of plankton. Phytoplankton vertical distribution should be associated with these gradients as different taxa maximize resource access, while minimizing competitive interactions using nutritional or physical niche partitioning. Furthermore, if phytoplankton do minimize competition by reducing spatial niche overlap (NO), a concomitant increase in diversity is expected where less overlap occurs. We examined the relationship between spatial NO between four major phytoplankton spectral groups and biogeochemical and morphometric gradients across 56 lakes in southwestern Québec. We then related both the taxonomic and functional diversity of the community to the degree of overlap. NO amongst different spectral groups of phytoplankton was affected by lake trophic status, then by water colour and finally by thermal stability. An increase in taxonomic as well as nutritional functional evenness and physical functional diversity occurred when less spatial NO was observed. Together with community composition, our study indicates that phytoplankton display lower motility and pigment trait diversity when spatial overlap is high which results largely from greater dominance by nitrogen-fixing and filamentous cyanobacteria.

Oral SCL (Migration, mixing, and dispersal)

CHARACTERIZING ATLANTIC WOLFFISH HABITAT IN THE GULF OF MAINE

Bennett, T.
School of Marine Sciences, University of Maine, Orono ME 04469 and Maine Dept of Marine Resources, West Boothbay Harbor, ME 04575 (timothy.d.bennett@maine.gov).

Due to estimates of low biomass and uncertainties regarding life history, the Atlantic wolffish is currently listed as a Species of Concern by the U.S. National Marine Fisheries Service. In 2010, Atlantic wolffish were added to the Northeast Multispecies Fishery Management Plan and the new management rules prohibit the retention of Atlantic wolffish by commercial and recreational fishermen and require that any caught wolffish be released alive. Due to their incidence as bycatch, any change in Atlantic wolffish status could have a significant impact on the groundfish, lobster, and recreational fisheries. As an apex predator, in near shore kelp forest ecosystems, the decline of the Atlantic wolffish in the Gulf of Maine may have a significant impact on near shore biodiversity in the region and may contribute to the dysfunction of more commercially valuable species. In 2010-2011 the Maine Department of Marine Resources along with the University of Maine and industry partners conducted an experimental fixed gear survey for Atlantic wolffish in an effort to develop an effective method to assess this cryptic species. In addition, pop-up satellite tagging and acoustic tagging experiments were conducted to elucidate habitat use in Atlantic wolffish. No wolffish were caught during the survey, but specimens were obtained for the tagging work with cooperation of local fishermen. Reasons for the absence of catch and the results of tagging experiments will be discussed.

Poster CCFFR (Species at risk)

AN APPLICATION OF EXPORT COEFFICIENT MODELLING (ECM) TO QUANTIFY WATERSHED-BASED SOURCES OF NUTRIENTS IN THE SAINT JOHN RIVER BASIN

Benoy*, G.[1], E. Luiker[2], J. Culp[2], and S. Hann[3].
[1]*Environment Canada and Agriculture & Agri-Food Canada, Potato Research Centre, 850 Lincoln Road, Fredericton, NB, E3B 4Z7* (glenn.benoy@ec.gc.ca). [2]*Environment Canada and Canadian Rivers Institute at Department of Biology, University of New Brunswick, 10 Bailey Drive, Fredericton, NB, E3B 5A3.* [3]*Agriculture & Agri-Food Canada, Potato Research Centre, 850 Lincoln Road, Fredericton, NB, E3B 4Z7.*

Estuarine and coastal ecosystems of the Gulf of Maine continue to be degraded by excessive loadings of sediments, nutrients and contaminants derived from surrounding watersheds. The Saint John River Basin (SJRB) is the largest basin in the Gulf of Maine and within it there are a significant number of major industries along the main stem of the river and vast expanses of land-based activities of forestry and potato production along many of the river valleys and floodplains. Export coefficient modeling (ECM) was used to estimate nutrient (nitrogen – N and phosphorus – P) exports for three datasets that differed according to spatial scale. The first dataset included delineated watersheds across most of the SJRB, the second was confined to watersheds in the potato belt near of northwestern New Brunswick (NB), and the third focused on a series of intensively monitored watershed near Grand Falls, NB. (1) Proportional contributions of N and P varied according to spatial scale and agricultural extent. (2) Weak or nonexistent relationships were found between estimates of nutrient exports and concentrations of nutrients extracted from water quality datasets. (3) From the intensively monitored watersheds, ECM estimates of N and P were validated by field-based estimates based on stream flow and nutrient concentration. (4) When all datasets were combined and evaluated near the mouth of the SJRB, the ratio of non-point to point sources was around 3:1. This ratio must be interpreted cautiously as there is evidence that point-source effluents are more bioavailable to aquatic biota and a greater threat to marine ecosystems.

Oral SCL (Nutrient dynamics)

NEWFOUNDLAND GREEN CRAB INVASION: A SUMMARY 2007-2011

Best*, K.[1], C.H. McKenzie[2], T. Wells[2], and C. Couturier[1].
[1]*School of Fisheries, Marine Institute of Memorial University, St. John's, NL, A1C 5R3*
(kiley.best@mi.mun.ca). [2]*Science Branch Fisheries and Oceans Canada, St. John's, NL, A1C 5X1.*

The invasive European green Crab *Carcinus maenas* was discovered in Newfoundland waters on the South East coast in August 2007. It was concluded that they had been present for a number of years as there was a well established population with at least five different year classes.The majority of the population is concentrated in North Harbour, Placentia Bay. Fisheries and Oceans Canada and Memorial University aquatic invasive species survey team have been monitoring sites in Placentia Bay since 2007 and the green crab has spread to many sites within the bay. They have also been found on the West coast of the island in small numbers. This population is

part of a more cold tolerant strain and we speculate they have more extreme ranges for salinity and temperature tolerances as well as reproductive tolerances such as age and size at maturity to have established themselves in this environment. DFO and MUN graduate students are studying the population dynamics, reproductive biology and recruitment, behavioural tendencies and ecological implications and impacts of this invader. Mitigation and adaptive management measures are being investigated to contain the spread and reduce the impact of this invasive species.

Oral CCFFR (Invasive aquatic species)

THE ANCIENT STURGEON FISHERY OF THE MIRAMICHI, NEW BRUNSWICK

Blair*, S., and M. Litvak.
Department of Anthropology, University of New Brunswick Fredericton, and Department of Biology, Mount Allison University (sblair@unb.ca).

The modern community of Metepenagiag Mi'kmaq Nation is located in northwestern New Brunswick, Canada, at the confluence of the Northwest Miramichi and the Little Southwest Miramichi, near the modern head-of-tide. This area has a very high density of recorded precontact archaeological sites, including two National Historic Sites, the Oxbow Site, and the Augustine Mound. When combined with local knowledge and historical information, these sites offer a rich, contextualize set of information about the period between 3500 and 500 years ago, and are the focus for long-term collaborative research between academic researchers, and community institutions, such as Metepenagiag Heritage Park, some of which is presented herein. On most of these sites, sturgeon remains, consisting of calcined scutes and spines, dominate faunal assemblages. Many of these have been identified as the remains of *Acipenser oxyrhynchus*. This paper will explore the distribution of sturgeon remains in these sites, and present preliminary research on their implication for our understanding of the relationship among the ancient Mi'kmaq of Metepenagiag, the Miramichi river, and sturgeon.

Oral CCFFR (Species at risk)

THE IMPACT OF THAWING PERMAFROST ON LAKES OF THE MACKENZIE DELTA

Blais*, J.M.[1], A. Houben[1], R. Deison[1], T. French[2], L.E. Kimpe[1], M. Pisaric[3], J. Thienpont[2], and J.P. Smol[2]
[1]Department of Biology, University of Ottawa, Ottawa, ON, K1N 6N5. [2]Department of Biology, Queen's University, Kingston, ON, K7L 3N6. [3]Carleton University, Ottawa, ON, K1S 5B6 (Jules.Blais@uottawa.ca).

Total permafrost in the Northern Hemisphere currently occupies an area of 26 million km^2, and by 2100, this area is expected to decrease by 19-35%. In the Mackenzie Delta, NWT, temperatures are projected to rise by 4 to 5°C in the next 50 years. Over the past 20 years, mercury and PCBs have been steadily rising in burbot from the Mackenzie River, which has

prompted speculation on how the changing physical environment, such as thawing permafrost, might be affecting contaminant cycles in these thermokarst environments. We tested the hypothesis that the presence of retrogressive thaw slumps in the Mackenzie Delta Uplands (north of Inuvik, NT, Canada) is affecting nutrients (total and dissolved N and P), persistent organic pollutants, metal concentrations, and phytoplankton community assemblages in small tundra lakes. Dissolved organic carbon, total phosphorus, soluble reactive phosphorus, and total and methyl mercury were significantly lower in lakes with retrogressive thaw slumps than reference lakes, possibly due to deeper water infiltration through clay-rich tundra soils. In addition, we have been tracking changes in the lake's biota over time using fossil diatoms in lake sediment cores. Striking changes in diatom assemblages over time may be linked to past changes in melting permafrost. Future studies will investigate the effect of thaw slumps on microbial transformations of mercury, the transfer of persistent organic pollutants to surface waters, and limnological responses to the changing permafrost status.

Oral SCL (Impacts of climate change)

ASSESSMENT OF FISH ABUNDANCE AND ACTIVITY USING COMBINED FISHERY ACOUSTICS AND TELEMETRY APPROACHES

Blanchfield*, P.J.[1], D. deKerckhove[2], L. Hrenchuk[1], S. Milne[3], L. Cruz-Font[2], M. Rennie[3], M. Guzzo[4], and B. Shuter[2].
[1]*Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, MB* (Paul.Blanchfield@dfo-mpo.gc.ca). [2]*University of Toronto, Toronto, ON.* [3]*Milne Technologies, Keene, ON.* [4]*University of Manitoba, Winnipeg, MB.*

The determination of fish abundance has long been a cornerstone of fisheries science. Annual abundance estimation of large- and small-bodied fish species traditionally requires a substantial investment in time and resources. Thus, methods, such as fishery acoustics are of interest because they present a cost-effective way to passively assess fish populations, including evaluation of fish abundance and biomass. However, these new approaches need solid ground-truthing for broad applicability. Annual estimation of fish abundance has occurred in a suite of small, boreal lakes at the Experimental Lakes Area (ELA) for many years. We are in the process of comparing fish abundance and biomass achieved through traditional annual mark-recapture methods (Jolly-Seber) to mobile fishery acoustic surveys, with plans to extend this analysis to CPUE estimates of small-bodied fish. These well-defined fish populations present a unique opportunity to compare with concurrent acoustic assessments in a number of lakes. A second approach we have undertaken is the use of stationary hydroacoustic stations to assess foraging and activity patterns of top predatory species. We first acquired estimates of fish activity determined through use of acoustic telemetry transmitters that are explicitly designed to record the relative frequency of sudden, high acceleration movement characteristic of predatory behaviour, as well as regular activity. The primary objective of this component of the study is to determine the ability of hydroacoustic approaches to quantify activity rates of fish under natural conditions; a key requirement for understanding fish bioenergetics. We present initial findings on these two fronts.

Poster CCFFR (Use of new technology)

A WHOLE-CATCHMENT MANIPULATION TO EVALUATE THE IMPACT OF DRY CONDITIONS ON BOREAL LAKES

Blanchfield*, P.J.[1], C. Spence[2], M. MacKay[3], and K. Beaty[1].
[1]*Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, MB* (Paul.Blanchfield@dfo-mpo.gc.ca). [2]*Environment Canada, Saskatoon, SK.* [3]*Environment Canada, Downsview, ON.*

Dry conditions caused by climate variability are expected to have impacts on the biophysical properties and processes of boreal shield lakes. Global Climate Model (GCM) 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. Lakes are strongly affected by climatic conditions, especially through amounts of inflow and resulting input of terrestrial nutrients and carbon. How lake productivity and fish habitat subsequently respond to reductions in water and 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. We present findings from the first full year of manipulation, with an emphasis on the impacts to lake trout, a cold-water species sensitive to disturbance and considered a sentinel for the impacts of climate across Canada's boreal freshwater ecosystems.

Oral CCFFR (Impacts of climate change)

NSERC HYDRONET: A NATIONAL RESEARCH NETWORK TO PROMOTE THE SUSTAINABLE DEVELOPMENT OF HYDROPOWER IN CANADA

Boisclair, D.
Département de sciences biologiques, Université de Montréal, C.P. 6128, Succursale «Centre-ville», Montréal, Québec H3C 3J7 (Daniel.Boisclair@UMontreal.ca)

The 470 hydroelectric facilities that have been developed in Canada produce 60% of the electricity used for domestic, commercial, and industrial purposes in this country. The capacity to generate renewable energy significantly contributes to the wellbeing and the prosperity of Canadians. However, the benefits provided by hydropower come at the cost of the effects on the physical, chemical, and biological attributes of natural ecosystems. It has long been recognized that reconciling the production of hydroelectricity with the conservation of aquatic ecosystems represents a major challenge requiring a collaborative structure that actively integrates industry,

government, and academic partners. NSERC HydroNet constitutes the realization of this partnership. The general objective of this national research network is to provide new knowledge and tools that will permit us to better assess, minimize, and mitigate the effects of hydropower, and hence, permit the sustainable development of hydropower in Canada. Given its central role in the decision-making process, the productive capacity of fish habitats has been adopted as the central theme for the Network. Conceptual models developed to synthesize processes that determine the productive capacity of fish habitats in rivers, lakes, and reservoirs were used to develop 31 research projects. The objectives of this presentation are to describe the structure, the mode of operation, and the projects conducted by NSERC HydroNet and, eventually, to foster new collaborations with members of CCFFR and SCL.

Oral CCFFR (General session)

USING JUVENILE DENSITY DATA TO INFER ADULT ABUNDANCE AND STATUS IN ATLANTIC SALMON

Bowlby*, H.D., and A.J.F. Gibson
(heather.bowlby@dfo-mpo.gc.ca)

Typically, juvenile survey data are not used explicitly to determine status, trends or abundance designations for Atlantic salmon, even though they can be the only source of information for a given population. In more data-rich populations, cohort analyses are often used to estimate age- and stage-specific survival rates, based on the idea that juvenile density data and adult abundance are related. To determine if juvenile data can be informative about adult abundance and status, we evaluated similarities in trends among age classes for two data-rich populations using a nested log-linear model. We found relatively consistent and significant trends for the age 0, adult, and egg time series, but trends in juvenile density data for older age classes were less consistent with adult abundance trends. A threshold-based, non-parametric analysis demonstrated that relatively low misclassification rates for adult status relative to a set reference level could be obtained from juvenile density estimates. Together, results suggest that juvenile density data can be an informative proxy for adult abundance and may be useful as a trigger for large changes in population status relative to reference points. However, these results are sensitive to the timing of density dependence in fresh water, which would necessitate prior knowledge of the underlying population dynamics before the method could be applied more generally.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

FROM PROPAGULE PRESSURE TO ESTABLISHMENT: USING IMPORT RECORDS TO QUANTIFY AQUARIUM FISH ESTABLISHMENT RISK

Bradie*, J., C. Chivers, and B. Leung.
Department of Biology, McGill University, 1205 Ave. Docteur Penfield, Montreal, PQ
(johanna.bradie@mail.mcgill.ca)

More than 28 million fishes from over 220 species are imported to Canada each year. Ornamental fish can pose an establishment risk if individuals are released to the wild. Indeed, the aquarium trade is one of the top 5 pathways for non-indigenous species (NIS) introduction and establishment. Previous research on the aquarium vector has quantified the probability of live release, identified fish at risk for invasion, and identified a link between establishment and propagule pressure. Our study quantitatively models the relationship between propagule pressure and establishment for the aquarium trade using Canadian live fish imports data as a surrogate for propagule pressure. We quantify the likelihood of invasion, the Allee effect associated with invasions, and the uncertainty in these estimates. Despite the relatively coarse data available, there is a need to generate these estimates for use in risk analyses. We use Bayesian methods to parameterize our model and characterize uncertainty. The results of this study help quantify the probability of NIS establishment via the aquarium trade and can be used by policy makers to guide decisions regarding potential import restrictions.

Oral CCFFR (Invasive aquatic species)

A NEW WETLAND CONSERVATION POLICY FOR NOVA SCOTIA

Brazner, J.C.
Nova Scotia Environment, 5151 Terminal Rd., Halifax, NS (braznejc@gov.ns.ca).

In 2007, the Environmental Goals and Sustainable Prosperity Act mandated that the government of Nova Scotia develop a policy to prevent the net loss of wetlands by the end of 2009. Public consultation on a draft policy occurred throughout the fall of 2009 and government approved a revised version in September, 2011. It is a comprehensive policy for the Government of Nova Scotia to ensure that the benefits that wetlands provide are maintained for the people of Nova Scotia. The policy highlights the important roles wetlands play in Nova Scotia's landscapes and their value to society. It represents a commitment to managing Nova Scotia's wetlands in a consistent manner and to maintaining a high level of wetland integrity for future generations, while allowing for sustainable economic development in our communities. The policy establishes specific objectives intended to prevent the net loss of wetlands across the province, provide enhanced protection for wetlands of special significance, restore wetland types that have suffered high historic losses, promote the use of buffers and educate Nova Scotians about the importance of conserving wetlands. Details associated with the policy and its implementation will be discussed.

Oral CSWS (Science for wetland policy and management)

IMPACT OF COPPER CONTAMINATION ON INDUCIBLE ANTIPREDATOR DEFENSES IN *D. PULICARIA*

Bresnehan*, A., and S. Arnott.
Department of Biology, Queen's University (amanda.bresnehan@queensu.ca)

Antipredator defenses are ubiquitous in aquatic ecosystems. In the widely studied *Chaoborus-Daphnia* predator-prey system, *Daphnia* elicit a variety of plastic responses to *Chaoborus* including: diel vertical migration (DVM), neck-tooth induction, increased size at first reproduction, and decrease in brood size. While these inducible defenses benefit the prey, metal contaminants have been shown to interfere with chemosensory functions, thereby inhibiting anti-predator defenses and decreasing survivorship. However, in lakes with a history of metal contamination, such as Kelly Lake in Sudbury, Ontario, there is evidence to suggest that *Daphnia* may have adapted to higher copper concentrations. Using seven distinct *Daphnia* clones that were hatched from resting eggs from Kelly Lake, we examined morphological and life history traits when clones were exposed to either a nominal concentration of copper, kairomone, or a combination of both. Size at first reproduction (SFR) was smallest in the control treatment, while SFR among the Cu, kairomone, and Cu x kairomone treatments remained relatively similar. There was little inter-clonal variation in mean body size amongst treatments. Number of neonates was greater in treatments with kairomone than in treatments without. Our results indicate that environmentally relevant copper concentrations do not inhibit defenses in *Daphnia* from Kelly Lake and that individuals reared in non-control treatments exhibit greater overall fitness. We conclude that Kelly Lake *Daphnia* have an adaptive tolerance to copper.

Oral SCL (Impacts of multiple stressors)

A SUCCESSFUL LAKE RESTORATION: ASSESSMENT OF GENETIC AND ECOLOGICAL FACTORS IMPORTANT FOR BROOK CHARR POPULATION SURVEY FOLLOWING A REINTRODUCTION

Brodeur*, N.N.[1], M. Plante[2], P. Magnan[3], and L. Bernatchez[1].
[1]*Université Laval, Québec City, QC.* [2]*La Mauricie National Park, QC.* [3]*Université du Québec à Trois-Rivières, Trois-Rivières, QC* (nathalie-n.brodeur.1@ulaval.ca)

The original brook charr, *Salvelinus fontinalis*, population of Lake Tessier (La Mauricie National Park, Québec, Canada) was extirpated circa 1940, probably due to anthropogenic activities before the creation of the Park. The purpose of this study was to test a protocol of reintroduction to restore the indigenous brook charr population in its original habitat, in accordance with the conservation priorities of Parks Canada: the protection and maintenance or restoration of the ecological integrity of the Park's ecosystems. The lacustrine brook charr of the Laurentian Shield exhibit a subtle "pelagic-littoral resource polymorphism", representing the early stage of sympatric population divergence. We aimed to transfer the existing standing genetic variation and resource polymorphism from a neighbouring wild population to the newly founded population of lake Tessier. Approximately 30,000 young-of-the-year were released in lake Tessier over a two-year period, and 1,000 F1 and 1,000 F2 offspring were genotyped at 15 microsatellite loci. Our results suggest that the genetic diversity in the source population was transferred and maintained in the newly founded population, and that the effective population size was comparable to that of the source one. Results of parentage assignment show that the relative survival of families is high between the two first age classes (0+ and 1+). Discriminant function analyses suggest that morphological differences were present between individuals of the

founding population and that part of this morphological diversity was transferred in the offspring captured in the littoral and pelagic zones of lake Tessier. However, stomach contents did not differ between individuals sampled in both zones of the lake, suggesting a high phenotypic plasticity in the feeding habits of expanding populations.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

FINE-SCALE BEHAVIOUR IN FISH: ACCELERATION SIGNATURES AND THE EFFECT OF SAMPLING FREQUENCY

Broell[*], F.[1], T. Noda[2], S. Wright[3], P. Domenici[4], J. Steffensen[5], and C.T. Taggart[1].
[1]*Department of Oceanography, Dalhousie University,1355 Oxford Street, Halifax, Canada B3H 4R2* (franziskabroell@dal.ca). [2]*Department of Social Informatics, Graduate School of Informatics, Kyoto University, Yoshidahonmachi, Kyoto, Japan 606-8501.* [3]*Cefas Laboratory, Pakefield Road, Lowestoft, Suffolk, England NR33 0HT.* [4]*IAMC–CNR Instituto Ambiente Marino Costiero Sezione di Oristano, Loc. Sa Mardini, 09072 Torregrande (Oristano), Italy Marine.* [5]*Biological Laboratory, University of Copenhagen, Strandpromenaden 5, 3000 Helsingør, Denmark.*

Accelerometer tags are used to remotely observe marine animals and to identify and quantify behavioural states and rates such as resting, swimming and migrating, used to estimate activity and energy budgets. Most studies use low frequency (≤32Hz) accelerometer sampling due to battery and data-archive constraints of commercially available tags. In this study we assessed the effect of sampling frequency (aliasing) on event detection frequency (D_R) using the great sculpin (*Myoxocephalus polyacanthocephalus*), pollock (*Pollachius virens*) and sturgeon (*Acipenser brevirostrum*). Feeding and escape events and spontaneous movements were triggered, observed and recorded using 100Hz accelerometer sampling and high-speed video among 7 different great sculpin. We demonstrate that multiple parameters in the time and probability domain can statistically differentiate among events. D_R for feeding and escape events decreased by 50% when sampling at <30Hz. Our analyses demonstrate additional problems associated with aliasing and how activity and energy-budget estimates can be compromised and misinterpreted. We recommend that high-frequency accelerometer sampling be used in similar (field) studies. If battery/storage is limited, we also recommend archiving the events via an on-board algorithm that determines the highest likelihood and subsequent archiving of the various event-classes of interest.

Oral CCFFR (Use of new technology)

WHY PRE-STOCKING PREDATOR RECOGNITION TRAINING OF HATCHERY-REARED SALMONIDS MIGHT NOT INCREASE POST-STOCKING SURVIVAL: LESSONS FROM BEHAVIOURAL ECOLOGY

Brown*, G.E.[1], M.C.O. Ferrari[2], and D.P. Chivers[3]
[1]*Dept. of Biology, Concordia University, 7141 Sherbrooke St. West, Montreal, Qc*

(gbrown@alcor.concordia.ca). [2]*Dept. of Biomedical Sciences, Western College of Veterinary Medicine, University of Saskatchewan, 52 Campus Dr., Saskatoon, SK.* [3]*Department of Biology, University of Saskatchewan, 112 Science Pl., Saskatoon, SK.*

The success of current salmonid restocking efforts is hampered by poor survival of new stocked hatchery-reared juveniles. This low survival is likely due, in part, to a lack of 'life skills' learning opportunities, including predator recognition, associated with hatchery settings. One commonly proposed method is to condition hatchery-reared salmonids to recognize potential predators prior to stocking in order to enhance survival. However, despite a wealth of laboratory and field studies demonstrating the sophisticated learning abilities of juvenile salmonids and the demonstrated survival benefits associated with predator recognition, recent reports suggest that predator recognition training does not appear to enhance post-stocking survival. Our recent studies suggest that while hatchery-reared salmonids are able to learn to recognize novel predator cues, individuals maintained on high growth trajectories or those with 'bold' risk prone behavioural phenotypes may not retain learned information as long as those with low growth rates or 'shy' risk averse phenotypes. Given that hatchery settings may select for fast growing and/or bold phenotypes, this difference in retention of learned information may explain the lack of post-stocking survival.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

PRIMARY AND SECONDARY SEXUAL CHARACTERS IN ALTERNATIVE REPRODUCTIVE TACTICS OF CHINOOK SALMON: ASSOCIATIONS WITH ANDROGENS AND THE MATURATION-INDUCING STEROID

Butts*, I.A.E., O.P. Love, M. Farwell, and T.E. Pitcher.
Department of Biological Sciences, University of Windsor, Windsor, Ontario, Canada, N9B 3P4
(ianbutts@uwindsor.ca).

The proximate mechanisms that underlie the evolution of within-sex variation in mating behaviour, sexual characters and reproductive investment patterns are still poorly understood. Species exhibiting alternative reproductive tactics (ARTs) are ideal model systems to examine these mechanisms. Chinook salmon (*Oncorhynchus tshawytscha*) exhibits two distinct ARTs: hooknoses, which are large males that establish spawning dominance hierarchies via intense male-to-male competition and jacks, which are smaller precocious sneaking males that steal fertilizations via sperm competition. In this study, we examine testosterone (T), 11-ketotestosterone (11-KT) and maturation-inducing steroid (MIS; 17α,20ß-dihydroxy-4-pregnen-3-one) profiles of spawning hooknoses and jacks. Furthermore, we examine relationships between androgens and primary (gonad mass, gonadosomatic index and sperm traits) and secondary (total mass, body size, hump depth and kype length) sexual characters. Relationships between MIS and sperm traits are also examined. We found that hooknoses and jacks did not significantly differ in terms of either T, 11-KT or MIS concentrations. Moreover, we found significant positive relationships between levels of both androgens within each ART. There were no significant relationships between androgens, MIS and sperm traits. T and 11-KT concentrations co-varied positively with gonad investment and kype length in jacks. In

hooknoses, 11-KT concentration was positively related to total mass, hump depth and condition factor. Overall, these findings suggest that there are differential androgen effects for each of the ARTs in Chinook salmon.

Poster CCFFR (General session)

A PROPOSED METHOD TO ASSESS THE PANMICTIC AMERICAN EEL STOCK

Cairns, D.K.
Department of Fisheries and Oceans, Box 1236, Charlottetown, Prince Edward Island, Canada C1A 7M8 (david.cairns@dfo-mpo.gc.ca)

The American eel may be the most widely distributed fish species in the world to have been declared a species at risk. However, no assessment currently exists which allows impacts of fisheries and other anthropogenic factors to be evaluated on a stock-wide basis. An assessment methodology is proposed, based on habitat quantification, modelling of demographic parameters, and spawner-per-recruit analysis. Growth habitat in marine waters will be mapped on the basis of degree of exposure to the open sea. Freshwater habitat will be quantified using relations between watershed size and wetted area. Densities will be compiled from field measurements or estimated from relations between density and catch-per-unit-effort. Demographic parameters will be compiled from field measurements or modelled from environmental data. Demographic models will apply spawner-per-recruit analysis to regions that have relatively homogeneous demographic traits and levels of fishing activity. The assessment will estimate standing stock by number and biomass, silver eel production and potential egg production, fisheries exploitation rates, and compliance with target and limit biological reference points. Results will be presented for management units, countries, and North America. The proposed assessment will provide the first diagnosis of and prescription for the eel's conservation problems that recognizes the American eel as a single panmictic stock.

Oral CCFFR (Species at risk)

TOWARD A BETTER UNDERSTANDING RIVER WATER TEMPERATURE DYNAMICS AND CORRESPONDING FORCING FACTORS

Caissie[*], D.[1], and N. El-Jabi[2]
[1]*Fisheries and Oceans, Moncton, NB* (Daniel.Caissie@dfo-mpo.gc.ca). [2]*Université de Moncton, Moncton, NB.*

The thermal regime of rivers plays an important role in the overall health of aquatic ecosystems. River water temperatures are also important for water quality, for conducting environmental impact assessments and for effective fisheries management. As such, it is important to understand the thermal behaviour of rivers and related heat exchange processes. This study looks at different river thermal processes responsible for water temperature variability on both the temporal (e.g., diel, daily, seasonal) and spatial scales, as well as providing information

related to different water temperature models currently found in the literature. The energy budget model will be presented and relevant heat exchange processes will be describe, both at the water – surface interface and at streambed – water interface. Modeling examples will be presented as well as the implication of water temperature models in a better protection of fish habitat and a more efficient fisheries management.

Oral SCL (General session)

POPULATION DYNAMICS OF THE INVASIVE ROUND GOBY FISH IN THE GREAT LAKES

Calder*, M.[1], Y. Zhao[2], and X. Zou[1].
[1]*Department of Applied Mathematics, University of Western Ontario, 1151 Richmond St. N., London, Ontario, N6A 5B7.* [2]*Aquatic Research and Development Section, Ontario Ministry of Natural Resources, 320 Milo Road, Wheatley, Ontario, Canada, N0P 2P0* (mcalder9@uwo.ca)

The round goby fish, *Neogobius melanostomus*, is an invasive species believed to have originated in ballast water from Eastern Europe and Western Asia that was first detected in the St. Clair River in 1990 and later known to be present in all of the Great Lakes by 2000. An unfortunate consequence is the decline or displacement of many native species such as the mottled sculpin, sturgeon, and trout. In this talk, I will present a density-dependent, discrete-time model of the population of the round goby that accounts for dispersion. Moreover, I will provide a preliminary analysis and simulation. This should lead to practical control strategies.

Oral CCFFR (Invasive aquatic species)

IS IT POSSIBLE TO HAVE A SUSTAINABLE FISHERY ON TOP PREDATORS SUCH AS SHARKS?

Campana, S.E.
Bedford Institute of Oceanography, Fisheries and Oceans Canada, P.O. Box 1006, Dartmouth, Nova Scotia B2Y 4A2 (steven.campana@dfo-mpo.gc.ca)

The conventional wisdom is that fisheries on top predators such as sharks are doomed to failure, and inevitably lead to population collapse. This view is understandable, given the inherently low productivity of most sharks. However, sensitivity to overfishing does not necessarily mean that overfishing is inevitable, especially if the science can provide a good basis for sound advice. Using porbeagle, spiny dogfish, and blue shark in Atlantic Canada as examples, I highlight how shark fishing can proceed in a sustainable manner, as long as the management backs up the science.

Oral CCFFR (Role of top predators)

COMMUNITY AND FOOD WEB STRUCTURE IS CRITICAL TO THE FISHERIES POTENTIAL IN PRAIRIE STORAGE RESERVOIRS

Campen*, M., and J.B. Rasmussen.
Department of Biology, University of Lethbridge, 4401 University drive west, Lethbridge, Alberta, T1K 3M4.

Southern Alberta storage reservoirs support a high diversity in fisheries potential (growth rates and survivorship) of target species, e.g. northern pike *Esox lucius* and walleye *Sander vitreus*. Development of food webs in these reservoirs generally relies on natural colonization by forage fish from upstream locations, e.g. small streams or rivers. Pelagic forage fish, such as lake whitefish, that link pelagic zooplankton to piscivorous fish, seem only to colonize in reservoirs situated downstream of headwater lakes. Reservoirs without pelagic forage fish thus lack a critical food web link, forcing piscivorous fish to rely solely on a (littoral) invertebrate diet. This lack of pelagic forage fish severely alters the growth and survivorship of piscivorous fish in reservoirs. A comprehensive survey of Fish and Wildlife Management Information Systems (FWMIS) data in combination with district maps is utilized to determine, whether the presence of upstream lakes/water bodies holding lake whitefish can explain the distribution of these fish in the storage reservoirs. Furthermore, we assess the importance of Lake Whitefish as a diet for piscivorous predators by analysing the reservoir fish community abundance and diversity. We compare available littoral and pelagic resources to fish diets using gut content and stable isotope analysis. We hypothesize differences in diets of piscivorous predators in the reservoir to be related to differences in prey community and abundance and to be intricately linked to the possible recruitment of forage fish from upstream water bodies.

Poster CCFFR (General session)

THE APPLICATION OF SULPHUR STABLE ISOTOPE ANALYSIS TO DETERMINE FISH MOVEMENTS IN ATLANTIC CANADA STREAMS

Charest*, M., B. Graham, and R.A. Cunjak.
Canadian Rivers Institute, Department of Biology, University of New Brunswick, P.O. Box 4400, Fredericton, New Brunswick, Canada E3B 5A3 (mchares1@unb.ca).

Stable isotope analysis is a well used analytical method in ecological research. Carbon and nitrogen are the most common elements used in food web, migration and nutrient dynamics research. Sulphur stable isotopes can also be used in these areas of research, but there has been little research done on the applicability of sulphur isotope analysis. Determining the sulphur isotopic difference between a consumer and its diet, the trophic enrichment factor (TEF), would allow sulphur stable isotopes to be used more accurately. The objective of this study is to determine the TEF of sulphur isotope ratios of brook trout (*Salvelinus fontinalis*) by conducting a diet shift laboratory experiment. Once the TEF is determined, a field-based study in the St-John River, NB will be conducted to determine if the results from the lab study can be applied to field based research. The fieldwork will focus on sulphur isotope values of fish throughout their distribution in the St-John River, from freshwater to the estuary. By determining the TEF of

sulphur isotope ratios in fish and testing its application we will ensure sulphur stable isotope analysis a stronger tool in freshwater ecology, in particular to be used as a natural tag to study fish migration.

Poster CCFFR (Use of new technology)

AN EVALUATION OF AN INSHORE BOTTOM TRAWL SURVEY DESIGN FOR AMERICAN LOGBSTER (*HOMARUS AMERICANUS*) USING COMPUTER SIMULATIONS (O) (CCFFR)

Cao[1], Jie, **Yong Chen[1*]**, Jui-Han Chang[1], and Xinjun Chen[2]

[1]School of Marine Sciences, University of Maine, Orono, Maine 04469, USA
[2]College of Marine Sciences, Shanghai Ocean University, Shanghai, China

*Email: jie.cao@maine.edu, ychen@maine.edu

Abstract

This paper evaluates the performance of five possible sampling designs to estimate the population abundance index for American lobster using computer simulation. They are simple random sampling (SRS), systematic sampling (SYS) and stratified random sampling with three stratification schemes (i.e., based on region, depth and region × depth). For the stratified random design with region and depth being used for stratification, we evaluated the performances of different strategies for allocating sampling efforts. Simulations were implemented on the "true" populations which were calculated annually from 2002 to 2008 for both spring and fall based on a habitat model developed in a separate study. Relative Estimation Error (REE), Relative Bias (RB) and design effect were used to measure the accuracy and efficiency of mean estimation. On average, SYS tended to yield the most accurate and efficient estimate of mean with specified sample size. However, its performance varied with sample sizes and realizations of "true" population, thus changed with lobster distribution. Appropriate stratification could significantly improve the accuracy and efficiency over SRS, such as using depth to determine strata. However, stratified design by region yielded little improvement. Allocating samples to each stratum appropriately could also significantly improve accuracy and efficiency.

Oral CCFFR (General session)

RELATING THE FORAGING STRATEGY TO CATCH RATES IN THE GULF OF ST. LAWRENCE SNOW CRAB FISHERY

Charles*, C., and D. Gillis
Department of Biological Sciences, University of Manitoba, Winnipeg, MB, R3T 2N2
(umcharle@cc.umanitoba.ca)

The snow crab fishery in the Gulf of St. Lawrence is one of the most important shellfish fisheries in Atlantic Canada with the 2004 crab season landings value exceeded $620 million. Each vessel in the fishery is equipped with a vessel monitoring system (VMS) that reports position at regular

time intervals which allows high spatial resolution for in-season management strategies. Levy flights are proposed for finding sparse, randomly distributed prey on a spatial scale that is beyond the searchers sensory range. It's foraging parameter (μ) can be calculated from the distribution of step lengths when they follow a power law distribution ($P(l) \sim l^{\mu}$). In this study we compared the fishing strategies employed by fishermen of different experience and home port locations. Specifically we look to relate searching behaviour with fishing success. We hypothesize that (1) vessels with higher catch rates will have more directed movement (μ approaches 1) and (2) As fishing season progresses catch rates will decrease and the foraging parameter will increase.

Poster CCFFR (General session)

INVESTIGATING MULTIPLE STRESSOR RESPONSES TO NUTRIENT ENRICHMENT AND SEDIMENTATION IN STREAM MESOCOSMS

Chase*, J.W.[1], G.A. Benoy[2], and J.M. Culp[3].
[1]Canadian Rivers Institute and Department of Biology, University of New Brunswick, Fredericton, NB, Canada (justinwchase1@gmail.com). *[2]Environment Canada and Agriculture and Agri-Food Canada, Potato Research Centre, Fredericton, NB, Canada. [3]National Water Research Institute and Canadian Rivers Institute, University of New Brunswick, Fredericton, NB, Canada.*

There is a present need to investigate freshwater ecosystem degradation as a function of multiple, often coinciding factors (*stressors*). Agricultural impacts on streams in the form of sedimentation and nutrient loading are significant threats to fluvial ecosystem integrity in North American watersheds. Artificial stream systems known as *mesocosms* provide a useful means of disentangling the contributions of individual stressors acting in a multiple stressor environment while also investigating interactions between these factors. This project examines the impacts of nonpoint source agricultural pollutants on benthic invertebrate assemblages characteristic of northern temperate streams. Experimental manipulations of fluvial environments were performed in mid summer of 2010 and 2011 using a mesocosm facility consisting of 96 self-contained artificial streams. Key questions that will be addressed include: (1) what are the individual contributions of sedimentation and nutrient loading when simultaneously acting on benthic environments; and (2) are the relationships between stressors simply additive or are there interactions inherent to specific combinations? It is anticipated that the results of this project will contribute to greater understanding of the complex associations between factors that lead to fluvial ecosystem degradation and will be of particular relevance to the management of freshwater systems in Eastern Canada's agricultural regions.

Poster SCL (Impacts of multiple stressors)

WITHIN- AND AMONG-LAKE VARIATION IN TOTAL PHOSPHORUS DECLINE DURING STRATIFCATION

Chen, F., and W.D. Taylor*.
Department of Biology, University of Waterloo, 200 University Avenue West, Waterloo, Ontario, Canada N2L 3G1 (wdtaylor@uwaterloo.ca)

The within-lake and among-lake variation in TP declines during stratification (TP trajectories) were explored for north temperate lakes. Seven lakes with multiple years of data were investigated to characterize the within-lake variation in TP trajectory. The TP trajectories were quantified as rate constants (primary exponents) obtained using exponential regression. Within each lake, the primary exponent was found to be significantly correlated with initial spring TP. We quantified the relationship between TP trajectory and spring TP with a secondary exponent, which describes the tendency of a lake to maintain a relatively constant summer TP level, and we hypothesize that the secondary exponent is a property of the lake that varies with morphological parameters including the maximum depth and lake area that affect return of P to the epilimnion, as well as biological properties that affect sedimentation velocity of particulate P. Among-lake variation in TP trajectories was examined using 18 north temperate lakes. These included the same seven lakes with long records as well as lakes with data for a single stratified season. A strong relationship between TP trajectory and spring TP was observed and this relationship was stronger when lakes are classified into shallow (< 10 m) and deep lakes. Together these analyses support the hypothesis that the decline in TP during stratification increases with TP, reflecting a tendency of lakes to move towards similar TP levels in summer despite variation in spring TP levels presumably related to differences in loading.

Oral SCL (Nutrient dynamics)

DOES THE CURRENT ONTARIO WETLAND EVALUATION SYSTEM ADEQUATELY PROTECT COASTAL WETLANDS OF EASTERN GEORGIAN BAY?

Chow-Fraser*, P., and J.D. Midwood.
Department of Biology, McMaster University, 1280 Main St. West, Hamilton, ON L8S 4K1 (chowfras@mcmaster.ca)

Within Ontario, a wetland that is designated as "Provincially Significant" receives maximum protection from human development under the law, and the method used to determine such a designation is the Ontario Wetland Evaluation System (OWES). In order for a wetland to be evaluated, however, it must be larger than 2 ha, and this size criterion precludes majority of the wetlands in eastern Georgian Bay from being considered, even though many of these are in pristine condition and provide excellent nursery and spawning habitat for Great Lakes fishes. The OWES makes a provision, however, that if there is a clear biological rationale, and if complexes are within 750-m of each other within the same watershed, smaller wetlands can be linked together to form larger complexes that qualify them for OWES protection. Results from a two-year study we have just completed show that while the vast majority of small-bodied fishes (sunfish, minnows, shiners) remain in a single wetland throughout the year, large mobile predators use multiple wetlands over relatively large areas during the active season. The northern pike, for example, tended to move an average of 1.4 km between wetlands, and one moved almost 4 km between wetlands. We therefore question 1) validity of using current size

and distance criteria as the basis for delineating wetland complexes and 2) the adequacy of current OWES for protecting fish habitat in coastal wetlands of eastern Georgian Bay.

Oral CSWS (Science for wetland policy and management)

EFFECTS OF CONSERVATION RELEASE AND CAPTIVE REARING STRATEGIES ON FITNESS-RELATED MEASURES FOR INNER BAY OF FUNDY (IBoF) ATLANTIC SALMON

Clarke*, C.[1], C.F. Purchase[2], and D.J. Fraser[3].
[1]Environmental Science Graduate Program, Memorial University of Newfoundland, St. John's NL A1B 3X9. [2]Department of Biology, Memorial University of Newfoundland, St. John's NL A1B 3X9. [3]Department of Biology, Concordia University, Montreal PQ H4B 1R6
(Corey.Clarke@pc.gc.ca)

The number of species assessed at some level of risk of extinction continues to increase. As a result, programs to captive rear and release wild-origin individuals are also increasing in number and scope in attempts to lower risk of extinctions. Salmon population trends in the Atlantic and Pacific oceans characterize this situation well. Despite considerable efforts in the development and implementation of various combinations of captive rearing and re-introduction programs, undesirable effects of domestication are cited among the factors most limiting the realization of program objectives. We developed a program to quantify the effects of both conservation release and captive rearing strategies on several characteristics related to the natural fitness of IBoF Salmon from 1-6 months post hatch through to hatch of the next generation. Conservation release strategies for this study include unfed fry and 6 month feeding parr. Rearing strategies include standard freshwater conservation hatchery and sea cages in the local marine environment. We quantified effects of release strategies within and between rearing environments. Here we present preliminary results on the effects of release strategy and physical smolt characteristics on growth and survival in the captive marine environment. Results suggest that fish released as six-month old feeding parr survived better than their unfed fry counterparts and that smolt weight had the most significant effect on growth in this captive environment. This project was designed to inform management on a Parks Canada species at risk program although certain aspects of the work are relevant to any captive rearing-based salmonid conservation program.

Oral CCFFR (Species at risk)

EVALUATING THE 'ZONE OF INFLUENCE' OF AN ENGINEERED STREAM TO PROVIDE SPAWNING HABITAT FOR LANDLOCKED ATLANTIC SALMON

Clarke*, K.D.[1], C.J. Pennell[1], and B. Sellars[2].
[1]Fisheries and Oceans Canada, PO Box 5667, St. John's NL. [2]Nalcor Energy P.O. Box 12400. St. John's, NL A1B 4K7 (keith.clarke@dfo-mpo.gc.ca)

The evaluation of habitat compensation tends to be conducted on a local scale but to be truly effective as a fisheries management tool, the induced change in habitat should be linked to population characteristics. A 1.6 km fish habitat channel, subsequently named Compensation Creek, was constructed by Newfoundland and Labrador Hydro to compensate for habitat losses associated with the Granite Canal Hydroelectric Development. One of the purposes of this engineered stream was to supply spawning habitat, which was deemed to be in limited supply, to the landlocked Atlantic salmon population utilizing Maelpaeg Lake. The effectiveness of the compensation habitat to function as designed was evaluated at the population scale by tagging spawning sized salmon throughout Maelpaeg Lake before the spawning migration and then monitoring their movements in and out of Compensation Creek during five spawning seasons (2006-2010). A total of 1497 salmon where tagged with Passive Integrated Transmitters (PIT Tags) over the course of the study with greater than 45%, on average, of these fish entering Compensation Creek for spawning during the year of tagging (range 33.5 – 62.6% yr^{-1}). Salmon from all areas of Maelpeg Lake that were successfully sampled migrated to Compensation Creek. Thus, it appears that Compensation Creek is functioning as designed and is providing spawning habitat for a large proportion of the land locked salmon population.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

SEASONAL MIGRATION OF YELLOW-STAGE AMERICAN EEL INFERRED BY STABLE ISOTOPE AND OTOLITH MICROCHEMISTRY ANALYSES AND CONFIRMED WITH PIT TAG TECHNOLOGY

Clément[*], M.[1], M. Sweezey[2], A. Chiasson[3], G. Veinott[4], S. Courtenay[1,2], and D. Cairns[1].
[1]*Department of Fisheries and Oceans, Gulf Region, Moncton, NB* (marie.clement@dfo-mpo.gc.ca). [2]*University of New Brunswick, Fredericton, NB.* [3]*Université de Moncton, Département de biologie, Moncton, NB.* [4]*Department of Fisheries and Oceans, Newfoundland and Labrador Region, St John's, NL.*

Between 2005 and 2007, stable isotopes of nitrogen and carbon were determined in tissue samples to study migration patterns of yellow-stage American eel (*Anguilla rostrata*) in the Upper Salmon and Point Wolfe Rivers (Fundy National Park, New Brunswick, Canada). Eels captured in fresh water during the spring and fall showed isotopic signatures indicative of a marine/estuarine diet (mean $\delta^{13}C > -15‰$ and $\delta^{15}N$ near or above 10‰). In contrast, eels captured in both rivers during the summer showed isotopic signatures indicative of feeding on freshwater organisms (mean $\delta^{13}C < -20‰$ and $\delta^{15}N < 8.00‰$). These results suggest that a large proportion (> 70%) of sampled eels migrated downstream in spring to forage in salt water during the summer, and returned to freshwater during fall for overwintering. Otolith microchemistry analysis yielded similar conclusions regarding recent habitat use. However, Sr/Ca ratios indicative of freshwater wintering were not found in any otoliths. Otolith microchemistry analysis may fail to detect winter residency because of slow otolith growth during winter. The presence of anadromous runs of fish is believed to be minor or nil in these rivers. Nonetheless, the hypothesis that eels remained in fresh water and preyed upon marine/estuarine organisms (characterized by a saline isotopic signature) could not be fully excluded. In 2009 and 2010, the

hypothesis that yellow-stage eels migrate to freshwater wintering sites on the Upper Salmon River was confirmed by tracking movements of eels fitted with PIT tags.

Oral CCFFR (Species at risk)

UNDERSTANDING AN APPARENT CONSERVATION ETHIC IN THE US WESTERN ATLANTIC BLUEFIN TUNA FISHERY

Condit*, C., T. Johnson, J. Wilson, and Y. Chen.
School of Marine Science, University of Maine (email: Christopher.condit@umit.maine.edu).

Atlantic Bluefin Tuna (*Thunnus thynnus*) is an extremely valuable and charismatic species inhabiting the North Atlantic Ocean and is present each summer in the Gulf of Maine. The highly migratory species crosses international boundaries and is managed at an international and domestic level. U.S. bluefin tuna fishermen, managers and enforcement agents agree that the regulations placed on U.S. tuna fishermen are strict and that incentives to violate regulations and over exploit the resource domestically are present. While violations occur, there are many more domestic fishermen who obey the rules, fish in a sustainable manner and even promote ideas that support conservation, in contrast to rational choice theory. Based on data gathered in interviews with managers, scientists, law enforcement agents and fishing industry members, it is proposed that the US domestic industry exhibits an apparent conservation ethic that is motivated primarily by economic interests. Specifically, conservation efforts to lower mortality, protect forage species, resolve bycatch and discards and improve enforcement all benefit the business interests of bluefin tuna fishermen. Conservation measures perceived as extreme, such as an Endangered Species listing or a CITES listing are strongly opposed by industry due to their economic impact.

Oral CCFFR (General session)

A TALE OF TWO STREAMS (AND INTRODUCED *LEPOMIS GIBBOSUS*) IN SOUTHERN ENGLAND

Copp*, G.H., M.G. Fox, S. Stakėnas, G. Zięba, E. Fobert, L. Vilizzi, and M.J. Godard.

The North American centrarchid, pumpkinseed *Lepomis gibbosus*, is one of the most successful introduced species in Europe, but it is not considered invasive in the more northerly countries. For example, the pumpkinseed is established in ponds of southern England but does not reproduce in streams where it occurs. However, the current climate models predict southern England to become warmer by 2–5°C and hydrological conditions to become more variable, conditions considered to benefit pumpkinseed. To examine the potential risk of pumpkinseed becoming invasive in England, the species' environmental biology in two streams (and in nearby experimental ponds) has been studied to assess how climate warming will influence reproduction, growth and recruitment. Both longer-term and preliminary results are considered, including the ramifications of hydrological variability for pumpkinseed dispersal and establishment in new environments.

Oral CCFFR (Invasive aquatic species)

EXAMINING THE ENVIRONMENAL TRIGGERS FOR AGGREGATION-TYPE BEHAVIOUR IN JUVENILE ATLANTIC SALMON (*SALMO SALAR*) SUBJECTED TO THERMAL STRESS

Corey*, E., C. Breau, T. Linnansaari, and R.A. Cunjak.
Department of Biology, University of New Brunswick/Canadian Rivers Institute, 10 Bailey Drive, Fredericton, NB E3B 5A3 (emily.corey@unb.ca)

Juvenile Atlantic salmon (*Salmo salar*) demonstrate a physiological stress response when temperatures exceed 23ºC. Once the physiological threshold is surpassed and water temperature approaches the upper lethal limit (27ºC), thermoregulation occurs via behavioural adaptations. Regular territoriality is abandoned in favour of an aggregated response in areas of cooler water (refugia). The objective of this study was to determine environmental threshold conditions required for initiating behavioural thermoregulation of salmon parr *in situ*. Passive Integrated Transponder (PIT) tags were used over two field seasons to monitor temperature-related movements in 635 individually tagged 1+ and 2+ parr within the Little Southwest Miramichi River, New Brunswick, Canada. Parr were found to have traveled >10km in order to locate refugia when water temperatures exceeded 30ºC. In year-2, 36.5% of current-year juveniles were re-sighted prior to thermal stressors, of which 53.0% were subsequently located within aggregations, with a total seasonal return rate for current-year fish of 66.8%. Preliminary data analysis suggests cumulative high-temperature exposure may encourage the initiation of aggregations. Adult Atlantic salmon exhibit an earlier response to similar thermal stressors. If a predictive model for presence of aggregations in juveniles can be conceived, it is possible that the model can be extrapolated to include the more temperature-sensitive adults. With various climate change scenarios predicting these temperature thresholds to be transcended on a more frequent basis, it is of utmost importance regulating agencies have an understanding of these behavioral coping strategies to ensure proper management of recreational fishing practices while maintaining conservation as a top priority.
Adult Atlantic salmon exhibit an earlier response to similar thermal stressors

Oral CCFFR (Impacts of climate change)

SPATIO-TEMPORAL DISTRIBUTION OF CUSK BYCATCH IN THE GULF OF MAINE LOBSTER FISHERY

Cushman*, J., and Y. Chen.
School of Marine Sciences, University of Maine, Orono, ME 04469, USA
(Jeanie.cushman@maine.edu).

Cusk (*Brosme brosme*) is a groundfish species found in moderately deep water, on hard bottom substrates, and in relatively cold temperatures on both sides of the North Atlantic. The cusk

fishery in the US is currently not under management, and the stock for the US and Canada is currently considered at a low biomass. Although there is little information on the Gulf of Maine cusk and the stock structure is unknown, the greatest concentration of cusk is found in the central Gulf of Maine extending onto the Western Scotian Shelf. This location of cusk coincides with the Maine lobster fishery, and cusk are found as bycatch in lobster traps. In this study we evaluate the bycatch data collected from the Maine DMR sea sampling and ventless trap survey program to quantify the spatial and temporal distribution of cusk. We evaluate and identify variables that may influence the distribution of cusk and compare the results with those derived from the Maine DMR inshore trawl survey. The implications for management in the Gulf of Maine lobster fishery and the cusk fishery are discussed.

Oral CCFFR (General session)

FISH AND ZOOPLANKTON ASSEMBLAGES COASTAL NORTH ATLANTIC ECOSYSTEM: SUMMERTIME SPATIAL PATTERNS AND ENVIRONMENTAL CORRELATES WITHIN NORTHUMBERLAND STRAIT

Debertin[*], A.[1], J.M. Hanson[2], and S. Courtenay[1,2]
1Fisheries and Oceans Canada at the Canadian Rivers Institute, Biology Department, University of New Brunswick, P.O. Box 4400, 10 Bailey Drive, Fredericton, New Brunswick, E3B 5A3. 2Department of Fisheries and Oceans, Gulf Fisheries Centre, Oceans and Science Branch, P.O. Box 5030, Moncton, New Brunswick, E1C 9B6.

The distribution and productivity of zooplankton and fish are controlled by both top-down (consumption and predation) and bottom-up (physical, chemical, and food availability) processes in the Northwest Atlantic. To further understand which processes most influence the distributions of these communities, this study concurrently sampled fish, zooplankton and key oceanographic characteristics during July-August of 2008 and 2009 within Northumberland Strait. From our analysis, two zooplankton assemblages (West and Center) occur at similar geographic locations in each year and a third assemblage (East) was detected when the sampling area was extended eastward in 2009. Similarly, six major fish assemblages were detected, three of which occurred in the same geographic areas each year and, as sampling extended eastward in 2009, a further three assemblages were detected. Using distance-based linear models, environmental predicator variables explained 29 to 49% of zooplankton assemblage structure in 2008 and 2009 respectively, and 25% of fish assemblage structure for both years of the survey. The observed spatial concurrence between zooplankton assemblages and fish assemblages suggest the possibility of trophic interactions. To establish the strength of these interactions and to determine the composition of prey items consumed by fishes, diet analysis using gut contents from planktivorous fishes collected concurrently with this study will be described in subsequent work. With the identification of distinct fish and zooplankton assemblages, we suggest that fisheries managers consider the Strait as three to five separate management units.

Oral CCFFR (Linking theory and application)

KEY OCEANOGRAPHIC CHRACTERISTICS OF A NORTH TEMPERATE COASTAL HABITAT DURING A SUMMER SNAPSHOT: NORTHUMBERLAND STRAIT

Debertin[*], A.[1], J.M. Hanson[2], and S. Courtenay[1,2].
[1]*Fisheries and Oceans Canada at the Canadian Rivers Institute, Biology Department, University of New Brunswick, P.O. Box 4400, 10 Bailey Drive, Fredericton, New Brunswick, E3B 5A3.*
[2]*Department of Fisheries and Oceans, Gulf Fisheries Centre, Oceans and Science Branch, P.O. Box 5030, Moncton, New Brunswick, E1C 9B6.*

Key oceanographic characteristics of a coastal ecosystem, Northumberland Strait, were investigated during July-August 2008 and 2009 (temperature, salinity, chlorophyll *a* concentration, turbidity, PAR/Irradiance, dissolved oxygen). Principal component analysis identified three distinct oceanographic zones and two transition zones. The West and East zones were deep (40 and 55 m depth, respectively), stratified with a cold, high salinity, (0-4 ^{o}C, salinity 29-32) bottom layer and a warm and relatively fresh (16-20 ^{o}C, salinity 26-29) surface layer. The large Center zone was shallow (< 25 m depth) and characterized by warm (up to 22 ^{o}C on the bottom) well-mixed waters. The Transitional-West zone gradually changed from stratified to well-mixed waters as the water depth decreased. The Transitional-East zone exhibits strong change from stratified to mixed conditions, corresponding deep channel and shallow shoals, and subsequently is an area where prominent upwelling occurs. Surface chlorophyll *a* concentrations varied spatially, with highest levels (7.4 µg/L in 2008 and 3.6 µg/L in 2009) detected in the shallow areas. Comparisons with small-scale monitoring surveys conducted in 1993-1996 indicate that surface chlorophyll *a* concentrations have increased 2 to 4 fold. Subsurface chlorophyll a maxima occurred between 10 and 20 m in the deeper West and East zones. In 2008, a small area of low oxygen concentration (3.2 mL/L, 55% saturation) was located in the central part of the Strait. This study established quantitative baseline of summertime oceanographic conditions in a shallow coastal ecosystem. Subsequent work assesses whether discrete zooplankton and fish assemblages are associated with the oceanographic spatial structure found in this study.

Poster CCFFR (General session)

UNDERSTANDING HOW PACIFIC SALMON RESPOND TO FISHERIES-RELATED STRESS IN A CHANGING CLIMATE

Donaldson*, M.R., S.G. Hinch, S.J. Cooke, D.A. Patterson, K.M. Miller, G.D. Raby, V.M. Nyguyen, and A.P. Farrell.
Department of Forest Sciences, Faculty of Forestry, University of British Columbia, Vancouver, BC (Michael.r.donaldson@gmail.com).

Adult Pacific salmon must cope with physiologically demanding water temperatures and flow conditions as they migrate from the ocean to natal spawning areas. Along with these inherent migration challenges, they are targeted by the recreational, commercial, and First Nations fisheries sectors in the Fraser River, British Columbia. Each fishery harvests fish directly, but fish can either escape or be released voluntarily (i.e., catch-and-release recreational angling) or

due to mandate (i.e., release of bycatch). Here, we summarize years of research aimed at understanding the response to and recovery from fisheries-related stress. Heart rate data loggers showed that capture simulations rapidly increased heart rate regardless of the magnitude of stressor, however, recovery duration was correlated with that of the capture event. QPCR was then used to test genes linked to both fisheries and temperature-related stress. We identified several genes that responded rapidly after the stressor and took up to 24 h to recover to control values. High temperatures influenced expression patterns in several genes, including some that were predictive of short-term mortality. Telemetry studies identified changes in behaviour correlated with physiological stress. Release from beach seines had higher survival than gill nets or hook-and-line and population-level differences in survival emerged long-after the stressor occurred. We have developed and tested techniques for promoting recovery from capture stress using specially designed recovery bags that can improve physiological condition and survival. To assess their utility, we integrated a social science survey designed to determine if stakeholders would use such techniques in practice.

Oral CCFFR (Impacts of climate change)

RECEIVER BIAS DETERMINES THE MESSAGE CONVEYED BY PUBLIC INFORMATION

Elvidge*, C.K., and G.E. Brown.
Department of Biology, Concordia University, 7141 Sherbrooke St. W., Montreal QC H4B 1R6
(chris.k.elvidge@gmail.com)

Behavioural responses demonstrated by fishes to damage-released chemical cues are typically examined in the context of predation risk, as the cues released following an attack elicit alarm responses in receivers subject to similar predation pressures. However, due to the public nature of chemical cues and the considerable olfactory discriminatory capabilities of fish, a cue indicating risk to a receiver of the same prey guild may convey qualitatively different information, such as foraging opportunities, to a less ecologically similar one. The prevalence of this signalling system, which transmits information to conspecifics and heterospecifics alike, and the absence of clear benefits to the sender strongly suggest that it was shaped by selection on the receiver. Alternatively, a potential benefit to the sender with some experimental support is increased probability of survival by attracting secondary predators which then create interference for the prey. In a series of laboratory and field experiments involving two sympatric tropical fish species and three common predators, a clear trend towards size- and trophic-based differences in behavioural responses to these cues within and between species provides support for both hypotheses and demonstrates the importance of receiver bias in determining the content of public information.

Oral CCFFR (General session)

EXTERNAL FACTORS AFFECTING *DICHELESTHIUM OBLONGUM* INFECTION IN ACIPENSERIDS

Fast*, **MD**
Department of Pathology and Microbiology, Atlantic Veterinary College – University if Prince Edward Island, Charlottetown, PEI.
mfast@upei.ca

High densities of marine-phase Atlantic sturgeon occurring in relatively shallow waters provide ideal situations for pathogen transmission. *Dichelesthium oblongum* is a common ectoparasite of acipenserids in coastal waters of both the Eastern and Western Atlantic. This parasite is known to cause significant external lesions and infection is associated with metabolic acidosis and osmoregulatory stress in its hosts. Similar to other ectoparsitic copepods, the life cycle of *D. oblongum* involves 8 stages, the first 3 of which are planktonic. The final planktonic stage, copepodid 1, is transitionary between planktonic and parasitic life stages and must find a host within a discrete time period, most likely determined by temperature. Due to its body shape and lack of swimming appendages throughout development, *D. oblongum* is considered to be solitary once undergoing its first moult on the host, thereby making copepodid 1 the sole infective stage. Despite early descriptions of *D. oblongum* as a saltwater parasite, the copepodid 1 stage has shown tolerance of <20 ppt for over 72 hrs. We currently lack understanding of the infective pressure of this parasite at reduced salinities, however within marine waters, we have used host recapture and time series data to estimate the development time of the parasite as well as peak exposure times of Atlantic sturgeon. These data will be discussed with respect to the host-parasite relationship and their ecological significance.

Oral CCFFR (Species at risk)

A HABITAT TEMPLATE APPROACH TO THE IDENTIFICATION OF VULNERABLE LOCATIONS AND MARINE FISHES OF NEWFOUNDLAND AND LABRADOR

Fisher*, J.A.D.[1], K.T. Frank[2], N.L. Shackell[2], and V.E. Kostylev[3].
[1]Centre for Fisheries Ecosystems Research, Fisheries and Marine Institute, Memorial University, St. John's, Newfoundland, Canada. [2]Ocean Sciences Division, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada. [3]Natural Resources Canada, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada (jonathan.fisher@mi.mun.ca).

Marine habitat template models integrate physical, chemical, and biological data and have the potential to both explain geographic variation in life-history traits within assemblages and to predict locations where species will be most vulnerable to fishing and other impacts. We extend analyses of a previously developed habitat template model based on spatial variations in scope for growth (SG) and natural disturbance (ND) northward, using trawl survey data from the sub-Arctic continental shelf off of Newfoundland and Labrador. The model's predictions of life-history traits, species diversity, and community composition of fishes suggest differential vulnerability of shelf locations and species occupying those habitats. Temporal trends in the magnitude of explained spatial variation exhibited similar patterns observed in a previous validation of the model based on temperate marine fish data. The heterogeneous vulnerabilities of marine habitats predicted by the model has implications for ecosystem-based management and expected recovery rates of former marine fish assemblages across this large marine ecosystem.

Oral CCFFR (Linking theory and application)

EFFECTS OF A DEEPENED THERMOCLINE ON ZOOPLANKTON COMMUNITY PHENOLOGY

Gauthier*, J., Y.T. Prairie, and B.E. Beisner.
Département des sciences biologiques, Université du Québec à Montréal
(gauthier.joanna@gmail.com)

Thermal stratification is one of the key structuring factors for lake plankton. Thermocline depth, can be altered by changes in wind stress affecting the lake surface. Increased wind velocities can be induced by altering the riparian regions of lakes (fires, logging) or through climate change. The main objective of our research was to assess the effect of changes in lake thermal stratification and its accompanying mixing on zooplankton community phenology. We experimentally deepened the thermocline in one basin of a three basin lake (Lac Croche, Québec) through mixing. The experimental basin was compared to a control which had no thermal alteration, and with an intermediate basin that acted as a thermal buffer (thermocline deepening, but no mixing). Biotic and abiotic data were collected in profile in all three basins at their deepest points every week during the ice-free season. Control data were collected in 2007 prior to manipulation, with 2008-2010 as experimental years. Principal Response Curves (PRC) using Redundancy Analysis (RDA) fit to zooplankton community data showed that the effect of deepened thermocline was more pronounced toward the end of the summer. Examination of the time series also demonstrated that the clear-water phase is practically absent in the experimental basin compared to the control. Our study suggests that deepened thermoclines can alter the trophic web through important shifts in the zooplankton community.

Oral SCL (Impacts of climate change)

GENETIC DIVERSITY AND POPULATION DIFFERENTIATION OF THE INVASIVE GOLDEN MUSSEL, *Limnoperna fortunei* IN ASIA AND SOUTH AMERICA

Ghabooli*, S., A. Zhan, E. Briski, P.V. Perepelizin, E. Paolucci, F. Sylvester, P. Sardiña, M.E. Cristescu, and H.J. MacIsaac.
Great Lakes Institute for Environmental Research, University of Windsor, N9B 3P4, Windsor, ON, Canada (ghabool@uwindsor.ca).

The introduction and spread of non-indigenous species (NIS) is widely accepted as a global concern, spurring ecologists to focus on research describing the mechanisms of biological invasions. Studying the population genetic structure of NIS has been proved invaluable in elucidating our understanding of the invasion process. Here we investigated the invasion genetics of golden mussel *Limnoperna fortunei*, a species considered one of the most invasive globally. We used both mitochondrial cytochrome c oxidase subunit I (COI) gene and eight microsatellite markers to explore the invasion genetics of *L. fortunei* in Asia and South America. We surveyed

native (China and Korea) and introduced (Japan, Taiwan, Argentina, Uruguay, and Brazil) locations worldwide. Our preliminary results suggest independent introduction events occurred in Asia (Japan and Taiwan) and South America. No loss of genetic diversity was observed in introduced populations in Japan and South America indicating high inocula and/or multiple introductions. Introduced populations in Asia exhibits higher level of genetic diversity suggesting higher propagule pressure received by these locations compared to South American populations which is possible given higher vector activity. Ballast water is considered the main vector transporting golden mussel to South America whereas in Asia aquaculture is believed to be a possible vector as well. Lack of haplotype diversity in Taiwan indicates possible genetic bottleneck through establishment process while nuclear allelic diversity is maintained.

Oral CCFFR (Invasive aquatic species)

AT-SEA SURVIVAL OF SOUTHERN UPLAND ATLANTIC SALMON: HOW MUCH HAS IT CHANGED?

Gibson*, A.J.F., and H.D. Bowlby.
(jamie.gibson@dfo-mpo.gc.ca)

Atlantic salmon in the Southern Upland region of Nova Scotia were recently designated as 'endangered' by the Committee on the Status of Endangered Wildlife in Canada. Although there are many threats to the persistence of salmon populations in this region, changes in at-sea survival has been implicated as one of the major causes for the abundance declines. However, smolt abundance time series, necessary to calculate smolt-to-adult return rates that are used as a proxy for at-sea survival, are only available for two populations and are of short duration relative to the time period over which the declines have occurred. To determine how much at-sea survival has changed, we modeled the dynamics of these populations using adult abundance data, juvenile abundance indices and the smolt abundance data to obtain estimates of smolt production and return rates in the time period prior to the abundance decline. For the LaHave River population, these analyses indicate that during the early 1980's, return rates for one and two sea-winter salmon at times exceeded 10% and 2% respectively, whereas return rates for these sea-age classes are often less than 1% and 0.3% in recent years. Return rates for the St. Mary's River population show a similar trend, although the actual rates values are slightly lower.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

AN INQUIRY ON PROTECTIVE EFFECTS OF NATURAL ORGANIC MATTER TO A *DAPHNIA* HYBRID EXPOSED TO WATER-BORNE NICKEL

Gibson*, C., and N. Yan.
Department of Biology, York University, Toronto (cgibson@yorku.ca).

Natural organic matter (NOM) in aquatic environments is known to diminish metal toxicity to *Daphnia*. Factors, however, of how land use, forest fire, and hydrological catchment

characteristics affect NOM capabilities to mitigate metal toxicity are not well established. In this study NOM was collected from various regions (Sudbury, Muskoka, and White River) exhibiting gradients of topography (i.e. streams and wetlands), man-made forest fire, and land use including industry and logging. The NOM was gathered by way of reverse osmosis and used in standard 48 hour static acute toxicity tests using a *Daphnia pulex/pulicaria* hybrid from the Sudbury region. Toxicity tests were performed in a synthetic soft water medium (FLAMES) and used to determine EC50 values for nickel with each NOM source measured as carbon at 6 mg/L. While all sources proved protective against nickel toxicity to *Daphnia*, only NOM collected from an industry impacted lake (Lake Laurentian) showed a significantly greater amount of protection compared to the other sources. Conversely, the sites affected by fire and logging provided significantly lower quality NOM, suggesting that land use and forest fire reduce NOM protective qualities.

Oral SCL (General session)

EFFECTS OF EXPERIMENTAL THERMOCLINE DEEPENING ON FISH COMMUNITY DYNAMICS AND TROPHIC ECOLOGY

Gillespie*, M., and J. Gunn.
Department of Biology, Laurentian University, Sudbury Ontario (mx_gillespie@laurentian.ca)

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. Fish community is dominated by creek chub, brown bullhead and white sucker. 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. Stable isotope ($\delta^{13}C$, $\delta^{15}N$) analysis showed that brown bullhead and creek chub exhibited changes in trophic dimensions represented by depletion of $\delta^{13}C$, indicating potential dietary changes. Biofilm consuming mayflies showed significant depletion of $\delta^{13}C$ following thermocline deepening suggesting observed changes in trophic ecology maybe related to microbial respiration and increased CO_2 content rather than dietary changes.

Oral CCFFR (Impacts of climate change)

AN ISODAR APPROACH TO QUANTIFYING THE IDEAL FREE DISTRIBUTION IN COMMERCIAL FISHERIES

Gillis*, D.M., and A. van der Lee.

Department of Biological Sciences, Faculty of Science, University of Manitoba, Winnipeg, MB. R3T 2N2 (dgillis@umanitoba.ca)

The Ideal Free Distribution (IFD) of behavioural ecology has been repeatedly used in the study of fishing effort through the past two decades. Though usually applied to the examination of aggregated data, its development is based upon the consideration individual behaviours in a game theoretic context. Its application has met with varying success, but it remains an important consideration in relating local catch rates to the underlying abundances. In fisheries, it has previously been examined through the proportion of catch and effort observed in simultaneously exploited areas. In evolutionary studies of foraging distributions in wild and human populations, theoretical curves of equal fitness (isodars, Morris 2003. Oecologia 136:1-13) have been developed to test the IFD hypothesis. We developed isodars based upon catch rates and unknown costs to determine their efficacy in fisheries analysis. Preliminary analyses indicate that 1) IFDs that include costs can generate isodars of effort between alternative areas similar to those observed in other ecological settings, 2) fluctuations in local fish availability within seasons will cause difficulties in fitting isodar models to fisheries data, and 3) differences in variable costs will be easier to estimate than fixed costs. Our results suggest that IFDs will result in clear statistical relationships in aggregated effort statistics between areas, but it will not be possible to extract area specific cost estimates from these relationships in many cases.

Oral CCFFR (General session)

RANGE-WIDE ANALYSIS OF GENETIC STRUCTURE, GENE FLOW, AND GENETIC DIVERSITY IN EASTERN SAND DARTER (*AMMOCRYPTA PELLUCIDA*) POPULATIONS

Ginson*, R., N.E. Mandrak, and D.D. Heath.
Great Lakes Institute for Environmental Research, University of Windsor, Windsor ON (ginsonr@uwindsor.ca)

Species ranges are often expected to conform to the widely accepted, but poorly tested, abundant centre model. This model suggests populations at the periphery of species' ranges likely inhabit marginal environments compared to central range populations and as a result, have smaller population sizes and increased population isolation. The resulting small populations will experience increased genetic drift and ultimately higher genetic differentiation among peripheral populations than those in the range centre. Eastern sand darters (*Ammocrypta pellucida*) are of conservation concern across large portions of their species range and populations are considered at the highest risk of extirpation at the periphery of their range. Eastern sand darters are also highly dependent on sand substrates, which may promote population fragmentation and hence drive conservation concerns across their range. This study focused on determining the range-wide dynamics of the genetic composition of eastern sand darter populations collected from multiple rivers in the centre and across the periphery of the species range. We analyzed genetic diversity and gene flow among peripheral populations compared to central range populations using ten recently developed microsatellite loci. By comparing effective population sizes and genetic diversity we test whether the peripheral populations experience the expected loss of genetic diversity and increased genetic divergence, resulting from genetic drift. By empirically

exploring the abundant centre model this study will provide insight into the genetic dynamics of species ranges in species of conservation concern.

Oral CCFFR (Migration, mixing, and dispersal)

NUTRIENTS AS CHEMICAL DRIVERS OF FISH PRODUCTION IN GEOGRAPHICALLY DIVERSE MOUNTAIN STREAMS

Good*, C., and J.B. Rasmussen.
Department of Biological Sciences, University of Lethbridge, Lethbridge, Alberta (c.good@uleth.ca)

Nutrient cycling and accumulation within a watershed is dependent on unique interactions among terrestrial, climatic and geological catchment characteristics. Nutrients have been established as drivers for primary productivity in aquatic systems, yet few studies have measured this trend across a range of landscapes. In south-eastern British Columbia, at the headwaters of the Kootenay-Columbia River system, geographic variability plays a role in nutrient concentrations in streams. Characterising the water quality attributes of the underlying geology of aquatic systems will help us identify how physiochemical relationships in mountain stream environments affect nutrient regimes and shift productivity of fish communities. At a local scale, we compare granite and limestone based streams (seven sites from each) in the Purcell and Southern Canadian Rocky Mountains to establish baseline relationships between nutrients and fish production. Nutrient sampling (total nitrogen, total phosphorus) and two-pass depletion electrofishing in a closed site were used to analyze the relationships between nutrient limitations and fish production. We expect that nutrient concentrations (predominantly total phosphorus) will be greater at limestone sites than granite sites and that total phosphorus will be a strong predictor of productive capacity of fish habitats. Preliminary findings have shown that fish communities differ between the two geologically distinct regions. Evaluation of the physical properties and variability of aquatic systems will help to identify geographic variability of nutrient regimes, and their influence on fish communities.

Poster CCFFR (Nutrient dynamics)

EFFECT OF AQUACULTURE ON WILD FISH DISTRIBUTIONS

Goodbrand*, L.[1], M. Abrahams[1], and G. Rose[2]
[1]*Department of Biology, Memorial University of Newfoundland, St. John's NL.* [2]*Centre for Fisheries and Ecosystem Research, Fisheries and Marine Institute of Memorial University, St. John's NL* (Livia.Goodbrand@mun.ca)

A growing body of literature suggests that sea cages can act locally as 'accidental fish aggregation devices' to which fish are primarily attracted because of lost feed. These fish aggregations can be large, diverse, and persistent; however, neither the ecological consequences of this behaviour nor the scale at which this effect should be considered are currently understood.

A key question is whether coastal aquaculture sites significantly affect the distribution of wild fish populations at a large scale, or whether this effect is limited to areas immediately adjacent to sea cages. We conducted hydroacoustic surveys in the Fortune Bay region of Newfoundland to compare the distribution and abundance of wild fish in bays containing salmon farms to control bays. Control bays have no history of aquaculture, but have been selected for future aquaculture production and were therefore considered to represent habitats of similar quality to the aquaculture sites. Preliminary results suggest that coastal aquaculture can affect the distribution of wild fish at a scale far greater than previously reported. Understanding and quantifying the telescopic effects of aquaculture on coastal ecosystems is a necessary step towards the mitigation of specific industry and conservation-related concerns; for example, the transmission of disease between wild and farmed fish, and the sustainable development of the aquaculture industry are mutually relevant to industry and conservation objectives.

Oral CCFFR (Migration, mixing, and dispersal)

CAN THE PREDICTION OF LONG-TERM ZOOPLANKTON ABUNDANCE BE IMPROVED UPON USING THE WIND FIELD OVER HARP LAKE?

Goral*, M.B., and N.D. Yan.
Department of Biology, York University (Melgoral@yorku.ca)

Zooplankton abundance under wind-driven currents has rarely been explored and further understanding can help improve the predictability of zooplankton communities in aquatic ecosystems. In this study, the relationships between daily and annual averages of abundance of zooplankton and the wind field were examined in Harp Lake, Ontario over the last 25 years, over which both wind speed and direction changed. Zooplankton samples were taken biweekly from a single station at the deepest portion of the lake. Residuals generated from regression models using various time steps were used to determine if the wind field could contribute to the prediction of zooplankton abundance determined at a single station. On average, wind speed has declined by 25%, while direction has shifted by 21 degrees towards the north. Despite these long-term changes, both linear-linear (speed) and linear-circular (direction) relationships indicated that the wind field would not lead to improvements in the prediction of annual abundance, with the exception of *D .thomasi* (direction, r^2=0.2540, p=0.003). However using daily data, 5 of the 8 species did show a predictive relationship between residual abundance and the wind field. We suspect that the decrease in wind has contributed to a change in spatial patterns of zooplankton in the lake, and thus a change in bias of lake-wide abundance estimates coming from a single station. Zooplankton are patchily distributed but most long-term monitoring programs sample only at one station. Our work suggests that we may well be able to correct for any bias emanating from a changing wind field.

ORAL SCL (Impacts of multiple stressors)

LINKING NUTRIENTS DERIVED FROM ANADROMOUS FISH TO AQUATIC INSECT PRODUCTION AND ITS TRANSFER TO TERRESTIAL ECOSYSTEMS IN ATLANTIC CANADA

Graham*, B., K. Samways, and R. Cunjak.
Canadian Rivers Institute, Department of Biology, University of New Brunswick. P.O. Box 4400, Fredericton, NB, Canada E3B 5A3 (grahamb@unb.ca).

Anadromous fish (e.g., salmon, smelt, lamprey) derive most of their biomass in the oceans before leaving to spawn in streams and lakes annually. These fish can positively impact the streams in which they spawn by depositing marine-derived nutrients (MDN) via excretion, gamete release, and carcass decay. Previous research demonstrated that MDN is quickly incorporated in a diverse assemblage of aquatic insects. In theory, the more anadromous fish that return during spawning will deliver more MDN and support greater in-stream production. This positive-feedback might not only benefit freshwater consumers, but may also benefit consumers in the terrestrial environment. If MDN enhances aquatic insect production, and, subsequently the export of emerging adults to the terrestrial environment, then MDN may also be important to terrestrial insectivores. We determined the importance of this subsidy to the surrounding habitat by measuring the $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ values of (a) emerging aquatic insects in the forest adjacent to stream sites in Atlantic Canada that received returns of smelt and lamprey and from sites that received no anadromous fish and (b) blood collected from riparian birds collected during the nesting period from these same sites. We demonstrate that the importance of MDN varies annually, but the production of insects emerging from stream reaches that receive MDN is consistently and considerably higher. During a time when ecosystem-based management is a goal for federal agencies, such research promises to extend our understanding of the impacts of anadromous fishes on riparian communities.

Oral CCFFR (Nutrient dynamics)

AS CLEAR AS MUD: WHAT HAVE WE LEARNED ABOUT THE EFFECTS OF TURBIDITY ON CANADIAN FISHES AT RISK?

Gray*, S.M.[1], L.J. Chapman[1], N.E. Mandrak[2].
[1]Department of Biology, McGill University, Montreal, QC. [2]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, ON
(suzanne.gray@mail.mcgill.ca)

Increasing water turbidity associated with deforestation and near-shore development is a key environmental stressor for freshwater fishes worldwide. In Canada, turbidity is suggested as a leading cause in the decline of many imperilled fishes, yet we know little about how increases in turbidity influence the behaviour, physiology, and ultimately the fitness of these species. To address these critical issues, we are examining sub-lethal impacts of turbidity on the behaviour and physiology of At Risk Canadian fishes, including Pugnose Shiner (*Notropis anogenus*), Bridle Shiner (*N. bifrenatus*), and Spotted Gar (*Lepisosteus oculatus*). We have discovered a behavioural shift in Endangered Pugnose Shiner exposed to a progressive increase in turbidity,

compared to three congeners. We have also found that Pugnose Shiner exposed to long-term turbidity have decreased swim performance (i.e. critical swim speed) compared to fish held in clear water. In a separate experiment, we demonstrated decreased hatching success in Threatened Spotted Gar held in turbid water. Ongoing studies of critical swimming speed and respiration rate in fish acclimated to low and high turbidity will be used to detect effects of turbidity on swim performance in related species. Further tests on different life stages in Spotted Gar will help elucidate critical stages of gar development that are sensitive to turbidity. Together, these studies will contribute to our knowledge of how turbidity is affecting Canadian fishes across species and life history stages, and identify thresholds of turbidity that affect behaviour and performance for management purposes.

Poster CCFFR (Species at risk)

ADDING PHYLOGENETIC INFORMATION TO PREDICTING TOLERANCE TO CHEMICALS

Guénard*, G.[1], S.C. Walker[1], P.C. von der Ohe[2], and P. Legendre[1]
[1]Département des sciences biologiques – Université de Montréal, CP 6128 succ. Centre-ville, Montreal, Canada H3C 3J7. [2]Department of Effect Directed Analysis – Helmholtz-Zentrum für Umweltforschung (UFZ) GmbH, Permoserstraße 15, 04318 Leipzig, Germany
(guillaume.guenard@gmail.com)

We present an approach to build statistical models of species tolerance to toxic substances using phylogenetic information together with chemical properties. Traits often bear the traces of the evolutionary processes that shaped them in phylogeny; imprinting phylogenetic signals in them. Methods now exist to use these phylogenetic signals to extend, to a larger set of species, empirical knowledge about traits that we only have for a limited number of species, perhaps when the trait are difficult to estimate. The capacity of species to tolerate environmental stressors is an important trait in assessing their ability to withstand the conditions the environment. In most practical situations, multiple stressors simultaneously affect many species in ecosystems. Hence, knowing the tolerances of sufficiently large number of the species towards a sufficiently large number of stressors is often a laborious task. To simplify that task, we propose to use an analytical framework whereby phylogenetic eigenfunctions (ie. a spectral decomposition methods for phylogenetic signals) are used within a bilinear model (ie. a multiple-response linear models with two tables of explanatory variables). We used components of the phylogenetic signals from 25 species together with chemical properties of six pesticides (lipophilicity and the mode of toxic action) in one bilinear model. The resulting model describe a substantial fraction of the variation ($R2_{adj}$ = 0.5-0.8) in the log-transformed tolerance (median lethal concentration: LC_{50}) of the species to the pesticides whereas 85% of predicted LC_{50} values deviated from observed values by a factor of ten or less in cross-validated models.

Oral CCFFR (Impacts of multiple stressors)

ECOSYSTEM-BASED MANAGEMENT FOR SHELLFISH AQAUCULTURE- DEVELOPING TOOLS AND DIAGNOSTICS FOR A CHAGING ENVIRONMENT

Thomas Guyondet*, Thomas Landry, Luc Comeau, Rémi Sonier
Department of Fisheries and Oceans; Gulf Region; 343, Université Avenue; Moncton, New Brunswick; E1C 9B6; Canada (thomas.guyondet@dfo-mpo.gc.ca)

Carrying capacity issues related to bivalve aquaculture warrant an ecosystem-based perspective to management. Bivalves rely directly on natural resources (phytoplankton), but also interact forcefully with ecosystem processes. Coupled physical-biogeochemical modelling is used to investigate these interactions and produce tools that are valuable for a sustainable development of bivalve aquaculture. While these models are suitable to investigate the effects of long term water temperature trends, climate change may be responsible for the alteration of the physical and/or biological structure of coastal ecosystems. Tracadie Bay (Prince Edward Island, Canada) represents one example. Due to storm surges and increased wave action, this semi-enclosed embayment has experienced the opening of a second inlet, dramatically modifying its exchange with the neighbouring Gulf of St. Lawrence and prompting a series of questions on previous carrying capacity predictions. The level of aquaculture development in this system is such that the filtering pressure exerted on lower trophic levels results in periods of particulate organic matter depletion at the bay scale. This pressure is counter-balanced by a relatively high primary production fuelled by river nutrient inputs originating from anthropic activities on land. Hence, Tracadie Bay is a striking case study of complex interactions between land and water. The site seems ideal for studying the consequences of different aspects of climate change.

Oral CCFFR (Impacts of climate change)

LINKING CATCH-PER-UNIT EFFORT TO MARK-RECAPTURE ABUNDANCE ESTIMATES FOR CYPRINIDS IN SMALL BOREAL LAKES

Guzzo*, M.M.[1,2], P.J. Blanchfield[1], and M.D. Rennie[1]
[1]*Department of Fisheries and Oceans Canada, Experimental Lakes Area, Winnipeg, Manitoba, R3T 2N6.* [2]*University of Manitoba, Biological Sciences, Winnipeg, Manitoba, R3T 2N2*
(mattguzzo12@gmail.com).

Catch-per-unit effort (CPUE) and biomass are often used as parameters to estimate the productive capacity of aquatic systems. Productive capacity is a central component in many environmental impact assessments, particularly those involving the alteration and destruction of water bodies for mining and other industries. While CPUE does provide a means to examine relative trends in fish populations over time, it fails to provide a quantitative estimate for fish abundance and biomass, both of which are often time and labour intensive to obtain. Cyprinid species are an important source of forage for many predatory fish species and in addition, represent a key link to the production at the base of aquatic food webs. We quantified the relationship between CPUE and mark-recapture abundance estimates for two cyprinid species with contrasting life-histories in two small boreal lakes over a seven year period. These

relationships could potentially be applied to CPUE data from other aquatic systems to provide estimates of abundance and biomass for cyprinid species.

Poster CCFFR (General session)

RELATIVE EFFECTS OF WAVE-INDUCED MIXING, IRRADIANCE REGIME, AND THERMOCLINE DEPTH ON THE DISTRIBUTION OF PHYTOPLANKTON ACROSS A DEPTH GRADIENT: IMPLICATIONS FOR FUTURE GLOBAL CHANGE

Haig*, H.A., M.V. Kingsbury, K.R. Laird, B.F. Cumming, and P.R. Leavitt.
Department of Biology, University of Regina, Regina, SK (haig.a.heather@gmail.com)

Pelagic and benthic phytoplankton are anticipated to vary in their response to future climate warming, ozone depletion, and hydrologic change, necessitating improved understanding of the mechanisms that control interactions between these two distinct communities. In general, the ecotone between benthic (B) and planktonic (P) habitats is assumed to be regulated by physical factors, including turbulence, irradiance, and thermal stratification. To identify the hierarchical relationship among mechanisms controlling this boundary, we quantified sedimentary pigments from algae and bacteria and sub-fossil diatoms along a depth transect in a shallow headwater lake in northwestern Ontario. Analysis by high performance liquid chromatography (HPLC) and light microscopy at 1-m depth intervals revealed synchronous changes in sedimentary pigment assemblages and sub-fossil diatom species composition, with the most significant transition occurring at ~6 m. Between ~3.2 and 5.5 m, concentrations of pigments from diatoms (diatoxanthin, diadinoxanthin, fucoxanthin) and chlorophytes (Chl *b*, pheophytin *b*) increased 2- to 5-fold and a rise in tychoplanktonic or benthic (including small *Aulacoseira* and *Fragilaria*) diatoms. Interestingly, these changes did not correspond to but were bracketed by the depth of wave-induced turbulence (3.1 m) and the base of the metalimnion (6 m). In addition, cluster analysis identified a secondary transition in phytoplankton pigment assemblages at ~2.5 -m depth, above which deposition of light-sensitive diatoms declined ~50%. Taken together, these findings suggest that in this lake, algal composition is regulated by a unique combination of diatom life-history traits turbulent mixing, and light penetration.

ORAL SCL (Impacts of climate change)

RESPONSE OF NATIVE FISHES TO AN INTRODUCED TOP PREDATOR (RAINBOW TROUT) MEDIATED BY COMPLEX LITTORAL HABITAT

Hanisch*, J., W. Tonn, C. Paszkowski, and G. Scrimgeour.
Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada T6G 2E9
(hanisch@ualberta.ca)

Strong negative effects of introduced trout on native species are frequently reported, especially from unproductive lakes. However, negative effects may not be universal. Recent research from productive lakes has documented few negative effects of stocked trout on native species. Our

objective was to determine how littoral macrophytes, common in productive lakes, affect the response of adult and young-of-year (YOY) native dace (*Chrosomus* spp.) and fathead minnow (*Pimephales promelas*) to the introduction of rainbow trout (*Oncorhynchus mykiss*) in boreal lakes of Alberta. We first quantified inshore/offshore habitat use by native fish in stocked and unstocked lakes containing heavily vegetated littoral zones. We then manipulated the presence/absence of trout and densities of macrophytes within semi-permeable enclosures in one unstocked lake and assessed the behavioral response of native fishes. We also determined the relative importance of littoral and pelagic carbon sources to native fishes via stable isotope mixing models. Our whole-lake comparisons revealed that adult and YOY fishes occurred more often in vegetated inshore areas in stocked relative to unstocked lakes. In the predator enclosure experiment, native fishes did not avoid introduced trout at natural macrophyte densities, but dace significantly reduced their occupation of enclosures with reduced macrophytes when trout were present. In stocked lakes, dace relied on nearly 90% littoral carbon sources, but in unstocked lakes, dace consumed littoral and pelagic carbon sources in nearly equal proportions. Our results suggest that complex littoral macrophyte beds provide important refuge habitat for native fishes, potentially mitigating negative effects associated with introductions of trout.

Oral CCFFR (Role of top predators)

STOCKING AND ENVIRONMENTAL CORRELATES OF HATCHERY-WILD ADMIXTURE IN BROOK TROUT (*SALVELINUS FONTINALIS*) POPULATIONS

Harbicht*, A. [1], M.A. Shamlih[2], C. Wilson[3], and D. Fraser[4].
[1]*Concordia University, Montreal, QC Canada* (aharbicht@yahoo.ca). [2]*Trent University, Peterborough, ON Canada.* [3]*Ontario Ministry of Natural Resources, Peterborough, ON Canada.* [4]*Concordia University, Montreal, QC Canada.*

Many wild and genetically distinct salmonid populations have experienced varying amounts of hybridization with their hatchery counterparts. Current research into hatchery-wild hybridization suggests that the extent of admixture resulting from comparable stocking practices can vary considerably among environments. The present study determined whether specific human actions and/or environmental characteristics were associated with the extent of hatchery-wild mixing in brook trout populations of Algonquin Park, Ontario. We found that certain abiotic parameters (lake elevation, pH) and anthropogenic parameters (accessibility and frequency of stocking events) affected the resulting amount of admixture as well as variation in individual admixture levels within a population..The results of this study highlight some of the most important factors that influence whether or not hatchery-wild mixing will occur in wild populations. They further provide an economical and feasible means of identifying previously stocked populations with minimal hatchery introgression or populations which likely contain individuals that are potential sources of native genes.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

DO MEASUREMENTS OF STRESS BIOMARKERS OF A TOP PREDATOR CAN HELP ASSESS THE EFFECTS OF HIGH DAILY FLOW VARIATIONS IN A HYDRO-PEAKING RIVER?

Harvey-Lavoie*, S., and D. Boisclair.
Département de sciences biologiques, Université de Montréal, C.P. 6128, succursale Centre-ville, Montréal, QC H3C 3J7 Canada (simonne.harvey-lavoie@umontreal.ca)

A field study on fish stress has been conducted in a context of natural flow regime alteration. The study took place in a hydro-peaking river, where hydropower facilities usually run in response to a high demand in energy. Therefore, events of massive and unpredictable flow discharge happen daily. The effects of this high flow variation have been assessed in a top predator, *Esox lucius* (Northern pike). A total of 40 fish have been caught in Mississagi River, regulated by Aubrey Falls Dam, and Aubinadong River, unregulated, both situated in Northern Ontario. Aubinadong River serves as a control for absence of high variations in flow, related to hydro-peaking management strategy. The natural river, which is a tributary of the regulated river, has similar physical characteristics of Mississagi River. Chosen traditional stress biomarkers are part of the primary, secondary and tertiary physiological responses. Besides, a heat shock proteins (HSP) expression assessment has been conducted on Northern pikes to determine the relationships between traditional stress biomarkers and HSP expression in fish cells. Assessing stress state of fish in regulated river is important for conservation of natural fish populations. By providing useful tools and concrete recommendations for healthy fish populations, this study will help dam hydropower managers to take decisions regarding their future hydropower flow management strategy.

Oral CCFFR (Impacts of multiple stressors)

CHANGES IN LAKE STURGEON (*ACIPENSER FULVESCENS*) HABITAT IN THE SOUTH SASKATCHEWAN RIVER UNDER REGIONAL CLIMATE CHANGE

Head*, K., J. Sereda, J. Hudson, M. Pollock, and A. Nazemi.
Department of Biology, University of Saskatchewan, 112 Science Place, WP Thompson Building, Saskatoon SK, S7N 5E2 (kerry.head@usask.ca)

Climate in the Canadian Prairie Provinces has been changing. Temperature is predicted to increase and precipitation decrease. River flow is anticipated to diminish as a result of climate change, and the South Saskatchewan River (SSR) has been classified as the most threatened river in Canada in terms of environmental flow. The SSR is vital habitat for lake sturgeon. Lake sturgeon are classified as endangered in Western Canada and a management strategy is being developed. Understanding habitat availability in relation to climate change and diminishing river flow will be a vital component of the management strategy. Therefore, we are developing empirical models to predict in-stream flow under future climate scenarios. Regional climate data (temperature and precipitation) along with global climatic indices (PDO, NAO, and ENSO) will be collected from online databases. A set of empirical models that relate global climatic indices and regional climate to in-stream flow will be developed with multiple linear regression and

Akaikes Information Criterion (AIC). In-stream flow under future climatic conditions will then be predicted with the models. Habitat suitability curves for lake sturgeon have been developed by Saskatchewan Watershed Authority and the Department of Fisheries and Oceans Canada. In-stream flow predicted from the models will be coupled with the habitat suitability curves to assess future changes in sturgeon habitat. These models will represent a novel advancement in sturgeon management in Western Canada.

Oral CCFFR (Species at risk)

DESIGNING A SENTINEL SURVEY/FISHERY IN THE EASTERN GULF OF MAINE

Henry*, A., and Y. Chen.
School of Marine Sciences, University of Maine, 210 Libby Hall, Orono, ME 04469 (anna.henry@maine.edu).

Fishing effort in the Gulf of Maine groundfish fishery has declined dramatically over the past thirty years. Existing effort is concentrated primarily in the western Gulf of Maine. This lack of fishing effort in the eastern Gulf has led to a shortage of information regarding the fine scale dynamics of groundfish populations. Currently in its second year, the sentinel survey/fishery is fishing in areas of historic groundfish populations. Researchers will map spatial and density distribution of groundfish populations based on data from these first two pilot years of the sentinel survey and the Maine Department of Marine Resources inshore trawl survey to design a more complete survey that has accurate spatial and temporal coverage and captures the spatial variability in species composition and size structure of key species. In future years, the survey will include fishing locations based upon a random stratified design, fixed stations, as well as those chosen by fishermen due to historical locations of groundfish to gather spatially explicit catch data to enhance current stock assessment and better understand the groundfish stock status in the eastern Gulf of Maine. Current groundfish management policies and stock assessments are developed primarily for the Gulf of Maine as a whole. The information gathered by the sentinel survey/fishery will increase our understanding of the spatial distribution of groundfish stocks in the Gulf of Maine and can be used to evaluate the need for separate assessment and management strategies in the Eastern Gulf of Maine.

Oral CCFFR (General session)

AMPHIBIAN MONITORING IN WETLANDS, TRANSLATED: A METHOD FOR SCIENTISTS, CITIZEN SCIENTISTS AND POLICY MAKERS

Hilchey*, K.G.[1], and R.W. Russell[2]
[1]*Nova Scotia Department of Environment, Water and Wastewater Branch, 5151 Terminal Road, Halifax, NS, B3J 2P8 (hilchekg@gov.ns.ca).* [2]*Saint Mary's University, Biology Department, 923 Robie Street, Halifax, NS, B3H 3C3.*

Given the current "global amphibian decline crisis"- interest in monitoring amphibian populations is growing. Because most North American amphibian species rely on both aquatic

environments and surrounding upland habitat, the presence of amphibian communities may be indicative of wetland health. In this multi-year study, we examined amphibian species presence in 100 wetlands across central Nova Scotia. Each wetland was analysed for a number of environmental and anthropogenic parameters that were suspected to influence amphibian distribution. We used Classification and Regression Trees (CART) to analyse and display our results, and propose a simplified display method that could be used: a) when the data to be analysed is collected by volunteers (increasingly the case in North America as governments have less capacity for monitoring), and b) when results of a complex study are to be shared with the public or used to inform policy.

Oral CSWS (Science for wetland policy and management)

SHORT & SIMPLE? FOOD WEBS IN STREAMS IMPACTED BY ACID MINE DRAINAGE

Hogsden*, K.L., and J.S. Harding.
School of Biological Sciences, University of Canterbury, Christchurch, New Zealand
(kristy.hogsden@pg.canterbury.ac.nz).

The structure of food webs is expected to change in stressed ecosystems due to the loss of sensitive species and removal of entire trophic levels. Acid mine drainage (AMD) is a major source of anthropogenic acidity and metals causing widespread contamination and notable species losses in stream ecosystems. However, it is less clear how this stress alters the underlying network of interactions and ecosystem function. We expected that the extreme acidity and elevated metal concentrations would generate highly simplified food webs in AMD-affected streams. To test this, we compared food web structure in 20 streams with either anthropogenic or natural sources of acidity and metals or circumneutral water chemistry. Community and diet analysis indicated streams receiving inputs of AMD had much simpler food webs (fewer species, shorter food chains, less links) than those in naturally acidic, naturally high metal, and circumneutral streams. These small, simple webs were sparsely populated by tolerant invertebrates and lacked fish. Food webs in naturally high metal streams were structurally similar to those in AMD streams (no fish predators, few species). Whereas, webs in naturally acidic streams differed very little from those in circumneutral streams due to strong similarities in community composition and diets of secondary and top consumers. The combined negative effects of anthropogenic acidity and metals on stream food web structure are clear. However, it appears that elevated concentrations of metals, regardless of source, may play a more important role than acidity in driving food web structure.

Poster SCL (Impacts of multiple stressors)

EFFECTS OF TROUT STOCKING ON ZOOPLANKTON COMMUNITIES IN SMALL BOREAL FOOTHILL LAKES

Holmes*, T., C. Paszkowski, and W. Tonn.

Department of Biological Sciences, University of Alberta, CW 405, Biological Sciences Bldg., Edmonton, Alberta, T6G 2E9 (teslin@ualberta.ca)

Trout stocking in boreal lakes is a common management practice used to enhance angling opportunities. Negative effects on native taxa, however, have been well documented, with the most pronounced effects documented in naturally fishless alpine lakes. Unlike those ecosystems, many boreal lakes contain native small-bodied fish, which may have shaped native invertebrate communities prior to trout stocking. My research examines zooplankton communities in small boreal Alberta lakes containing three different food web structures: stocked lakes (containing both non-native trout and native fish), unstocked lakes (containing only native fish), and naturally fishless lakes. The main ecological contrast in zooplankton community structure was between the fish-bearing lake types and fishless lakes, where several species were found to be exclusive to one of the two categories. Fish-bearing lakes also supported a higher abundance, but a smaller mean length, of calanoids, compared to fishless lakes, with no difference in total biomass. Cyclopoids had a higher abundance and biomass in fish-bearing compared to fishless lakes, with no difference in length. No differences in cladoceran biomass and length were detected between lake types, although a marginally higher abundance was found in stocked vs. fishless lakes. Stocked lakes were also found to have greater zooplankton diversity compared to the other treatments. Negative impacts of trout stocking were not detected in these boreal lake ecosystems that already contained native fish; stocking may even create new niches that allow for the coexistence of additional species.

Oral CCFFR (Role of top predators)

SURVEILLANCE FOR AQUATIC INVASIVE SPECIES IN THE CANADIAN ARCTIC

Howland*, K.L.[1], P. Archambault[2], and H.J. MacIsaac[3].
[1]*Fisheries and Oceans Canada - Arctic Research Division, Winnipeg, Canada* (kimberly.howland@dfo-mpo.gc.ca). [2]*Université du Québec à Rimouski - Institut des Sciences de la Mer, Rimouski, Canada.* [3]*University of Windsor – Great Lakes Institute for Environmental Research, Windsor, Canada.*

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. As part of the Canadian Aquatic Invasive Species Network (CAISN), surveys of estuarine and coastal marine biota in major Arctic ports (expected to be at highest risk for introduction of NIS) are now being conducted. This research is part of a national program to develop a database on occurrence of AIS and to aid in rapid

detection of high risk AIS in key ports across Canada. The program combines traditional taxonomic with modern molecular genetic analyses (barcoding, pyrosequencing) to establish the complement of AIS and native species present in all four aquatic coasts in Canada. Arctic surveys have been completed in the ports of Churchill, MB and Iqaluit, NU and are planned for Deception Bay, QC and Steensby Inlet, NU in 2012-13.

Poster CCFFR (Invasive aquatic species)

VARIATION IN MORPHOLOGY, LIFE HISTORY AND HABITAT USE OF CISCO IN GREAT BEAR LAKE (O CCFFR)

Howland, K.L.[1]*, L. Chavarie, L.[2], Eshenroder, R.[3], Reist, J.D.[1], Tallman, R.F.[1] and Todd, T.[4]

[1]Arctic Stock Assessment and Integrated Ecosystem Research, Freshwater Institute, Fisheries and Oceans Canada, Winnipeg, MB, Canada, [2]Department of Biological Sciences, University of Alberta, Edmonton, AB, [3]Great Lakes Fishery Commission, Ann Arbor, MI, [4]United States Geological Survey, Ann Arbor, MI (kimberly.howland@dfo-mpo.gc.ca)

Taxonomic uncertainty and a high diversity of cisco forms have been identified in most of the remnant proglacial Great Lakes in North America running from the Laurentian Great Lakes northwest to Great Slave Lake. With the exception of Great Bear Lake, shortjaw cisco (*Coregonus zenithicus*), a SARA listed species, has been reported from most of these lakes. To date there has been very little research examining the diversity of cisco in Great Bear Lake, the northernmost in this string of lakes. The existing diversity in most of the Laurentian Great Lakes has been eroded through the impacts of harvesting and introduced species, and many members of the cisco complex, including shortjaw cisco, have experienced substantial declines. The northern great lakes provide a unique opportunity to examine the role of the ciscoes in a relatively pristine large lake ecosystem and to learn about the mechanisms responsible for promoting and maintaining diversity among forms/species. Over the past 5 years (in conjunction with ongoing lake trout assessment work) we have developed a program on Great Bear Lake with a focus on retaining cisco for detailed morphological examination. To date we have collected samples from deep and shallow water habitats from each of the five arms of the lake (Keith, McVicar, McTavish, Dease and Smith). Based on initial findings from the Keith Arm area of the lake, cisco captured in deeper waters are clearly distinct from those captured in shallow water and have a number characteristics that are consistent with those described for shortjaw cisco including shorter, fewer and more widely spaced gill rakers, longer paired fins and slower growth. Thus our findings may represent a northern range extension for this form or species. Shallow water cisco align more closely with lake cisco (*C. artedi*) and form 3 distinct groups distinguished mainly by head shape and gillraker length, suggesting feeding specialization.

Oral CCFFR (Use of new technology)

DISPERSAL KERNEL ESTIMATION VIA DIRECT MEASURES OF REAL PARTICLE DISPERSION AND RESULTING COMPARISON TO A NUMERICAL MODEL

Hrycik[*], J.M.[1], J. Chassé[2], C.T. Taggart[1], B.R. Ruddick[1].
[1]*Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4R2, Canada* (janelle.hrycik@dal.ca). [2]*Fisheries and Oceans Canada, Gulf Fisheries Centre, Moncton, NB, E1C 9B6, Canada.*

Dispersion estimates were measured through the use of magnetically attractive particles (MAPs) and a moored magnetic-collector array. Collectors were moored within a predicted dispersal domain (nominally 2–4 x 10^3 km^2) enveloping putative "sink" locations based on empirically-driven, 200 m and 4 km resolution, 3D hydrodynamic nested models. At a source location, ~10^9 MAPs (nominally 300 µm diameter) of a near-surface buoyancy were released and allowed to disperse over time (nominally 5–7 d) after which the collector array was retrieved and the number of MAPs captured by each collector were enumerated. These numbers were then used to estimate the relative probability of physically-driven Lagrangian exchange within the dispersal domain - the dispersal kernel. The results were then compared to the hydrodynamic models (real-time conditions) by comparing the time integral of the model-particle concentrations at each of the collector locations (expected) against the MAP abundance estimates at each collector in the field (observed). Deviations between the expected and observed were used to assess model parameters. Our results show that a higher than expected random walk diffusion parameter is necessary for the models to best reproduce the observed MAP dispersion, and that the models exhibit a sensitivity to this value.

Oral CCFFR (Use of new technology)

SPATIAL HETEROGENEIGTY OF WATER QUALITY IN A LARGE FRESHWATER RESERVOIR IN RELATION TO ANTHROPOGENIC ACTIVITY

Hunter, K., J. Johansson, D.Vandergucht, J. Sereda*, J. Hudson, L. Huber, C. Prestie, K. Head, and H. Yip.
Global Institute for Water Security, University of Saskatchewan (email: jeff.sereda@usask.ca)

We have begun a multi-year study to assess the spatial heterogeneity of water quality in Lake Diefenbaker in relation to anthropogenic activity. Lake Diefenbaker is a large reservoir located in Saskatchewan, Canada. Lake Diefenbaker supplies greater than 50% of Saskatchewan's population with drinking water, supports one of the largest inland aquaculture facilities in Canada, and has extensive on-shore watering of livestock and several large marinas. Anthropogenic activity is generally concentrated in the numerous large deep embayments that characterize the lake. Observations suggest that the frequency and severity of algal blooms are increasing; although, blooms have been sporadic and localized. This localized eutrophication may be related to local stratification patterns, point source nutrient loading, and/or internal lake processes (i.e., internal nutrient loading). We selected 32 sampling locations that include the main lake body and numerous embayments. Each site was then classified by potential impact; livestock, marina, aquaculture and control (no impact). Each site was sampled monthly (June

through October) and monitored for phosphorus (P) concentrations (TP, TPP, TDP, SRP), phosphorus sufficiency/deficiency, and chl *a*. Chlorophyll *a* and phosphorus concentrations were heterogeneous throughout the lake with the greatest differences occurring between the main lake body and the embayments. The proportion of TP as TDP and SRP also differed among sites. Plankton assemblages ranged from P deficient to P sufficient, with the greatest difference occurring between embayments and the main lake body. Preliminary results did not provide a clear pattern between water quality and anthropogenic activity.

Oral SCL (Nutrient dynamics)

TEMPORAL (ANNUAL) CHANGES IN EFFECTIVE AND CENSUS POPULATION SIZES IN A SMALL ANADROMOUS ATLANTIC SALMON (*SALMO SALAR*) POPULATION OVER A 21 YEAR PERIOD FROM 1991 TO 2011

Johnstone*, D., and D.E. Ruzzante.
Biology Department, Dalhousie University (devon.johnstone@dal.ca)

The continuous range wide decline of anadromous Atlantic salmon (*Salmo salar*) populations over the last few decades resulted in the eventual closure of the commercial fishery in 1992. Population recovery since this closure has generally been weak, particularly in the southern portions of the species range. We describe temporal changes in the genetic composition of a small anadromous Atlantic salmon population from south Newfoundland, an area where salmon populations are considered as Threatened (COSEWIC 2010). We examined the genetic variability (13 microsatellite loci) in N= 793 smolt (out migrating) and post-spawning kelt samples, collected annually or nearly so from 1991 to 2011 (median N=38 per year of sample) for a total of 19 annual collections. We examined changes in genetic composition among cohorts and in the genetic contribution from precocious parr to the next generation. Estimates of the effective number of breeders (N_b) were obtained for cohorts using a variety of methods and combined to reduce bias. Changes in effective sizes through time were then compared to changes in census population sizes (N_c). By harnessing combined estimates of effective size, we discuss evidence for the importance of genetic contribution by precocious parr, and the relationship between N_b and N_c through time.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

THE INFLUENCE OF LIGHT ON THE FORAGING ABILITY OF BYTHOTREPHES LONGIMANUS

Jokela*, A.[1], S.E. Arnott[1], and B. Beisner[2].
[1]*Biology Department, Queen's University, Kingston, ON.* [2]*Department of Biological Sciences, UQÀM, Montreal, QC* (anneli.jokela@queensu.ca)

Introduced predators can have large impacts, especially in freshwater ecosystems. Understanding factors that influence the foraging ability of introduced predators is an important step in

determining the potential impacts to invaded zooplankton communities. The exotic predatory cladoceran *Bythotrephes longimanus* occupies a shallow position in the water column relative to other native macroinvertebrate predators such as *Chaoborus* and *Mysis*. This position may be advantageous for *Bythotrephes* by decreasing the amount of spatial overlap with potential competitors. Occupying a shallower position may also be necessary for successful foraging since *Bythotrephes* is a predominantly visual predator. We conducted a series of in-situ enclosure experiments to determine the effect of light on the foraging ability of *Bythotrephes*. In 1L enclosures containing *Daphnia* prey, a strong effect of predation under ambient and reduced light was observed. There was no evidence of predation in treatments where light was completely excluded, suggesting that unlike most macroinvertebrate predators, *Bythotrephes* is unable to feed by mechanoreception alone. A subsequent experiment using larger enclosures exposed an assemblage of prey from an uninvaded lake to *Bythotrephes* predation across a similar light gradient. These results will examine the community level effects of *Bythotrephes* predation under different light environments and determine if prey preferences by *Bythotrephes* vary with light conditions. Results from this study will provide insight into how *Bythotrephes* predation may shape zooplankton behaviour and community composition across invaded lakes.

Oral SCL (Invasive aquatic species)

MODELLING DISSOLVED ORGANIC CARBON AND NITROGEN IN STREAMS AND RIVERS ACROSS ATLANTIC CANADA

Jutras*, M.-F., M. Nasr, T. Clair, and P. Arp.
Department of Forestry and Environmental Management, University of New Brunswick, NB.

Stream water sampling for 24 small to large watersheds across Atlantic Canada showed dissolved organic carbon (DOC) and nitrogen (DON) increased with increasing wet- area but decreased with increasing open-area percentages per basin. Highest DOC and DON concentrations were found for forested catchments with large wet-area and wetland proportions, and little to no open areas, specifically fields, barrens, or lakes. The day-to-day variations of these concentrations were highly synchronized according to local weather patterns, which allows for modelling based on local weather station records for precipitation and air temperature, while accounting for the upland-wetland transport of DOC and DON by way of surface water and groundwater flows. This presentation explores the implications of these patterns on upland-wetland-stream-lake DOC and DON transfer fluxes as affected by land-use and climate change, and discusses upland-wetland nitrate-N transfer and denitrification as well.

Oral CSWS (Science for wetland policy and management)

PREDICTING LARVAL DISPERSAL OF THE VASE TUNICATE CIONA INTESTINALIS IN A PRINCE EDWARD ISLAND ESTUARY USING A MATRIX POPULATION MODEL

Kanary, L.[1,2], A. Locke*[3], J. Watmough[1], J. Chassé[3], D. Bourque[3], and A. Nadeau[3].

[1]*Department of Mathematics and Statistics, University of New Brunswick, P.O. Box 4400, Fredericton, NB, E3B 5A3.* [2]*Present address: British Columbia Cancer Association, 399 Royal Ave., Kelowna, BC, V1Y 5L3.* [3]*Gulf Fisheries Centre, Fisheries and Oceans Canada, P.O. Box 5030, Moncton, NB, E1C 9B6* (andrea.locke@dfo-mpo.gc.ca).

The invasive tunicate, Ciona intestinalis, is a major nuisance species to the bivalve aquaculture industry in Prince Edward Island. The species has been observed for several years on boats and mooring structures in Charlottetown Harbour, but has not established a reproducing population in the harbour nor dispersed the ~12 km downstream to Hillsborough Bay, an important source of blue mussel (Mytilus edulis) spat for the PEI aquaculture industry. A population matrix model used in conjunction with an oceanographic model suggests that advection of larvae from the harbour to the spat production area requires more than one or two generations, and the use of intermediate settlement nodes, such as navigational aids and aquaculture sites located in the upper part of Hillsborough Bay, as 'stepping stones'. Maintaining these 'stepping stone' nodes in a tunicate-free condition could delay oceanographic dispersal of C. intestinalis within the estuary. According to observations of colonial tunicate dispersal in 2010, most likely originating from colonies established in the same locations where C. intestinalis inoculations have been detected, dispersal was occurring in the vicinity of one of the 'high-risk' nodes identified by the model, but had not yet reached the other node. A major finding is that the dispersal of solitary tunicates by oceanographic processes, often considered uncontrollable, is evidently amenable to management through monitoring and cleaning of the intermediate settlement nodes.

Poster CCFFR (Invasive aquatic species)

FACTORS AFFECTING BRUISING IN COMMERCIALLY HARVESTED YELLOWTAIL FLOUNDER (*LIMANDA FERRUGINEA*)

Kenney*, J., M. Santos, H. Manuel, and P. Winger.
Fisheries and Marine Institute, Memorial University of Newfoundland, P.O. Box 4920, St. John's, NL, A1C 5R3 (Jessica.kenney@mi.mun.ca).

The commercial flounder fishing industry has been an integral part of Newfoundland's economy since the 1960's. One of the challenges facing this industry is unintentional fillet damage inflicted through harvesting and processing techniques. Fillet bruising is caused when physical and/or physiological trauma causes blood vessels to rupture and blood residue to pool in certain locations. This bruising detracts from retail value, and thus must be trimmed away prior to packaging and distribution. The trimming process leads to a decrease in fillet size, and consequently a loss in total yield and profit. In an effort to minimize this loss, this study investigated a number of factors that are thought to contribute to bruising, including tow duration (1, 2 and 3 hour tows), freezer orientation (vertical and horizontal), bleed method (gut, bobtail and gill slit methods) and time spent in the bleed tank (5, 10 and 15 minutes). The results of this study may have implications for current harvesting and processing techniques, in the commercial flounder industry.

Oral CCFFR (General session)

FINE-SCALE ATTRIBUTES OF SQUALUS ACANTHIAS TROPHIC DYNAMICS IN THE GULF OF MAINE

Kersula*, M., and Y. Chen.
School of Marine Sciences, University of Maine, Orono, ME 04469, USA
(michael.kersula@maine.edu).

This study is focused on the fine-scale trophic role of spiny dogfish (Squalus acanthias) off the eastern Maine coast. We examined stomach contents of 35 dogfish of different sizes sampled in a pilot sentinel fishery over a range of depths, locations, and times during the summer and fall of 2011. The results are compared with those derived from the NEFSC offshore bottom trawl survey which targets individuals in deep offshore waters in the Gulf of Maine.. Significant differences are found between samples collected in these two programs, suggesting large spatial variability in trophic dynamics. The fine-scale dynamics of the spiny dogfish trophic role have important implications for the region in terms of the potential recovery of groundfish stocks (which may be constrained by spiny dogfish predation on juvenile groundfish) and the function played by the spiny dogfish in the absence of that recovery. This study provides some tentative insights into the localized trophic role of dogfish and the extent of its significance for eastern Maine fisheries ecosystem dynamics.

Oral CCFFR (Role of top predators)

HOW LANDSCAPE CHARACTERISTICS MAY INFLUENCE THE COLONIZATION AND DISTRIBUTION OF A FRESHWATER AMPHIPOD IN SUDBURY, ONTARIO

Kielstra*, B.[1], and S.E. Arnott[1], and J.M. Gunn[2].
[1]*Department of Biology, Queen's University, Kingston, Ontario, Canada.* [2]*Cooperative Freshwater Ecology Unit, Living With Lakes Centre, Laurentian University, Sudbury, Ontario, Canada* (brian.kielstra@queensu.ca)

The historically degraded aquatic and terrestrial landscapes of Sudbury, Ontario offer unique opportunities to investigate the resilience of aquatic organisms and patterns of biological recovery over a heterogeneous landscape. Over 7000 lakes and associated watersheds were damaged by acid deposition as a result of mining operations in the Sudbury area. Despite widespread improvements in water chemistry, many acid-sensitive populations including the once-ubiquitous amphipod, *Hyalella azteca*, have irregularly re-established populations across lake systems. Recent studies have revealed terrestrial linkages with aquatic recovery, where subcatchment confluence sites become 'hot-spots' for benthic invertebrate diversity and colonization as a result of terrestrial organic subsidies. Here we present preliminary results from a six lake study where we assessed the current distribution of *H. azteca* across dominant littoral substrates and subcatchment confluence sites. The lakes differed in estimated years of colonization (<2 - 20+ years) and expected re-colonization potential. We expected that there would be high variation in *H. azteca* prevalence among lakes that corresponded with time since

chemical recovery. We also expected that within-lake distributions would be influenced by terrestrial subsidies such that abundances would be high at subcatchment sites relative to other habitats. Species occurrences tended to be higher at subcatchment confluence sites in recently colonized lakes than in lakes occupied for longer periods. Occurrence patterns at these subcatchment sites tended to be sporadic and highly variable compared with other sites. Information from this within-lake study will be used to determine if associated subcatchment biophysical variables can explain variation in *H. azteca* occurrence patterns.

Oral SCL (Impacts of multiple stressors)

IMPACTS OF PREY QUALITY ON THE INVASIVE AQUATIC ZOOPLANKTIVORE, *BYTHOTREPHES*

Kim*, N., M.T. Arts, and N.D. Yan.
Department of Biology, York University, 4700 Keele Street, Toronto, ON M3J 1P3
(natkim@yorku.ca)

Bythotrephes longimanus continues to rapidly invade Canadian Shield lakes. Via a food-chain approach, we consider the influence of prey quality on *Bythotrephes* growth, survival and reproduction at 21°C and 26°C. The green alga *Scenedesmus obliquus* was cultured at these two temperatures, and enriched with the omega-3 fatty acid, eicosapentaenoic acid (EPA, 20:5n-3). Algae with or without EPA were then fed to *Daphnia ambigua*, which were offered as prey to *Bythotrephes*. At 21°C, daphniids reared on EPA-enriched algae were larger than those fed unenriched algae, and consequently perhaps, feeding rates of young *Bythotrephes* on EPA-supplemented daphniids were much lower than those fed unenriched daphniids. By day 11, *Bythotrephes* reared on the EPA-enriched daphniids had larger clutch sizes than those consuming the unenriched daphniids. *Bythotrephes* fed the EPA-enriched daphniids were also bigger in size than those fed unenriched daphniids. In both food treatments, however, we observed delays in time to reproduction and widespread embryo resorption by the *Bythotrephes*. The results of lipid analyses as well as comparisons to published values suggest that our laboratory-reared *Bythotrephes*—even those consuming EPA-enriched daphniids—were severely EPA-impoverished. At 26°C, EPA supplementation did not appear to benefit the daphniids or the *Bythotrephes*. This is, to our knowledge, the first evidence that a single fatty acid may affect the population growth, and hence establishment success, of an invasive species.

Oral SCL (Invasive aquatic species)

SELENIUM IMPACTS IN STREAMS DRAINING SURFACE COAL MINES: TOXICITY AND FISH COMMUNITY EFFECTS

Kuchapski*, K.A., and J.B. Rasmussen.
Department of Biological Sciences, University of Lethbridge (k.kuchapski@uleth.ca)

Selenium (Se) is a micronutrient that can produce toxic effects (mainly developmental abnormalities) in fish when present at concentrations above the nutritional requirement. At surface coal mines, Se is released into aquatic systems due to high weathering rates of disturbed bedrock and soil. Se toxicity thresholds for these systems are often expressed as effect concentrations for individual fish but are difficult to apply to effects at the fish community and/or population level. We investigated the extent of Se inputs from surface coal mine sites and the impacts of long-term Se exposure on fish communities in coal mining areas of Alberta and British Columbia, Canada. We compared Se concentrations in water, sediments, primary producers, invertebrates, and fish in streams with long-term mining impacts to reference streams. Fish community data was collected to determine the relationship between Se exposure and community metrics such as relative species abundance, biomass and age structure. Water analyses indicate elevated Se concentrations downstream of mines and suggest that food chain Se levels at impacted sites are greater than those at un-impacted sites and comparable to published toxicity thresholds for aquatic organisms. We expect that the cumulative effects of long-term Se exposure will have negative impacts on fish communities. Species differences in Se sensitivity could lead to changes in community composition where Se-tolerant species become relatively more abundant when Se concentrations are greater. Further, the overall biomass and age structure of the population may be altered as toxic Se impacts on development increase the potential for recruitment failure.

Oral CCFFR (Impacts of multiple stressors)

REPRODUCTIVE SUCCESS OF FARMED AND WILD CHINOOK SALMON IN COMPETITION

Lehnert*, S.J., and D.D. Heath.
Great Lakes Institute for Environmental Research, University of Windsor, Windsor ON
(lehnert@uwindsor.ca).

The expansion of salmon aquaculture coupled with escaping fish from those sites have raised concerns about the possible impacts of escaped farmed fish on wild fish populations. Hybridization through reproductive interactions between escaped farmed and wild salmon can have significant impacts on the fitness and genetic composition of the natural population, as farmed populations often diverge genetically from their wild counterpart. The potential for hybridization between farmed and wild stocks to occur will depend on the ability of the escaped fish to survive and mate in the wild wherein the role of behavioral factors such as male-male competition will be important. Through domestication, farmed Chinook salmon (*Oncorhynchus tshawytscha*) are exposed to inbreeding, artificial selection and isolation. As a result of domestication, we would predict that farmed salmon would experience a reduction in reproductive success relative to wild salmon. To test these predictions the relative reproductive success of wild and farmed Chinook salmon males in competition for female mates was examined under semi-natural spawning channel conditions. Relative reproductive success was determined through parentage assignment of offspring from spawning channels with the use of genetic microsatellite markers. The results of this study provide insight into the potential impacts of Chinook salmon farm escapes on the wild population.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

CHANGES IN THE RESTING EGG BANKS OF GOOSE IMPACTED SUBARCTIC PONDS

Lemmen*, K.D., and S.E. Arnott.
Department of Biology, Queen's University, Kingston Ontario (k.lemmen@queensu.ca)

Cladocera resting eggs provide an excellent record of changes in zooplankton populations over time. In regions where environmental change has occurred, the egg bank can provide information on how populations were affected. Lesser Snow Goose (*Chen caerulescens caerulescens*) populations increased their nesting area 16-fold over 30 years in Wapusk National Park, northern Manitoba. 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. To examine how *Daphnia* populations have been affected by this change in salinity, resting eggs from sediment cores were collected from a goose impacted and a non-impacted pond within the park. Eight 9-cm cores were collected from each pond and were extruded at 0.5-cm intervals. Pb210 dating was combined with survey data to determine the periods of pre-goose impact (1933-1990, 4.5-9cm) and post-goose impact (post 1990, 0-4.5 cm). In each layer ephippia were identified to species and categorized as either viable or degraded. Egg bank densities in the non-impacted lake were significantly less than those found in the goose impacted lake throughout the core and were dominated by *D. tenebrosa*. In the goose pond the *Daphnia* community shifted from being composed of several species including *D. magna* and *D. tenebrosa* to a community dominated by *D. magna* after the expansion of goose populations. Future work will include hatching of resting eggs from lakes impacted by expanding goose populations to test if changes in salinity tolerance have occurred within *Daphnia* populations over time.

Poster SCL (Impacts of multiple stressors)

TURNING THE TABLES: ARE CUTTHROAT TROUT BENEFITING FROM CHANNELIZATION ON THE CROWSNEST RIVER?

Lennox*, P.A.III, and J.B. Rasmussen.
Department of Biological Sciences, University of Lethbridge, Lethbridge, Alberta
(preston.lennox@uleth.ca)

Stream channelization is a common form of anthropogenic disturbance which has significantly altered the natural state of the Crowsnest River, AB. The Crowsnest once supported a healthy cutthroat trout population, however, since the introduction of rainbow trout in the 1930's, native cutthroat populations have diminished greatly with putative populations existing only in upper tributaries. Stream channelization reduces instream habitat diversity, yet, it is unclear how this loss of diversity may affect assemblages of native and introduced salmonids. We examined the relationship between habitat factors (habitat diversity and stream morphology) and salmonid

communities of the Crowsnest River. To assess how habitat composition is affected by alterations to stream morphology (resulting from channelization), we used an integrated GIS mapping framework. We performed one-man snorkel surveys and single pass tote barge electro-fishing to assess the community structure of native and introduced salmonids. We show that channelized reaches lack habitat features such as deep pools and undercut banks, which are crucial for larger and more dominant individuals. We found that the largest and most dominant individuals are present almost exclusively in unaffected reaches, defending habitat features which are either unavailable or very limited in channelized reaches. In the absence of larger individuals, channelized reaches feature a greater proportion of small individuals, and significantly greater numbers of native cutthroat trout. We propose that channelized reaches with poor or limited "optimal" habitat are unable to support large, dominant individuals, and as such may possibly be a final "main channel" refuge for cutthroat trout.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

DEVELOPMENT OF AN ENVIRONMENTAL FLOW REGIME BASED ON NATURAL FLOW VARIABILITY USING AN ADAPTATION OF THE BUILDING BLOCK METHODOLOGY

Linnansaari*, T.[1], K. Alfredsen[2], A. Harby[3], and O. Ugedal[4].
[1]Canadian Rivers Institute, University of New Brunswick, Fredericton, Canada. [2]Department of Hydraulic and Environmental Engineering, NTNU, Trondheim, Norway. [3]Sintef Energy Research, Trondheim, Norway. [4]Norwegian Institute of Nature Research, Trondheim, Norway.

Static minimum flow regimes are often defined for rivers regulated for hydropower, usually having fixed values for winter and summer flow. Improved knowledge on the importance of variability in flow regimes has led to research on alternative solutions to the static minimum flow regimes. This presentation describes the development of an environmental flow regime that is designed to follow the variation in natural inflow but is achieved without dramatically altering the energy production in the hydropower utility. The design of a variable environmental flow regime includes many challenges related to defining suitable flow for various species and user groups of the river, but also to practical implementation, legislation and control. In this pilot study, a flow regime is designed using an adaptation of the holistic building block methodology and linked to high, normal and low natural flow conditions. The work is focused on the river Daleelva in western Norway where Atlantic salmon is the key species. The paper also describes how the variable environmental flow regime can be implemented in practice.

Oral CCFFR (General session)

THE PAST, PRESENT AND FUTURE OF STURGEONS; AN ELEMENTAL ANALYTIC APPROACH TO BETTER UNDERSTAND AND PROTECT

Litvak*, M.[1], S. Usvyatsov[1], A. Taylor[1], S. Blair[2], and M. Power[3]

[1]*Department of Biology, Mount Allison University, 63B York St, Sackville, NB, E4L 1G7* (mlitvak@mta.ca). [2]*Department of Anthropology, University of New Brunswick Fredericton, 13 MacAulay Lane, Annex C, Suite 28, Fredericton, NB, E3B 5A3.* [3]*Department of Biology, University of Waterloo, 200 University Avenue West, Waterloo, Ontario, N2L 3G1.*

Order Acipenseriformes consists of two extant families; Acipenseridae, comprised of five genera with 25 species, and Polydontidae, with one genus and two species. The order has a circumpolar distribution in the northern hemisphere. Many exhibit some form of diadromy; however, all spawn in freshwater. The wide distribution and extensive migrations of Acipenseriformes make them difficult to manage, as they often cross state, provincial and international boundaries. Historically, they have been an important food source. Currently, they are among the most endangered fishes in the world, with all 27 species listed on the IUCN's Red List. Listing has resulted from human activities, including damming, water regulation, pollution and over-harvesting, either through directed fisheries and/or by-catch. Wild caviar is still harvested; however, aquaculture production of sturgeon products now exceeds wild harvest. A number of NGO's have suggested that aquaculture production may be a positive factor for the conservation of sturgeon if it leads to a reduction in wild sturgeon fisheries. However, complicating this issue is the fact that currently it is very difficult to distinguish between farmed and wild sturgeon products. Here we will: 1) provide a brief introduction to the historical and present uses and issues that confront sturgeons; and 2) examine the potential of using stable isotopes to certify product origin as aquaculture or wild source. It is hoped that this approach will lead to accurate labelling, thus protecting wild stocks from further persecution and, ultimately, extinction.

Oral CCFFR (Species at risk)

DISTRIBUTION AND HABITAT ASSOCIATIONS IN STOCKED AMERICAN EELS, *ANGUILLA ROSTRATA*, IN LAKE ONTARIO TRIBUTARIES, MOIRA AND NAPANEE RIVER

Lloyst*, M.[1], S. Reid[2], T. Pratt[3], and M.G. Fox[1].
[1]*Environmental and Life Sciences, Trent University, Peterborough Ontario K9J 7B8, Canada.* [2]*Ministry of Natural Resources.* [3]*Department of Fisheries and Oceans Canada* (meganlloyst@trentu.ca).

The abundance and distribution of American Eels (*Anguilla rostrata)* have significantly decreased from freshwater and coastal habitats of eastern North America. The species is now considered endangered under the Ontario Endangered Species Act. The importance of eels in Lake Ontario and the Upper St. Lawrence River as a commercial fishery and as an integral part of the food web has lead to the initiation of stocking experiments in these areas. As part of a post stocking monitoring program, the abundance, dispersion, and condition of eels below two dams in the Moira and Napanee River was assessed. The influence of biotic and abiotic factors on habitat selection by eels was also assessed. Point sampling backpack electrofishing was conducted at two sites in the Moira and Napanee River, downstream of dams. Water depth, flow and substrate composition were the main habitat predictors assessed at each sampling point. The distance of sampling points from river banks and dams were also expected to be important

descriptors of eel abundance. In addition, it has been suggested that habitat variables can influence eel growth and sex determination, so otolith and gonad samples were preserved. The results of this study will be used to assess if eels are randomly distributed, clumping or evenly distributed at our sites in the Moira and Napanee Rivers and help explain behavioural attributes such as competition and co-occurrence. We will also present whether the habitat variables assessed influenced growth rates and gender of captured eels.

Oral CCFFR (Species at risk)

THE KEY ELEMENTS OF ECOSYSTEM-BASED MANAGEMENT AND AN ASSESSMENT OF THEIR APPLICATION IN 3 FISHERIES IN THE BAY OF FUNDY, CANADA

Long*, R.D.[1], T. Charles[2], and R.L. Stephenson[3]
[1]Applied Sciences, Saint Mary's University, 5669 Inglis St. apt 3, Halifax, NS, B3H 1K2, Canada (rachel.long@smu.ca). *[2]Saint Mary's University, Halifax, NS. [3]DFO St. Andrews Biological Station, St. Andrews, NB & University of New Brunswick, Fredericton, NB.*

Over the last decade Ecosystem-Based Management has gained popularity in the fisheries sector. The lack of consensus on a single definition of Ecosystem-Based Management has resulted in no universal application framework, inhibiting its implementation. The immense number and variation of key elements associated with Ecosystem-Based Management makes it difficult to recognize where EBM is being utilized and a list of the essential ingredients of Ecosystem-Based Management is vital to assess its successful application on the ground. My research compiles and compares the frequency of the key elements of Ecosystem-Based Management from a variety of published sources, across various disciplines. This is used to develop a list of the minimum core elements that must be applied for Ecosystem-Based Management to be fully implemented. This set of key elements is used to assess the degree and method by which Ecosystem-Based Management is currently being applied in the soft-shell clam, lobster and groundfish fisheries in the Bay of Fundy in both southwest New Brunswick and southwest Nova Scotia. Face to face surveys will be conducted with industry representatives to determine which key elements of Ecosystem-Based Management are being implemented at the ground level, along with an analysis between these coexisting fisheries. Multiple parties (industry, community, government and academic) will be interviewed and accompanied by local technical and government reports to compare the perspectives of Ecosystem-Based Management and get a well rounded, in depth view of the Ecosystem-Based Management process in the area.

Oral CCFFR (Linking theory and application)

EFFECTS OF POTATO AGRICULTURE ON THE PRODUCTION AND COMMUNITY COMPOSITION OF STREAM INVERTEBRATES

Loomer*, H.A.[1], K.A. Kidd[1], G. Benoy[2,4], P. Chambers[3], and J. Culp[2]

[1]*University of New Brunswick, Saint John, NB* (heather.loomer@gmail.com). [2]*Environment Canada, Fredericton, NB.* [3]*Environment Canada, Burlington, ON.* [4]*Agriculture Agri-Foods Canada, Fredericton, NB.*

Till cropping and the use of pesticides and fertilizers required for commercial production of potatoes are known to negatively affect local waterways. Grand Falls, New Brunswick is a main region of potato production in Canada, and streams draining the agricultural catchments have higher concentrations of pesticides and dissolved nutrients, more deposition of fine sediments on the stream bed and, as a result, more algal production and pollution tolerant invertebrate communities, as determined by the modified Family Biotic Index. Although it is known that the invertebrate community in altered, it is unknown if it still remains productive in response to potato agriculture. The influence of potato agriculture on invertebrate community productivity was investigated through biomass estimates and the analysis of invertebrate community composition. Invertebrate samples were collected with u-nets in the riffle areas of 14 small streams (watershed area 9 -30 km^2) supporting a gradient of potato agriculture (% ag = 0.7 - 83%) in and around Grand Falls in August 2010. Estimates of total invertebrate biomass increased with agricultural activity until 50% of the watershed supported potato production; above this, invertebrate biomass begins to decrease eventually returning reference site levels once 80% of the watershed is in agricultural production. Changes in community composition agree with previous findings showing a positive increase in pollution tolerant species with agricultural activity. These results indicate that while lower intensity potato agriculture (<50% ag) stimulates productivity in the invertebrate community, higher intensities shift the community to more pollution tolerant species but leave productivity unaffected.

Poster SCL (General session)

IS REDUCTION OF SELENIUM CONTAMINATION IN END-PIT MINE LAKES POSSIBLE THROUGH ECOSYSTEM MANIPULATION? TWO DIFFERENT APPROACHES

Luek*, A.[1], C.S. Brock[2], J.B. Rasmussen[1]
[1]*University of Lethbridge, AB.* [2]*Alberta Environment* (andreas.luek@uleth.ca).

Selenium (Se) is a trace nutrient that at elevated concentrations leads to severe impacts on aquatic ecosystems. It leaches out of waste rock at open-pit coalmines as well as from irrigated agricultural soils. Management policies for the discharge of Selenium are in place, but remediation methods are still scarcely developed. We tested two potential large-scale methods of reducing the concentration of Se in the water of end-pit mine lakes utilizing the anaerobic bacterial community present in the lakes' sediment, which can substitute Se for S during anaerobic respiration. Both Se reduction technologies are considered passive treatment methodologies, however, the first experiment presents a continuous treatment method while the second is a pulse manipulation to reduce Se and bind it as an inert compound in the sediment. In the first experiment a bioreactor was used in which lake sediment containing anaerobic bacteria was mixed in the reaction chamber with organic material and an additional carbon source. Se-laden water was diverted through the bioreactor under anaerobic conditions and water chemistry

was monitored at the inflow and outflow. The reactor significantly reduced selenium concentration but its efficiency is limited by maximum flow-through, as well as ambient temperature. The second experiment involved the fertilization of an entire end-pit lake. Increased primary production and subsequent decreased light penetration in the epilimnion provided a carbon source for the anaerobic bacteria while increasing anoxia in the hypolimnion. Selenium concentration did not change significantly during the experiment, but results suggest that a longer manipulation time would yield higher success.

Oral SCL (Impacts of multiple stressors)

CHANGES IN A RECOVERING FOOD WEB DUE TO THE INTRODUCTION OF A TOP PREDATOR: A WHOLE LAKE BEFORE-AFTER-CONTROL-IMPACT (BACI) STUDY

Luek*, A.[1], G.E. Morgan[2], B. Wissel[3], J. Gunn[2], and C.W. Ramcharan[2]
[1]*University of Lethbridge, AB.* [2]*Laurentian University, Sudbury ON.* [3]*University of Regina SK* (andreas.luek@uleth.ca).

We present results of a five-year full BACI designed manipulation experiment. Smallmouth Bass were introduced into two Yellow Perch dominated lakes to study the effects of increased food web complexity on an ecosystem recovering from acidification and metal contamination. We quantitatively sampled littoral and pelagic invertebrates and the fish communities over the course of the four-year experiment. We applied various models for stable isotope analysis and compared metrics of diet likelihood and trophic niche overlap within and between the fish communities. In the introduced Smallmouth Bass lakes offshore perch utilized less littoral diet sources over time while onshore perch maintained a high reliance on benthic invertebrates. Perch in all lakes however fed predominantly on zooplankton, which made up 50% of their diet. There was a stronger separation of diet choices between offshore versus onshore perch in the manipulated lakes. This might translate into a lesser trophic niche space overlap between those two groups. Bass diet reflected their efficiency in preying on the perch. In both manipulated lakes, perch abundance declined and bass showed a strong reliance on perch as a primary diet item. However, in the lake with the lowest perch abundance, bass utilized larger invertebrate prey (crayfish). An introduction of a top predator into a recovering system can challenge the present fish community to compete for a limited amount of resources, especially in terms of the littoral invertebrate community.

Oral CCFFR (Role of top predators)

IMPACT OF FLOW ALTERATION ON FISH POPULATIONS ACROSS NATURAL AND REGUALTED RIVERS IN QUÉBEC

Macnaughton*, C.J., and D. Boisclair.
Département des Sciences Biologiques, Université de Montréal, Pavillon Marie-Victorin, local F-215, 90 avenue Vincent-d'Indy, Montréal, QC, H2V 2S9 (camille.macnaughton@gmail.com)

Extensive ecological alteration and loss of biodiversity resulting from river regulation has generated widespread concern for the viability of maintaining and restoring healthy river ecosystems. Fish are typically adapted to a wide range of variability in stream flow, but the scarcity of high quality data sets showing accurate quantitative data on fish communities complicates the task of entirely comparing environmental and biological parameters between natural and regulated systems. Complementary fish surveys via electrofishing and snorkelling were conducted during the summer of 2011in 256 sites in 10 regulated and natural rivers in Québec. Fish densities and biomass were measured for all species and compared to the physical attributes of the sampled rivers. Characterizing the variability of fish density, diversity and biomass found within and between rivers of the same drainage realm may elucidate the spatio-temporal impacts of altered flow regimes in shaping ecological patterns and processes in riverine ecosystems.

Oral CCFFR (General session)

PRESENCE OF SLIMY SCULPIN (*COTTUS COGNATUS)* IN RELATION TO DEPTH, TEMPERATURE, AND DISSOLVED OXYGEN IN CLEAR LAKE, RIDING MOUNTAIN NATIONAL PARK, MANITOBA

Malcolm*, C.[1], K. McLaughlin[2], and T. Sallows[3].
[1]*Department of Geography, Brandon University, Brandon, MB* (malcolmc@brandonu.ca).
[2]*Department of Geography, Brandon University, Brandon, MB.* [3]*Wildlife Lab, Riding Mountain National Park, Wasagaming, MB.*

The slimy sculpin (*Cottus cognatus*) is a small, benthic fish native to Clear Lake, Riding Mountain National Park, Manitoba. The species has been suggested as an effective ecological indicator of aquatic health. Clear Lake is a 2,922 ha, oligo-mesotrophic lake, with depths reaching 34 meters, which typically stratifies in late spring and turns over in early fall. From May through September, 2010 and 2011, the locations of slimy sculpins were monitored in relation to depth, temperature, and dissolved oxygen (DO). The project aims to understand habitat selection of slimy sculpin and use the species as an indicator of the hypolimnetic health of the lake. The lake was divided into four depth strata and 40 minnow traps were set for 48 hours on a weekly basis. Over the two years 299 slimy sculpins were captured. On average 43.5% of slimy sculpin were captured in the deepest strata (> 30 m), indicating a preference for this depth; however, temporal habitat selection differed between years. In 2010, no sculpins were captured in the deepest strata after August 6, while sculpins continued to be captured to mid-September in 2011. Water temperatures in the deepest strata of the lake were similar in both years. However, in 2010 DO in the deepest strata approached 0 mg/L in early August, while in 2011 DO did not decrease below 1.26 mg/L, and sculpins continued to be captured. Sculpins may have moved out of the deepest strata in 2010 due to low DO, while they were able to remain in 2011.

Poster CCFFR (General session)

FORAGING AND TERRITORIAL DECISIONS BY JUVENILE ATLANTIC SALMON UNDER CHRONIC PREDATION THREAT

Malka*, P.H., and G.E. Brown.
Department of Biology, Concordia University, 7141 Sherbrooke Street West, Montreal, Quebec, Canada H4B 1R6 (patrickhmalka@gmail.com).

Prey animals must deal with the conflicting demands of predator avoidance and a suite of other fitness related activities such as foraging and territorial defence. Recent data suggests that juvenile Atlantic salmon reduce the size of defended areas (territories) under conditions of chronic elevated risks. Optimality models predict that a reduction in the size of the defended area is costly in terms of lost foraging opportunities. Here, we directly test the effects of chronic elevated predation risk on the territorial defence and foraging patterns and resulting growth rates in wild juvenile Atlantic salmon under natural conditions. Young-of-the-year salmon were dip netted from the lower reaches of the Catamaran Brook (NB), measured, tagged and placed into replicate in-stream 6 x 1 x 1 m mesh enclosures at ecologically relevant densities (~1 YOY m^{-1}) for a period of 7 days. Enclosures were exposed to high or low risk cues, twice daily. We measured territory size (Days 1 and 7) and foraging rates (daily). Our results demonstrate a significant reduction in territory size under elevated predation risk conditions, confirming our previous research. However, there was no significant difference between high vs. low predation risk treatments in either foraging or growth rates. These data suggest that at the densities tested, juvenile salmon are able to behaviourally compensate for elevated predation risk without increased costs.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

GROWTH OF DOMESTIC AND WILD STRAINS OF RAINBOW TROUT (*ONCORHYNCHUS MYKISS*) IN EXPERIMENTAL TRAILS

Martens*, M.T.[1], P.J. Blanchfield[2], A.J. Wall[2], and R. Devlin[3].
[1]*Department of Biological Sciences, University of Manitoba, Winnipeg, MB.* [2]*Fisheries and Oceans Canada, Freshwater Institute/ELA, Winnipeg, MB.* [3]*Fisheries and Oceans Canada, Centre for Biotechnology Regulatory Research, West Vancouver, BC* (matthew.t.martens@dfo-mpo.gc.ca).

Body-size in fish is an important factor in driving many of the physiological and behavioural traits inherent among a variety of taxa. Size and growth can dictate community structure, feeding habits, and environmental tolerance. Although greater growth is generally considered a competitive advantage in teleosts, it may also incur costs such as decreased anti-predator response due to greater need to forage. Selective breeding, an approach used in aquaculture for accelerating growth rate in salmonids is one case where differences in size among a single species can lead to varying success. Here, as a pre-cursor to a whole-lake experiment, tank trials were preformed to compare growth-rates between two strains of rainbow trout (*Oncorhynchus mykiss*), the most common fish produced in Canadian freshwater aquaculture. From the Laurentian Great Lakes, naturalized Ganaraska and domesticated strains of rainbow trout were

grown in isolation and competition treatments for 100 days. The domesticated strain had a greater average weight, fork length and growth rate than the 'wild' strain in both competition and isolation experiments ($p < 0.05$). This study suggests that under controlled conditions, in the absence of selective pressures, domesticated salmonids have increased growth compared to wild conspecifics. This data provides a comparison to how each strain has the potential to succeed under conditions in nature.

Poster CCFFR (Population dynamics, health, and ecology of salmonids)

GROWTH AND MORTALITY OF DOMESTICATED AND NATURALIZED RAINBOW TROUT (*ONCORHYNCHUS MYKISS*) IN NATURE

Martens*, M.T.[1], P.J. Blanchfield[2], A.J. Wall[2], and R. Devlin[3].
[1]*Department of Biological Sciences, University of Manitoba, Winnipeg, MB.* [2]*Fisheries and Oceans Canada, Freshwater Institute/ELA, Winnipeg, MB.* [3]*Fisheries and Oceans Canada, Centre for Biotechnology Regulatory Research, West Vancouver, BC* (matthew.t.martens@dfo-mpo.gc.ca).

Selective breeding of salmonids for freshwater aquaculture has occurred in Canada for over 100 years. The most common commercial species produced in this manner is the rainbow trout (*Oncorhynchus mykiss*). Domesticated strains of this species are often reared in open-pens in large freshwater systems. Accidental escape events from these holding pens, allowing thousands of rainbow trout at a time to be released into natural systems are frequent. The interaction between naturalized and domestic strains of rainbow trout in the event of an escape is currently poorly understood. Because domesticated strains of rainbow trout exhibit very different physical and behavioural characteristics than their wild conspecifics, the potential exists for competition between strains, which is of concern to the health and sustainability of wild fish stocks. Here, we investigate the comparative growth and mortality of domestic and 'wild' phenotypes of rainbow trout in nature. We first quantified the relative growth rates of each strain in a controlled laboratory setting using treatments reared in isolation as well as in competition. Next, we conducted a whole-lake study in Lake 304 at the Experimental Lakes Area (ELA) to determine how these same strains perform under the selective pressures of the natural environment. This research will help to better explain how wild populations of salmonids can be affected by an escape event from aquaculture.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

LANDSCAPE GENETICS OF A HIERARCHICALLY STRUCTURED LAKE TROUT (*SALVELINUS NAMAYCUSH*) SYSTEM IN NORTHERN LABRADOR

McCracken*, G.[1], R. Perry[2], D. Keefe[2], and D.E. Ruzzante[1].
[1]*Department of Biology, Dalhousie University, 1355 Oxford St. Halifax, Nova Scotia, B3H4R2* (gr354555@dal.ca). [2]*Newfoundland and Labrador Department of Environment and Conservation, 117 Brakes Cove Corner Brook, Newfoundland, A2H7S1.*

Landscape genetics employs the tools of landscape ecology and population genetics in an effort to interpret how the physical attributes of an environment can shape the genetic structure of a species within a system. We examined the relationship between landscape attributes and molecular genetic diversity and differentiation among lake trout (*Salvelinus namaycush*) subpopulations inhabiting a hierarchically structured freshwater system in northern Labrador, the Kogaluk River system. Samples were collected from a total of 11 lakes differing in size, altitude, connectivity and position within this system (e.g. headwater vs. non). Preliminary analyses provide evidence of a hierarchical structured population complex exhibiting a varying degree of asymmetric gene flow influenced predominantly by the presence of waterfalls. Geographic proximity and connectivity (e.g. presence of waterfalls) influence population structure as assessed by PCA and STRUCTURE analyses. We will discuss our results in the context of a spatially complex and hierarchically structured (metapopulation) system.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

MOVEMENT, BEHAVIOUR, AND DIET OF ATLANTIC STURGEON TAGGED WITH ACOUSTIC TRANSMITTERS IN THE MINAS BASIN, BAY OF FUNDY

McLean*, M.F.[1], M.J. Stokesbury[1], M.J. Dadswell[1], and F. Smith[2].
[1]*Department of Biology, Acadia University, Wolfville, Nova Scotia.* [2]*Vemco Ltd., Halifax, Nova Scotia* (105829m@acadiau.ca).

Atlantic sturgeon, *Acipenser oxyrinchus* Mitchill 1815, are a highly migratory anadromous species, distributed along the eastern seaboard of North America. Aggregations of mixed populations are well known in warm summer enclaves, such as the inner Bay of Fundy and recent analysis of DNA indicates individuals are traveling from natal streams in the US (including the Hudson River, New York and Kennebec River, Maine) and Canada (primarily the Saint John River, New Brunswick; Wirgin et al. 2011 *in press*). Little is known about the movement and behaviour of Atlantic sturgeon in Canadian waters. To address this knowledge gap, in 2010 and 2011 we deployed 83 uniquely coded transmitting tags in Atlantic sturgeon from the seasonal mixed aggregation in Minas Basin. Hydroacoustic receivers (VR2W; Vemco ltd.) were placed in strategic locations inside Minas Basin, and in Minas Passage which connects Minas Basin to the rest of the Bay of Fundy. Twenty-eight of 30 individuals tagged in 2010 were detected that summer. Twenty-three of those individuals also returned to Minas Basin in 2011. Forty-three of 53 additional tags deployed in 2011 have been detected so far. In May of 2011, a VR2W Positioning System (VPS) was situated at a known sturgeon aggregation site to examine fine-scale movement, including foraging behaviour. Twenty stomach samples were also collected in 2011 using a gastric lavage procedure. Preliminary analysis shows a high abundance of polychaete worms, primarily Nereidae. In this study we are attempting to identify how the summer population of Atlantic sturgeon utilizes Minas Basin as well as to determine critical habitat by examining spatial distribution and environmental preferences. We are also using fine-scale movement patterns of acoustically tagged fish and diet analysis to investigate feeding ecology.

Oral CCFFR (Species at risk)

EFFECTS OF ARTIFICIALLY DEEPENED THERMOCLINE ON THE TRANSFORMATION OF CARBON IN LAKES

Mercier-Blais*, S., B.E. Beisner, and Y.T. Prairie.
Department of Biological Sciences, University of Quebec at Montreal (UQAM), P.O. Box 8888, Succursale Centre-Ville, Montreal, Quebec, Canada, H3C 3P8 (saramercierblais@gmail.com)

A changing climate, more precisely an increase in wind at lake surfaces, could lead to a significant deepening of lake thermoclines. The effect of such deepened thermoclines on the dynamics of the transformation of carbon in lakes has not been assessed previously. The objective of the TIMEX project is to experimentally manipulate the thermal regime of a lake to simulate some anticipated effects of a changing climate at the ecosystem scale. Using this whole-lake experimental manipulation, we examined the effects of a change in thermal structure on the carbon cycle; specifically on CO_2 and CH_4 fluxes to the atmosphere and on heterotrophic respiration rates. A primary effect of thermocline deepening was to increase the heat content of the manipulated basin by an average of 1.1°C relative to the control basin, with a maximum increase of 2.2°C in July. Compared to the control, CO_2 fluxes in the experimental basin increased by about 3-fold and the epilimnetic planktonic respiration rate increased by 2.5 times. Calculations based on the increase in temperatures and the expanded extent of epilimnetic sediment indicated that benthic respiration increased in the modified basin. Our results suggest that augmented respiration is largely responsible for the elevated CO_2 flux to the atmosphere observed. As the impacts of climate change are predicted to continue to increase, lakes could become an even more important source of greenhouse gases to the atmosphere than they are already.

ORAL SCL (Impacts of climate change)

CHARACTERIZATION OF SELENIUM EXPOSURE IN EXPERIMENTALLY STOCKED FISH AND INVERTEBRATES FROM PIT LAKES ON RECLAIMED METALLURGICAL COAL MINES

Miller*, L.L.[1], J.B. Rasmussen[2], V.P. Palace[3], and A. Hontela[2]
[1]University of New Brunswick, Saint John, New Brunswick. [2]University of Lethbridge, Lethbridge, Alberta. [3]Department of Fisheries and Oceans, Winnipeg, Manitoba (lmiller2@unb.ca).

The creation of pit lakes is becoming a common reclamation strategy for open pit mines; however, they may not be suitable fish habitat as they are often contaminated by metals or metalloids. The objective of this study was to characterize exposure of fish and invertebrates to selenium (Se) and other metals and metalloids from pit lakes formed by open pit coal mining. Juvenile rainbow trout and brook trout (hatchery stock) were stocked into two pit lakes with low Se (< 2 µg/L) and two pit lakes with high Se (> 15 µg/L) concentrations. Selenium accumulation

in the fish and invertebrates were characterized over a period of two years. Both benthic and pelagic invertebrates accumulated more Se from the exposed than the reference pit lakes. Similarly, fish from the contaminated lakes accumulated more Se than those from the reference lakes. Rainbow trout and brook trout accumulated similar concentrations of Se in their muscle, had similar biomagnification factors, and exhibited a similar relationship between whole-body and muscle Se concentrations. Information from this experiment may be used by resource managers to determine compliance with whole-body tissue guidelines, such as the one proposed by the USEPA, using non-lethal muscle plugs. It may also be used to determine if the creation of pit lakes with elevated Se levels pose a significant risk to wildlife or human health.

Poster CCFFR (Population dynamics, health, and ecology of salmonids)

EFFECT OF INTRODUCED CHAIN PICKEREL (*ESOX NIGER*) ON FRESHWATER FISH COMMUNITIES

Mitchell*, S.C.[1], and J.E. LeBlanc[2]
[1]*Waterways Environmental Services, Antigonish, NS.* [2]*Nova Scotia Department of Fisheries and Aquaculture, Pictou, NS* (smitchel@stfx.ca).

The chain pickerel (*Esox niger*) has been introduced to Nova Scotia since the 1940s and is now known in 95 lakes of the province. As a predator, this fish may have significant impact on native lake fish communities. The purpose of the work described here was to: (1) assess the distribution of introduced chain pickerel throughout the East River, Pictou system, (2) determine the population structure and biological attributes of two lakes with known pickerel populations, (3) compare fish community structure in lakes with and without pickerel. Fifteen lakes were sampled for pickerel presence and fish community structure between May and October, 2010. Fish species richness and diversity is higher in non-pickerel than in pickerel lakes. The most widely distributed fish species in lakes were white sucker, brook trout, and golden shiner; yellow perch were absent from most lakes sample. Mean Catch per Unit Effort was two orders of magnitude less in pickerel than in non-pickerel lakes. Distribution of fish sizes was greater in non-pickerel lakes than in pickerel lakes. Insects appear to dominate in the diet of pickerel sampled, with evidence of fish in stomach contents at low frequency. The effect of the pickerel on the native fish population is to: (1) simplify fish communities, (2) reduce overall fish abundance, and (3) truncate fish size distribution. I speculate that this may have trophic and ecological ramifications on lake functioning and the trophic web associated with piscivorous birds and mammals.

Oral CCFFR (Role of top predators)

EFFECTIVENESS OF GENETIC RESTORATION OF AURORA TROUT IN CAPTIVITY AND THE WILD

Mouland*, J., and C. Wilson.
Environmental and Life Science Program, Trent University (jasonmouland@trentu.ca).

Genetic restoration has been used to reverse inbreeding depression across a range of endangered taxa with varying degrees of success. Although uncontrolled trials entail some risk, using experimental breeding crosses in controlled environments can test the feasibility of genetic restoration for enhancing fitness in populations or species of conservation concern without risking outbreeding depression and irreversible genetic loss. Aurora trout were extirpated from their native lakes in northeastern Ontario 50 years ago by acid rain. All contemporary aurora trout are descended from nine founding individuals in 1958, followed by multiple generations of hatchery rearing. With so few founders and unavoidable inbreeding in the early captive generations, inbreeding depression has been identified as a significant risk to their long term survival. We investigated the effectiveness of genetic restoration in aurora trout by monitoring the survival, comparative fitness, and maintenance of the aurora phenotype in two generations of crosses between aurora trout and brook trout. As well as tracking the comparative life history of first- and second-generation crosses under controlled hatchery conditions, aurora trout and two backcross types were marked and stocked into two inland lakes to assess their comparative survival and ecological fitness. Results from both the hatchery and wild trials showed significantly greater survival and performance of introgressed (backcross) aurora trout over pure aurora trout, with substantial retention of the aurora trout phenotype. These results suggest that backcrossing provides an opportunity to restore the fitness of aurora trout without compromising their phenotypic and evolutionary distinctiveness.

Oral CCFFR (Species at risk)

ROCKY BREAKWATERS AS HABITAT FOR BENTHIC INTERTIDAL BIOTA: AS GOOD AS NATURAL ROCKY ENVIRONMENTS?

Musetta-Lambert*, J.[1], E. Keppel[2], R. Scrosati[2], P. MacDonald[3], and S. Courtenay[1].
[1]*Fisheries and Oceans Canada at the Canadian Rivers Institute, Department of Biology, University of New Brunswick, Fredericton, NB* (jordanmusetta@gmail.com). [2]*Saint Francis Xavier University, Department of Biology, Antigonish, Nova Scotia.* [3]*Fisheries and Oceans Canada, Small Craft Harbours, Maritimes and Gulf Regions, Antigonish, NS.*

Comment [C1]: Add in Elise's STFX email address

Present policy regards construction of rocky breakwaters as destroying habitat for coastal biota and this triggers a requirement for compensation. Furthermore, construction of breakwaters and coastal armoring is expected to increase as numbers of people living along coasts increase, sea levels rise, and severe meteorological events become more frequent. Yet there is very little information available on whether such anthropogenic structures really do reduce habitat for plants and animals or, in fact, present new or different habitat. During Summer 2010 we quantified the abundance of intertidal macro-algae and macro-invertebrates living on 21 established breakwaters (at least 10 years old) and 30 nearby, natural, rocky areas between Pleasant Bay, NS, and Petit-Cap, NB, in the southern Gulf of St. Lawrence. Preliminary analyses of data indicate greater species richness and overall abundance of biota on wave-sheltered than on wave-exposed areas for both breakwaters and natural rocky shores. The relatively low richness and abundance found on exposed surfaces was similar between breakwaters and natural areas. At sheltered areas, breakwaters had significantly lower species

richness and overall abundance than natural rocky areas. Multivariate analyses are underway to explore which species are driving community differences between habitats. The benthic biota represent only one aspect of habitat productivity and other studies will be required to examine fish and mobile invertebrates such as lobster and crab. Based on our benthic intertidal biota data, the present study suggests that breakwaters do not create the same quality of habitat as natural rocky shores.

Oral CCFFR (General session)

EFFECTS OF A FISHING MORATORIUM ON SNOW CRAB *CHIONOECETES OPILIO* IN BONNE BAY, NEWFOUNDLAND AND FUTURE IMPLICATIONS FOR THE LOCAL FISHERY

Neville, V.
Department of Biology, Memorial University of Newfoundland, P. O. Box 4200, St. John's, NL A1C 5S7 (vk.neville@mun.ca)

Bonne Bay, on the west coast of Newfoundland, possesses a local stock of snow crab, *Chionoecetes opilio*, which was first commercially harvested in 1995. Fishery yields dropped drastically in 2007-2008, to the point that harvesters requested and were granted a two year recovery closure. This local moratorium provided an opportunity to evaluate the effectiveness of fisheries regulations in maximizing sustainability and commercial value of this discrete stock. This study examined snow crab recovery during the closure primarily through examination of size distribution, with particular emphasis on recruits to legal size and reproductive capacity. The strongest size cohorts were observed from 80 - 100 mm carapace width. The strength of the cohorts balanced below and scarcely above legal carapace width (95 mm), and weakness of cohorts of larger individuals, suggests that immediate re-opening of this fishery would result suboptimal landings, consisting mostly of immature animals. A large discrepancy was found between the proportion of snow crab that were legally exploitable and the proportion which had achieved the morphological characters of terminal molt, indicating maturity. This indicates that the current legal minimum carapace width is not large enough to ensure reproductive protection for the Bonne Bay stock. The inappropriately placed legal minimum carapace width has potential consequences to the long term recovery and sustainability of snow crab in Bonne Bay. A comprehensive re-evaluation of management assumptions and regulations is necessary to maximize sustainability and benefits to snow crab industry.

Oral CCFFR (Species at risk)

A QUANTITATIVE ASSESSMENT OF FISH PASSAGE EFFICIENCY

Noonan*, M., J. Grant, and C. Jackson.
Department of Biology, Concordia University, Montreal (m_noona@live.concordia.ca).

In an attempt to restore the connectivity of fragmented river habitats, a variety of passage facilities have been installed at river barriers. Despite the cost of building these structures, there has been no quantitative evaluation of their overall success at restoring fish passage. We reviewed articles from 1960 to 2011, extracted data from 65 papers on fish passage efficiency, size and species of fish, and fishway characteristics to determine the best predictors of fishway efficiency. Because data were scarce for fishes other than salmonids (order Salmoniformes), we combined data for all non-salmonids for our analysis. On average, downstream passage efficiency was 68.5%, slightly higher than upstream passage efficiency of 41.7%, and neither differed across the geographical regions of study. Salmonids were more successful than non-salmonids in passing upstream (61.7 versus 21.1%) and downstream (74.6 versus 39.6%) through fish passage facilities. Passage efficiency differed significantly between types of fishways; pool & weir, pool & slot, and natural fishways had the highest efficiencies, whereas Denil and fish locks/elevators had the lowest. Upstream passage efficiency decreased significantly with fishway slope, but increased with fishway length, and water velocity. An information theoretic analysis indicated that the best predictors of fish passage efficiency were order of fish (i.e. salmonids > non-salmonids), type of fishway, and length of fishway. Overall, the low efficiency of passage facilities indicated that most need to be improved to sufficiently mitigate habitat fragmentation for the complete fish community across a range of environmental conditions.

Oral CCFFR (Migration, mixing, and dispersal)

LiDAR-BASED DELINEATION OF WETLAND BORDERS

Oglivie*, J., K. Wen, and P. Arp.
Department of Forestry and Environmental Management, University of New Brunswick, NB.

This presentation introduces a GIS-based method designed to sharpen the delineation of wetland borders. This method utilizes LiDAR point-cloud data (1m resolution) in the ESRI environment for systematic digital representations of bare-ground elevation, slope, mean of the standard deviation slope within a 20 m radius, vegetation height above bare ground and depth-to-water (DTW). The criteria for an automatic delineation of wetlands borders are set as follows: DTW < 1m, standard deviation of slope within a 20 m radius < 0.1, and vegetation height < 2 m. These criteria delineate GPS-tracked wetland borders within 4 m 8 times out of 10, conform well to high-resolution surface images, and tend to be more consistent in this regard than image delineated wetland borders. Once the various LiDAR derived data layers are assembled, the results can be further scrutinized through image overlay and by way of line scanning, to obtain a vertical view of the upland-wetland- wetland upland transitions. Applications of this methodology within the context of rural and urban development and related wetland conservation planning are also discussed.

Oral CSWS (Science for wetland policy and management)

INFLUENCES OF TEMPERATURE AND BATHYMETRY ON SPAWNING MIGRATION ROUTES OF ICELANDIC CAPELIN (*MALLOTUS VILLOSUS*)

Olafsdottir*, A.H., and G.A. Rose.
Centre for Fisheries Ecosystem Research, Fisheries and Marine Institute of Memorial University of Newfoundland, P.O. Box 4920, St. John's, NL, Canada, A1C 5R3
(anna.olafsdottir@mi.mun.ca).

Capelin (*Mallotus villosus*) is one of the largest commercial fish stocks in Icelandic waters and an important forage fish. Capelin have adapted to seasonality in their sub-arctic environment by developing extensive migrations (1000-1500km) between feeding and spawning areas. It was known that capelin migrated north (67-72ºN) to feed during summer in deep (>500m) cold waters (1-3ºC) before migrating south (63-64ºN) to spawn in winter in shallow (<100m) warm waters (5-7ºC) south of Iceland, but exact spawning migration routes and the effects of environmental factors were largely unknown. Hydroacoustic and oceanographic data from 1992 to 2007 indicated that the southward spawning migration utilized one major route. Capelin swam actively (ground velocity>>current velocity) along the east coast of Iceland (latitude 63-68ºN). North of 65ºN, capelin followed the bathymetry, skirting the shelf edge (>200m bottom depth) within a band of near constant temperatures (ca. 2.5ºC). Further south, between 65 and 64ºN, as temperatures warmed to ca. 5ºC, capelin abruptly moved onto the shelf and towards coastal spawning areas. Capelin spawning migration appears to be an innately based southward search for appropriate spawning locations, guided by bathymetry and temperature. We suggest that capelin avoided entering the shelf further north to minimize exposure to cod predation. With temperature guiding inshore movement of the spawning migration, warming conditions north of Iceland may result in a northward shift in spawning locations (and routes), as occurred in the 1920s and 1930s.

Oral CCFFR (Migration, mixing, and dispersal)

COMPARISON OF THE EFFECTS OF DIEL FLUCTUATIONS OF WATER TEMPERATURE ON THE STANDARD METABOLIC RATE OF ATLANTIC SALMON PARRS (*SALMO SALAR*) ORIGINATING FROM RIVERS POSSESSING DIFFERENT TEMPERATURE REGIMES

Oligny-Hébert*, H., and D. Boisclair.
Département des sciences biologiques, Université de Montréal, Québec (helene.oligny-hebert@umontreal.ca)

Water temperature plays an important role on river fishes by regulating their metabolic, feeding, and growth rates. Metabolic responses of fish to a variety of temperatures kept constant in time is widely studied, though in rivers, fish are more likely to encounter a range of diel temperature variations, which is far less studied. A previous study from our laboratory showed that, at a given water temperature, salmon parrs from River Ouelle held under a fluctuating temperature regime had standard metabolic rates (SMR) on average 1,8-times higher than fish held under a constant temperature regime. The present study focuses on the comparison of the reaction of Atlantic

salmon parrs originating from two rivers (Ouelle and Cascapedia Rivers; Quebec) to water temperature fluctuations. The average water temperature in River Ouelle (20°C) is higher than that found in Cascapedia River (15°C). Fish from both rivers were acclimatized to a fluctuating (15±2,5°C) and a constant (15°C) temperature regime. Standard metabolic rates were measured using intermittent-flow respirometry on 24-hour time periods. The results obtained will allow us to, first, assess if diel fluctuations of temperatures modify the minimal oxygen consumption compared to constant temperatures and also evaluate if the SMR responses are the same for parrs adapted to different thermal regimes. Our findings could be useful to develop new bioenergetics models based on temperature regimes that are more representative of what is really found in nature.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

THE USE OF MICROSATELLITE GENOTYPE INFORMATION AND PARENTAGE ASSIGNMENT IN ASSESSING THE EFFICACY OF ATLANTIC SALMON CONSERVATION PROGRAMS IN THE MARITIMES

O'Reilly*, P.
Department of Fisheries and Oceans, 1 Challenger Drive, Bedford Institute of Oceanography, Dartmouth NS, Canada B2Y 4A2 (patrick.oreilly@dfo-mpo.gc.ca)

Atlantic Salmon of Southern Nova Scotia and New Brunswick, from the US/Canada border north along the coast through to Eastern Cape Breton, are listed (or designated to be listed) as endangered. In many instances, juveniles are no longer detected in former salmon-bearing rivers, and in most others, populations are low and declining. In order to prevent the imminent extirpation of individual river populations or in some cases, entire assemblages of populations, a number of different groups have undertaken programs to either maintain or restore salmon under their jurisdiction. Many of these programs involve elements of captive breeding and/or rearing, though they often vary somewhat in terms of their proximate objectives, and management strategies employed. In many instances, microsatellite genotype information and parentage assignment is being used to assess either the utility of specific management actions or overall program efficacy. Here, we present an overview of many of these conservation actions underway for Maritime Atlantic Salmon, and results from two specific programs, one involving the release of early-stage juveniles, and another release of mature adults.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

INTEGRATED COASTAL ZONE MANAGEMENT: AN OYSTER RESOURCE PERSPECTIVE

Ouellette, M.
Fisheries and Oceans Canada, Gulf Fisheries Centre, Ecosystems Management, Moncton, NB, E1C 9B6

The coastal zone is an area of high ecological complexity and productivity given the intrinsic connectivity between habitats and processes of terrestrial, freshwater and marine aquatic ecosystems. Furthermore, it is often where aquatic ecosystems are the most vulnerable to cumulative environmental effects caused by human activities, of various types and intensity, and where management lies within a complex jurisdictional backdrop. Thus, the coastal zone is a complex mosaic of variable zones of influences and vulnerabilities along the land-water interface. Coastal shellfish species, such as the American oyster (*Crassostrea virginica*), the blue mussel (*Mytilus edulis*) and the soft-shell clam (*Mya arenaria*), have been fished commercially and recreationally for well over a century. The oyster and the blue mussel are also presently key species in the development and growth of the shellfish aquaculture industry in Atlantic Canada. Therefore, they constitute an important socio-economical component for coastal communities, as a natural resource. However, several indicators of the state of those natural resources seem to be showing signs of significant exhaustion, most likely due to the increasing cumulative anthropogenic effects. These findings are particularly problematic given the ecological functions of bivalves, as filter feeders among other things, in coastal aquatic ecosystems. Thus, the need to take action must not only be limited to an economical context but also be considered with environmental implications. The discussion will focus on presenting fundamental concepts of shellfish restoration, using the American oyster as a case study, in the context of integrated coastal zone management and ecosystem-based risk management.

Oral CCFFR (Impacts of multiple stressors)

POPULATION GENETIC STRUCTURE OF NORTHERN PIKE (*ESOX LUCIUS*) IN ST. LAWRENCE RIVER – LAKE ONTARIO SYSTEM

Ouellet-Cauchon*, G.[1], M. Mingelbier[2], and L. Bernatchez[1]
[1]*Institut de Biologie Intégrative et des Systèmes, Université Laval, Québec (Québec).* [2]*Ministère des Ressources Naturelles et Faune, Québec (Québec)* (genevieve.ouellet-cauchon.1@ulaval.ca)

Elaboration of appropriate management plans of a given species requires knowledge of its population structure which allows the identification of distinct management units. This is particularly important for species such as the northern pike (*Esox lucius*), which is heavily exploited and suffers from human-driven habitats perturbations. In this study, we performed a genetic analysis in the St. Lawrence River – Lake Ontario system to define the number and extent of distinct northern pike populations in this system and quantify the extent of connectivity between these. To this end, 3411 northern pikes were sampled at 45 sites into St. Lawrence River and Lake Ontario and genotyped at 22 microsatellite markers. The extent of genetic divergence within and among sites was quantified by means of F-statistics, BARRIER and GENELAND analysis in order to define the number and distribution of genetically distinct populations in the system. General results revealed a generally weak genetic structure but the extent of structuring varied spatially. Thus, while 4 populations were identified in St. Lawrence River, no significant genetic structure was observed in the dowstreasm part, suggesting the occurrence of a single panmictic population over a river stretch of about 90 km. In contrast, three genetically distinct populations (mean *Fst* = 0.00348) were depicted in the upstream section of the St. Lawrence

River over a river stretch of about 67 km. We are currently completing the landscape genetics analysis in order to identify environmental factors responsible for this population structuring.

Oral CCFFR (Migration, mixing, and dispersal)

QUANTIFYING THE RELATIVE IMPORTANCE OF MANAGEABLE AND NATURAL FACTORS OF COASTAL WATERSHED ECOSYSTEM HEALTH

Patoine, A.
Secteur des sciences, Université de Moncton, Campus de Shippagan, Shippagan (Nouveau-Brunswick) E8S 1P6 (alain.patoine@umcs.ca)

The influence of land-use on water chemistry and plankton biodiversity is often apparent when considering large gradients of watershed perturbation, encompassing ecosystems that are nearly pristine to those transformed by decades of extensive resource extraction activities. However, in environments that are still relatively unimpacted, the influence of past land-use management strategies on aquatic ecosystem health is more difficult to evaluate because natural factors of variability can become more important than anthropic factors of watershed-scale land transformations. As a consequence, informing land-management decisions at a local scale is particularly challenging. Here we present preliminary results quantifying the relative importance of manageable (land-transforming activities) and natural factors (watershed morphometry, landscape position, annual and seasonal variability) of watershed health variability in north eastern New Brunswick estuaries. Four watersheds within a 1 000 km^2 area are being sampled twice a year since 2010 at an upstream and a downstream station. Road density (0.1 to 3 km/ha) and agricultural area (1 to 14%) values suggest that land transformation intensity is variable, but low relative to other previously studied coastal watersheds. Spatial and short-term temporal variability of water quality parameters (nutrients, chl-a) suggest the predominance of unmanageable factors (e.g., drainage density, inter-annual climatic variability) over manageable ones. Long-term temporal variability of algal biomass was estimated by quantifying pigments preserved in bottom sediments and indicates that present-day algal biomass is lower than 60 years ago, when agriculture activities peaked. Future analyses will aim at identifying thresholds of watershed perturbation intensity and spatial scale resolution above which the impact of land transformation become detectable.

Oral SCL (Impacts of multiple stressors)

SUPER SALTY STURGEON: ACUTE EFFECTS OF SALTWATER EXPOSURE IN SHORTNOSE STURGEON

Penny, F.
Department of Biology, University of New Brunswick, P.O. Box 5050, Saint John, NB (faith.penny@unb.ca)

This study focused on the acute physiological responses to saltwater exposure in juvenile shortnose sturgeon, *Acipenser brevirostrum*. Adult shortnose sturgeon routinely enter saltwater to forage, yet little is known about how (or if) juveniles cope with the associated osmoregulatory pressures. In two laboratory experiments, juvenile shortnose sturgeon were exposed to either full (32 ‰) or half-strength (16 ‰) seawater for up to 24 hours. First, blood and tissue samples were analyzed at 6, 12 and 24-hrs for various measures of osmoregulatory status (plasma osmolality & ions) and water loss. Second, oxygen consumption rates were used to estimate metabolic costs over 24-hours. Juveniles exposed to full-strength seawater had significantly increased plasma osmolality and ions (Na^+ & Cl^-), in addition to a 17% loss of total wet weight. Furthermore, decreases in oxygen consumption rates were observed after 24 hours in full seawater. To a lesser extent, similar increases in osmolality, ions and weight loss were observed in fish exposed to half-strength seawater yet with no changes to oxygen consumption. These results imply an inability to regulate water/ions in full-strength seawater within 24-hours. Nonetheless, no mortality occurred in any exposure, suggesting juvenile shortnose sturgeon can tolerate short periods in saline environments. In the future, I will explore the hormonal (e.g. cortisol) and performance (e.g. exhaustive exercise; critical swimming tests) effects.

Oral CCFFR (Species at risk)

EFFECT OF MULTIPLE STRESSORS ON FOOD WEBS OF TEMPERATE LAKES

Persaud*, A.D., and P.J. Dillon.
Department of Chemical Sciences, Trent University, Peterborough, Ontario
(adpersaud@trentu.ca)

Anthropogenic stressors, such as climate change, acid rain, and eutrophication, interact to modify key ecological drivers of freshwater lakes such as dissolved organic carbon (DOC). In turn, these drivers can alter many biological, chemical and physical aspects of these systems. Here we focus on the biological community, specifically trophic interaction between fish, benthic invertebrates and zooplankton. Organisms were collected from a number of temperate lakes with a wide range of DOC concentration and stable isotope analyses ($\delta^{13}C$ and $\delta^{15}N$) were done. Additionally, stomach contents analyses were performed on *Perca flavescens*, the most widespread fish species. Modeling of dietary contributions for several fish species in low DOC and high DOC lakes indicate that diet differed among lakes, species and ontogenetically. For example, *P. flavescens* from low DOC lakes had comparatively larger amounts of fish and smaller amounts of benthic invertebrates and leeches in their diet compared to those from high DOC lakes. Among the species observed here, *A. rupestris* had the largest proportion of small fish in their diet. For ontogenetic changes in *P. flavescens*, lipid corrected $\delta^{13}C$ ($\delta^{13}C_{LC}$) decreased, where as trophic position (based on $\delta^{15}N$) increased with size. Regression slopes for *P. flavescens* size versus $\delta^{13}C_{LC}$ or trophic position were steeper for low DOC lakes compared to high DOC lakes, suggesting a more rapid shift in diet with growth in low DOC lakes. Differences in modeled dietary contributions for *P. flavescens* are in agreement with their stomach contents information. Together our results indicate that there are differences in trophic interactions among fish, zooplankton, and benthic invertebrates in lakes experiencing different levels of anthropogenic stressors.

Oral SCL (Impacts of multiple stressors)

MUDDY WATERS: AN ASSESSMENT OF AMERICAN EELS IN ATLANTIC CANADA'S NATIONAL PARKS

Plummer*, A., and D. Austin.
Fundy National Park, P.O. Box 1001 Alma, New Brunswick, E4H 1B4
(alana.plummer@pc.gc.ca).

With the decline of American Eels (*Anguilla rostrata*) in the Upper St. Lawrence River-Lake Ontario region and resulting Special Concern designation by COSEWIC, there has been renewed interest in determining the status of eels in Atlantic Canada. Targeted sampling in freshwater and estuarine habitats was undertaken in five Maritime national parks. Initially, we attempted to estimate the number and timing of the movement of elvers (juvenile stage) from the marine to freshwater environments. Sampling techniques have included 3 trap designs (ramp, habitat & Sheldon) and night dip-netting, all with relatively low capture success. Determining the timing of the elver run is difficult given the small catches, however, preliminary results suggest that the timing may vary for each park, depending on geographic location. Despite low numbers of elvers, observations from electrofishing, rotary screw trap and eel pot operations suggest that adult eels are relatively common in all five parks. This coupled with low catches of elvers may suggest that the trapping techniques are ineffective, or that there are very small numbers of elvers entering our parks. It remains uncertain whether either of the aforementioned factors or a combination of the two is responsible for our lack of success. However, after 4 years of sampling with a variety of techniques, we have greater confidence that sampling technique is likely not the problem. Therefore, given difficulties in estimating recruitment via the elver life stage, we have recently shifted our focus to the adult life-stages, examining abundance and distribution from estuary to headwaters.

Poster CCFFR (Species at risk)

DISTRIBUTION OF RESIDENT AMERICAN EELS (*ANGUILLA ROSTRATA*) IN WATERS OFF THE EAST COAST OF CANADA BASED ON MARINE SURVEY DATASETS

Poirier*, L.
Acadia University, Department of Biology (lpoirier@upei.ca)

Despite intense conservation interest, there exists no robust methodology to assess the panmictic American eel stock. To address a key information need for the development of such a methodology, eel distribution in marine waters was mapped with GIS tools by compiling presence-absence data from marine surveys involving ca. 75000 trawl sets over several decades. Surveys in the Northumberland Strait and on the Newfoundland Shelf reported no eel captures, while captures were low ($\leq$5 eels) in the Southern and Northern Gulf of St. Lawrence, the Scotian Shelf and the Northern Gulf of St Lawrence Sentinel survey. Ten eels were captured in trawl surveys in the St. Lawrence estuary downstream from Ile D'Orleans, but the timing of

captures suggests that these may have been migrating silver eels. These findings indicate a virtual absence of American eels in open marine waters on the east coast of Canada. Further work will compile and examine inshore survey data sets from eastern Canada and the US, to more clearly define the limits of habitat occupied by resident American eels.

Oral CCFFR (Species at risk)

NEAR LACK OF PLASTICITY IN BROWN TROUT SPERM PERFORMANCE TO pH

Purchase[*], C.F.[1], and D. Moreau[1,2].
[1]*Biology Department, Memorial University, St. John's, NL, Canada, A1B 3X9* (cfpurchase@mun.ca). [2]*Current address: Department of Fisheries & Aquaculture, Government of Newfoundland & Labrador, Canada.*

Phenotypic plasticity occurs when a genotype produces variable phenotypes under different environments; the shapes of such responses are known as reaction norms. Plasticity has important ecological and evolutionary consequences but is often difficult to assess. Fish sperm represent an ideal system for studying plasticity: they are tightly linked to fitness, highly sensitive to environmental variation, can be assessed very quickly, and allow one to quantify reaction norms for individual animals. Brown trout (*Salmo trutta*) are considered one of the world's 100 worst invasive species. They were introduced to Newfoundland in the 1880s and continue to invade new watersheds. We investigated potential plasticity of brown trout sperm performance to river pH. Adult fish were collected from two streams in St. John's in 2008 and used to create offspring that were reared under common conditions until fall 2010. In November 2010, 20 mature F_1 captive males were assessed for sperm quality using water of five different pH (4,5,6,7,8). Although reaction norms varied markedly among genotypes there does not appear to be a difference in average response by the two populations (which live in streams of similar chemistry). On average, initial sperm velocity declined marginally from pH 8 to 5, but dropped substantially at pH 4. We propose that the near canalization of sperm performance over a wide pH range is adaptive in a species that strays into new rivers of varying chemistry. This could also explain why brown trout are able to become invasive in so many river systems.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

ROLE OF WARMING WATER TEMPERATURES ON FATTY ACIDS OF KEY ALGAL SPECIES FOUND IN SOUTHERN CANADIAN SHIELD LAKES

Quinn*, L., N. Yan, and M. Arts.
National Water Research Institute, 867 Lakeshore Road, P.O. Box 5050, Burlington, Ontario, Canada, L7R 4A6 (liamq@yorku.ca)

The fatty acid (FA) content was analyzed in two freshwater algae species, *Asterionella formosa* (Diatom) and *Synura petersenii* (Chrysophyte). Polyunsaturated fatty acids (PUFA) produced by algae, especially of the omega-3 and omega-6 groups, are essential nutrients required for the

growth and optimal development of zooplankton, fish and shellfish. PUFA also play several important roles in human nutrition, metabolism and cognitive processes. Over the past thirty years diatom species have been replaced by chrysophytes as the dominant phytoplankton group in lakes of the southern Canadian Shield. The role of warming water temperature on the types and proportions of FA produced by these species has yet to be determined. Additionally, the full biochemical implications of the widespread switch from diatoms to chrysophytes are as yet unclear. The phytoplankton species were grown in continuous cultures vessels over a range of temperatures from 16 – 26°C. FAs were analyzed quantitatively (µg/g dry weight) using a gas chromatograph. The total FA of *A. formosa* decreased with increasing temperature from 171.8 ± 26.4 to 111.5 ± 2.0 µg/g dry weight. In particular, the essential omega-3 PUFA 18:3n3 was found to decrease significantly at temperatures >20°C (1.8 to 0.8 µg/g dry weight). The highly conserved longer chain omega-3s 20:5n3 (EPA) and 22:5n3 (DPA) were found to decrease slightly at higher temperatures, while omega-6 22:6n3 (DHA) exhibited no change. Warming temperatures may result in a decrease in the quality and quantity of the available biochemical nutrients produced at the base of the food chain.

Oral SCL (Impacts of climate change)

SINGLE NUCLEOTIDE POLYMORPHISM ANALYSES OF MITOCHONDRIAL DNA VARIATION IN RECENT AND HISTORIC SAMPLES OF BAY OF FUNDY ATLANTIC SALMON

Rafferty*, S.[1], P. O'Reilly[1], R. Wissink[2], and A. Caissie[3].
[1]Department of Fisheries and Oceans, 1 Challenger Drive, Bedford Institute of Oceanography, Dartmouth NS, Canada B2Y 4A2 (Sara.Rafferty@dfo-mpo.gc.ca). *[2]Pacific Rim National Park, Heritage Canada, P.O. Box 280 Ucluet, BC., Canada V0R 3A0. [3]Fundy National Park, P.O. Box 1001, Alma, NB, Canada E4H 1B4.*

Earlier studies of DNA sequence variation identified a unique mitochondrial DNA (mtDNA) haplotype present in a subset of a group of phenotypically distinctive and endangered Atlantic Salmon from the inner Bay of Fundy (iBoF), Canada. Patterns of mtDNA variation observed were originally interpreted as indicating limited long-term gene flow between Minas Basin and all other regions of the Bay of Fundy area, including between phenotypically similar populations from the Minas Basin and Chignecto Bay regions of the iBoF. Single Nucleotide Polymorphism (SNP) analyses of a large number of recent and archival samples, however, has identified this distinct mtDNA haplotype in Chignecto Bay populations as well. In general, the frequency of this unique mtDNA haplotype increases in Chignecto Bay populations with the age of the archival samples analyzed, and approaches that observed in Minas Basin populations surveyed in earlier studies. These new analyses increase the correspondence between phenotypic and molecular datasets used in resolving important within-species biodiversity in the area. Along with existing microsatellite genotype information, these new mtDNA SNP results also provide important insights into the timing and origins of recent genetic changes observed in Chignecto Bay populations of endangered iBoF Atlantic Salmon.

Poster CCFFR (Species at risk)

AVOIDANCE BY SAND SHRIMP, *CRANGON SEPTEMSPINOSA*, OF SANDY PATCHES COVERED BY HYDRATED LIME (CALCIUM HYDROXIDE) DEPOSITS

Reebs, S.G.[1], P.M. Jackman[2], A. Locke[3], and W.L. Fairchild*[3].
[1]*Département de biologie, Université de Moncton, Moncton, New Brunswick, E1A 3E9.* [2]*Environmental Science Centre, Environment Canada, P.O. Box 23005, Moncton, New Brunswick, E1A 3E9.* [3]*Gulf Fisheries Centre, Fisheries and Oceans Canada, P.O. Box 5030, Moncton, New Brunswick, E1C 9B6* (wayne.fairchild@dfo-mpo.gc.ca).

Proliferation of invasive tunicates in Prince Edward Island estuaries has necessitated management of tunicates that foul mussel aquaculture structures. Spraying or immersion of tunicates with saturated solutions of hydrated lime (calcium hydroxide, Ca(OH)2) is effective, but can be biocidal to non-target organisms such as sand shrimp, *Crangon septemspinosa.* To investigate sublethal behavioural effects, individual sand shrimp were offered a choice between one side of a 6-L aquarium with a sandy bottom, and the other side that had the same sandy bottom covered by a layer of deposits resulting from the injection of hydrated lime, into the water column. The injection raised water pH from 7.7 to 9.4 and deposited a flocculent mixture of magnesium carbonate and calcium carbonate on the bottom. Shrimp significantly avoided the aquarium side with flocculent material in the first 24 h. Mortality was high during the ensuing three days, but the survivors continued to avoid the flocculent side. A control group (no lime injection) showed only a moderate mortality of 15% after 96 h and no avoidance of any particular side within the aquaria. Large quantities of concentrated lime solutions can be released where bio-fouling treatment is applied to mussel socks, and particles have been observed drifting to the bottom at such locations. Results suggest that such particles can reduce the preference of sand shrimp for the affected sediment. It remains to be seen whether deposits persist on the seafloor, and whether sand shrimp are present in areas where hydrated lime is used.

Poster CCFFR (General session)

STOCK ASSESSMENT AND MANAGEMENT IN DATA-POOR COMMERCIAL FISHERIES: LAKE NIPIGON LAKE WHITEFISH

Reid*, K.[1,2], K. Tsiplova[2], Y. Jiao[3], T. Nudds[1], and E. Desson[4].
[1]*Department of Integrative Biology, University of Guelph, Guelph, ON.* [2]*Ontario Commercial Fisheries' Association, Blenheim, ON.* [3]*Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA, U.S.A.* [4]*Anishinabek/Ontario Fisheries Resource Centre, North Bay, ON* (kevin.reid@uoguelph.ca).

Quantitative stock assessment for Lake Nipigon lake whitefish is challenging due to the data-poor nature of this fishery. Time series of CUE data, catch at age, growth-, and mortality-related information for Lake Nipigon lake whitefish stocks are absent or incomplete. We developed and implemented of a series of alternative hierarchical and uniform Bayesian surplus production models suitable for this data-poor fishery. These models were used to estimate biological

reference points, i.e., F_{MSY} and B_{MSY} and their uncertainty. We estimated the historic and current fishery status of the Lake Nipigon lake whitefish and showed that both the reference point estimates and stock status were highly uncertain. The results are 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., $P(B_{2010}<B_{MSY})$ is 0.544 due to high uncertainty about both B_{2010} and B_{MSY}. The estimated catch at F_{MSY} = 624,000kg (95%CI 166,000 – 2,174,000) is well above 2010 harvest levels of 154,000kg. We discuss implications for harvest policy and several options to reduce stock status uncertainty to more acceptable levels.

Oral CCFFR (General session)

CHANGES IN SALMONID COMMUNITY ON PRINCE EDWARD ISLAND: THE INFLUENCE OF LAND USE PRACTICES

Roloson*, S., M. Coffin, T. Dupuis, and M.R. van den Heuvel.
Canadian Rivers Institute, Department of Biology, University of Prince Edward Island, 550 University Avenue, Charlottetown, PE Canada C1A 4P3 (sroloson@upei.ca)

On Prince Edward Island, recent decades have been marked by declines in native salmonid populations. Most notably, Atlantic salmon (*Salmo salar*) have been eliminated from 69% of their original range. Alternately, non-native rainbow trout (*Oncoryhnchus mykiss*) have established anadramous populations in at least 21 watersheds across the Island; their relative success indicates that they are competitively advantaged in this ecosystem. Indeed, there is concern that juvenile rainbow trout may out-compete Atlantic salmon for riffle habitat, contributing to their decline on the Island. One plausible explanation for the success of rainbow trout is their resilience to environmental perturbation (e.g. sedimentation or pesticide runoff). To better understand the lifecycle of rainbow trout, adult trout were tagged and tracked using sonic telemetry in collaboration with the Ocean Tracking Network. We investigated the hypothesis that PEI may be a source of vagrant rainbow trout migrating throughout the Gulf of St Lawrence. Trout were tagged in rivers draining into the Monatgue estuary. Trout in this study did not migrate long distances, in fact none of the tagged fish left the receiver arrays in the estuary. During the study period nutrient loading and water chemistry were monitored throughout the watershed. Like many estuaries across PEI, mid-summer macroalgal blooms resulted in depleted oxygen levels. Tagged fish exhibited an extreme tolerance for both the high temperature and the hypoxic and anoxic conditions, showing no avoidance of such conditions. Thus, this investigation adds support to the body of information suggesting the rainbow trout have been successful because of their tolerance of degraded ecosystem integrity.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

HAVE NON-NATIVE IBERIAN PUMPKINSEED (*LEPOMIS GIBBOSUS*) LOST THEIR ANCESTRAL RESISTANCE TO HARSH NORTH AMERICAN WINTERS?

Rooke*, A., and M.G. Fox.
Environmental and Life Science Program, Trent University, 1600 West Bank Dr, Peterborough, ON K9J7B8 (annarooke@trentu.ca)

Fish from northern climates employ a variety of strategies to reduce their risk of winter mortality, thus northern populations are better able to survive severe winters than fish from more mild climates. This pattern has been assessed for fish populations that are well established, however few studies have considered populations recently introduced to a novel climate. The pumpkinseed (*Lepomis gibbosus*) is native to North America and is highly successful in the milder climate of the Iberian Peninsula where it was introduced about 100 years ago. We used simulated winter conditions in the laboratory to compare overwinter mortality of native and Iberian populations of juvenile pumpkinseed under typical Ontario winter conditions. Individuals for this experiment were taken from artificial colonies established with adults from two Ontario and two Spanish populations. Non-native fish had significantly higher instantaneous mortality rates during the winter than native fish populations. Body condition at the beginning of the winter and of mortalities during the winter was similar for all populations. Estimated dry weight loss during the winter period was also similar among populations, suggesting that vulnerability to starvation could not explain differential mortality rates. These results suggest that ancestral resistance to severe winter conditions can be impaired by relatively short periods of environmental selection under mild climates; however determination of the specific mechanism causing increased overwinter mortality in Iberian pumpkinseed requires further research.

Oral CCFFR (Impacts of climate change)

MODELLING INSTREAM FLOW EFFECTS ON JUVENILE SALMONID CAPACITY IN SMALL STREAMS: DO HABITAT SUITABILITY CURVES SYSTEMATICALLY UNDERESTIMATE OPTIMAL FLOWS?

Rosenfeld, J.S.
Aquatic Conservation Science Section, B.C. Ministry of Environment, 2202 Main Mall, Vancouver, B.C. V6T 1Z4 (Jordan.rosenfeld@gov.bc.ca).

The Instream Flow Incremental Methodology (in conjunction with Habitat Suitability curves) remains one of the most widely used methods for assessing the consequences of reduced instream flows for fish. Despite its widespread use, IFIM predictions are rarely validated against direct measures of fish abundance or production, and recent studies suggest that IFIM may underestimate the consequences of low flows for production of juvenile salmonids. I compared instream flow predictions using IFIM to predictions of optimal energy flux to fish using a drift-foraging model applied to a small coastal stream using standard habitat suitability curves for juvenile coho. The use of a drift-foraging model is based on the inference that production of juvenile drift-feeding salmonids depends not only on the availability of habitat, but also on the flux of energy to available habitat, and that the available energy flux may better

represent productive capacity. Relative to energy flux estimates from the drift-foraging model, IFIM using Habitat Suitability curves systematically underestimated the negative consequences of decreasing flow, indicating that the delivery of energy (invertebrate drift) to useable habitat declines much more quickly with decreasing flow than the availability of useable habitat as modelled with Habitat Suitability curves, supporting the potential for a systematic bias in IFIM predictions.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

POPULATION STRUCTURE AND INADEQUACY OF CURRENT MANAGEMENT APPROACHES FOR AN EXPLOITED MARINE FISH UNDER COSEWIC CONSIDERATION

Roy[*], D.[1], T.R. Hurlbut[2], and D.E. Ruzzante[1]
[1]*Marine Gene Probe Laboratory, Department of Biology, Dalhousie University, 1355 Oxford Street, Halifax, Nova Scotia, Canada B3H4J1.* [2]*Fisheries and Oceans Canada, Oceans and Science Branch, Marine Fish Section, Gulf Fisheries Centre, 343 Université Ave., P.O. Box 5030, Moncton, New Brunswick, Canada E1C9B6* (denisroy1@gmail.com)

Understanding factors generating patterns of genetic diversity is critical to the implementation of robust conservation and management strategies for exploited species. Yet, often too little is known about population structure to properly tailor management schemes. White hake was once highly exploited on the east coast of Canada. Substantial abundance declines in the southern Gulf of St. Lawrence (SGSL) during the 1990s resulted in the fisheries' closure in 1995 and restriction of catches in surrounding management zones. Since then, no significant recovery of the resource has been evident. Abundance monitoring via scientific surveys during the 1990s-2000s has demonstrated further declines culminating in the current review of white hake's conservation status by COSEWIC (Committee on the Status of Endangered Wildlife in Canada). Here we report evidence of substantial population structure in white hake (*Urophycis tenuis*) in the northwest Atlantic, perhaps among the highest levels exhibited by a highly exploited, widely dispersed, long-lived marine fish. We show that depth plays a role in this extensive and temporally stable structure, which does not conform to established fisheries management units. Three genetically distinguishable populations were identified with two straddling management divisions and two overlapping in their range and coexisting within a single division. The most highly exploited population in the SGSL was also the most isolated and likely the smallest (genetically effective). This work shows that conservation and management priorities must include population structure and stability in establishing effective species recovery strategies.

Oral CCFFR (Species at risk)

SCRATCHING THE SURFACE OF STREAM PRODUCTIVITY: COMPOSITIONAL CHANGES OF BIOFILM COMMUNITIES IN ATLANTIC RIVERS RECEIVING MARINE-DERIVED NUTRIENT INPUTS

Samways*, K.M. [1], Z.J. Quiñones-Rivera[2], M.A. Charest[1], P.R. Leavitt[2], and R.A. Cunjak[1].
[1]*University of New Brunswick, Canadian Rivers Institute, Department of Biology, P.O. Box 4400, Fredericton NB.* [2]*University of Regina, Department of Biology, Regina, SK* (Email: kurt.samways@unb.ca)

Spawning anadromous fish can enhance stream productivity by depositing marine-derived nutrients (MDN), which stimulate the production and growth of algae, aquatic invertebrates and fish. With the dramatic decline of these fishes throughout Atlantic Canada in the past century, the scarcity of these MDN may have profound effects on aquatic production, particularly in nutrient-poor systems. Benthic biofilm is an assemblage of algae, fungi and bacteria covering submerged surfaces, and contributes significantly to overall primary productivity, nutrient uptake and transfer to higher trophic levels. Research on nutrient limitation in streams is primarily centred on algae. However, measuring a single component of this matrix may not accurately represent the biotic potential to sustain higher trophic levels. To understand how influxes of MDN influence freshwater productivity, changes in abundance and composition of the biofilm community were measured in several Atlantic rivers using group specific analytical techniques: spectrophotometric analysis of chlorophyll for algae, HPLC separation of ergosterol for fungi, and microscopic cell counts for bacteria. We predicted that abundance and composition of biofilm should vary through time and space as the community is established, with an increase in abundance coinciding with MDN inputs from spawning activity. Preliminary results indicate that sites receiving MDN have an increased rate of algal colonization; which is maintained throughout the season. The connectivity between freshwater and marine inputs may be larger in scope than previously understood. The investigation of individual matrix components is necessary for addressing complex questions about processes and function, especially when dealing the dynamics of riverine productivity.

Oral CCFFR (Nutrient dynamics)

THE INFLUENCE OF WATER COLUMN STRATIFICATION ON ZOOPLANKTON COMMUNITY COMPOSITION, ZOOPLANKTON PRODUCTIVITY AND FOOD WEB EFFICIENCY

Sastri*, A.R., P. Juneau, and B.E. Beisner.
Department of Biological Sciences, University of Quebec at Montreal, C.P. 8888, Succ. Centre Ville, Montreal, QC, H3C 3P8, Canada (sastriakash@gmail.com)

Patterns of thermal stratification in North Temperate lakes are predicted to change in response to climate change. A mechanistic understanding how aquatic planktonic food webs will respond to changes in stratification requires both process-oriented studies and demonstrations of stratification effects on community composition and standing biomass. In this whole-lake study, we were primarily focused on the response of the crustacean zooplankton community to an experimentally lowered thermocline. Rates of crustacean zooplankton production, community-level biomass, and composition were monitored weekly in a lake in which the thermocline was experimentally lowered in one of three basins by mixing throughout the summer; a second basin also experienced a lowered thermocline without mixing while a third acted as a control.

Zooplankton community composition was temporally autocorrelated in all basins, with the experimental basin diverging the most. Crustacean zooplankton community productivity was estimated as the rate of chitobiase (crustacean moulting enzyme) production. During an experimental year, the mean summer chitobiase-based biomass production rate for the mixed basin was significantly greater than the control basin. Meanwhile, in a control year (no mixing), production rates were comparable in all basins. Comparisons of the mean of the date-specific differences between years yielded a significant positive effect of mixing on secondary production rates. The effect of the measured crustacean zooplankton community response on the plankton food-web will be discussed in the context of changes in: 1) the composition of zooplankton diets; and 2) temporal patterns of phytoplankton to zooplankton transfer efficiency.

Oral SCL (Impacts of climate change)

THE FEASIBILITY OF STOCKING STORMWATER PONDS WITH RAINBOW TROUT FOR THE PURPOSE OF HUMAN CONSUMPTION

Seward*, S., and J.B. Rasmussen.
Department of Biological Sciences, University of Lethbridge, 4401 University Drive, Lethbridge, Alberta, Canada T1K 3M4 (scott.seward@uleth.ca)

Stormwater ponds are becoming a common feature in urban landscapes owing to their ability to manage water discharge from urban areas and protect the water quality of downstream systems. They can contain high levels of urban pollution not associated with natural watersheds including heavy metals, suspended solids, oil and grease, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, nutrients and bacteria. Despite the abundance of information pertaining to stormwater systems and stormwater pollution, little is known about how suitable these ponds are for aquatic organisms and how much of a threat these toxicants are. We explore the feasibility of stocking stormwater ponds with rainbow trout for human consumption within the context of the following two questions: 1.) Can rainbow trout survive in stormwater ponds based on the physical, chemical and biological attributes of the ponds? 2.) Would fish tissue samples from trout reared in these ponds exceed guidelines for human or wildlife consumption? Preliminary results suggest that few stormwater ponds meet the physical properties and water quality standards necessary for trout survival. Stormwater ponds are often designed too shallow, with high levels of water fluctuation. Low dissolved oxygen levels, high ammonia levels, excessive amounts of macrophytes and dense algal blooms are limiting factors for rainbow trout survival in several ponds investigated.

Poster CCFFR (Impacts of multiple stressors)

ASSESSING THE IMPACT OF MULTIPLE STRESSORS (FISHING AND AN INTRODUCED PREDATOR) ON LIFE HISTORY TRAITS OF *RASTRINEOBOLA ARGENTEA* - LAKE VICTORIA'S MOST IMPORTANT NATIVE FISH STOCK

Sharpe*, D.M.T., S.B. Wandera, and L.J. Chapman.

Department of Biology, McGill University (diana.sharpe@mail.mcgill.ca)

Fishing and introduced species are among the most important stressors affecting freshwaters, and can be important selective agents, with the potential to drive contemporary phenotypic change in native prey/harvested species. However, much uncertainty remains regarding the rate, limits, and ubiquity of such responses, particularly when multiple stressors act simultaneously. This uncertainty compromises our ability to predict species' persistence in the face of continuing anthropogenic disturbance and to inform management decisions. We examined the combined effects of commercial fishing and an introduced predator (Nile perch, *Lates niloticus*) on life history traits in an African cyprinid fish (*Rastrineobola argentea*) native to the Lake Victoria basin in East Africa. To understand whether these two stressors have driven shifts in life history traits of *R. argentea*, we tested for associations between life history phenotypes and the presence/absence of stressors both spatially (across 10 Ugandan lakes) and temporally (over 4 decades in Lake Victoria). Overall, introduced Nile perch and fishing tended to be associated with a suite of life history responses in *R. argentea*, including: decreased body size, maturation at smaller sizes, and increased reproductive effort (larger eggs; and higher relative fecundity, clutch volume, and ovary weight). This is one of the first well-documented examples of fisheries-induced phenotypic change in a tropical, freshwater stock; the magnitude of which raises some concerns for the long-term sustainability of this fishery, now the most important (by mass) in Lake Victoria.

ORAL CCFFR (Impacts of multiple stressors)

LIMITED GENE FLOW AND DISPERSAL IN BROWN BULLHEAD (*AMEIURUS NEBULOSUS*): CONTAMINANT EFFECTS AND LOCAL ADAPTATION

Söderberg*, L.I., M.J. Ouellette, R.P. Walter, and D.D. Heath
Department of Biological Sciences and Great Lakes Institute for Environmental Research, University of Windsor, 401 Sunset Ave., Windsor, ON, N9B 3P4, Canada (email: soderbe@uwindsor.ca)

Stressful habitat disturbance leaves organisms two options; they can either relocate or adapt/acclimate to their local environment. Local adaptation results from natural selection, such that individuals have a higher fitness in their native environment than in other environments, and immigrants will have reduced relative fitness. However, local adaptation needs reproductive isolation and high levels of gene flow will limit adaptive divergence among populations. This study examines the potential for local adaptation in the brown bullhead in the Great Lakes. Brown bullhead live in both "contaminated" and "clean" habitats, and are often used as an indication species for the effect of sediment contamination and water quality. We used 11 polymorphic microsatellite loci to investigate genetic divergence and dispersal patterns across the lower Great Lakes and the St. Lawrence River at 25 sample sites. We found high genetic differentiation indicative of low gene flow. Isolation was mainly driven by distance, and the number of first generation migrants was low even between proximate sites. Thus brown bullhead do not emigrate from their native environment, although we found evidence that there is higher dispersal rates from contaminated to clean sites than expected by chance. We conclude that local

adaptation or acclimation is possible and likely among brown bullhead populations in the Great Lakes.

Oral CCFFR (Migration, mixing, and dispersal)

CHARACTERIZATION AND COMPARISON OF AMERICAN EEL (*ANGUILLA ROSTRATA*) DIETS IN TWO STOCKING LOCATIONS IN LAKE ONTARIO AND THE UPPER ST. LAWRENCE RIVER

Stacey*, J.[1], T.C. Pratt[2], and M.G. Fox[3].
[1]*Environmental & Life Sciences Graduate Program, Trent University, Peterborough, ON.* [2]*Fisheries and Oceans Canada, Sault Ste. Marie, ON.* [3]*Environmental and Resource Studies Program and Department of Biology, Trent University, Peterborough, ON.* (joshuastacey@trentu.ca).

To offset the widespread decline of American eels (*Anguilla rostrata*) in Lake Ontario and the St. Lawrence River, the DFO and OPG have implemented stocking programs in the regions of the Thousand Islands (TI) and Bay of Quinte (BQ). As these two locations may vary in their suitability for eel growth and development, the aim of this study was to i) characterize the dietary components of eels in both regions, and ii) compare prey items and the amount consumed by eels between regions. Boat-electrofishing was used to capture eels in May and September, 2010-2011. Stomach contents were identified to order and quantified based on their percent by weight, volume, and number. The percentage of empty stomachs was calculated, and stomach fullness index was compared between locations and seasons using a two-way ANOVA. The results from 2010 indicate there was no effect of season, but eels from TI had a significantly higher index of stomach fullness. The percentage of empty stomachs was 22.7% and 58.6% in TI and 52.4% and 44.4% in BQ for spring and fall, (respectively). The estimated mean densities varied from 53 – 91 eels/ha with slightly higher density in BQ; however mean biomass density was approximately one third of that found in TI. The mean total lengths of eels caught were generally higher for each age class in TI in both seasons. These initial results suggest that the TI stocking locations may be more suitable for feeding and growth, despite the higher biomass of individuals found there.

Oral CCFR (Species at risk)

THE EFFECT OF DOC ON ISOTOPIC NICHE PARTITIONING BETWEEN WALLEYE (*SANDER VITREUS*) AND SMALLMOUTH BASS (*MICROPTERUS DOLOMIEU)* IN SMALL BOREAL SHIELD LAKES

Stasko*, A.S., T.A. Johnston, and J.A. Gunn.
Cooperative Freshwater Ecology Unit, Department of Biology, Laurentian University, 935 Ramsey Lake Rd., Sudbury, ON, P3E 2C6 (ax_stasko@laurentian.ca)

It is unclear what effect smallmouth bass invasions are having on native walleye populations in northern Ontario, or how shifts in water clarity caused by climate change and land development (via changing dissolved organic carbon (DOC) inputs) will affect interactions between these species. Here, preliminary results will be presented from a study investigating how DOC affects the degree of niche overlap between sympatric populations of walleye and smallmouth bass. Twenty of each species were collected from 34 small (100-200 ha) Boreal Shield lakes across Ontario that spanned a wide clarity gradient, as measured by DOC concentration and Secchi depth. Stable isotope analysis of nitrogen and carbon in fish muscle tissue was used to estimate isotopic niche widths for each population in $\delta^{15}N$ vs. $\delta^{13}C$ biplot space and to calculate metrics of isotopic interaction (area of overlap between multivariate ellipses, and distance between species centroids). Metrics of isotopic interactions were then compared across the lake water clarity gradient to investigate changes in niche overlap and feeding ecology associated with changes in DOC. Other community variables (relative abundance of walleye vs. smallmouth bass, presence of specific prey types, predator-to-prey ratios) were also investigated as potential co-variables. It is predicted that interspecies competition will decrease with decreasing water clarity. Knowledge gained from this research will shed light on how DOC can impact walleye resilience in the face of competition with invading smallmouth bass.

Oral CCFFR (Invasive aquatic species)

PATTERNS OF ZOOPLANKTON ABUNDANCE IN ST. PAULS INLET: A BRACKISH WATER SYSTEM IN GROS MORNE NATIONAL PARK, NEWFOUNDLAND AND LABRADOR

Stevens*, E.[1], and C. Campbell[2].
[1]*Department of Biology, Memorial University, 253 Elizabeth Avenue, Arts and Administration Building, St. John's, NL A1C 5SJ.* [2]*Division of Science, Grenfell Campus Memorial University, 1 University Dr., Corner Brook, NL A2H 6P9* (erin.n.stevens@mun.ca).

St. Pauls Inlet is a brackish-water estuarine fjord located in Gros Morne National Park (GMNP), Canada. Water sources for the inlet include freshwater input from highland lakes, rivers, precipitation, and groundwater as well as saltwater from the Atlantic Ocean. During June to August of 2009 & 2010 five sites were studied within the inlet as part of Memorial University's Community-University Research for Recovery Alliance (CURRA). The purpose of the study was to determine i) abundance of zooplankton in St. Pauls Inlet, ii) potential patterns in zooplankton species composition along the inlet, iii) whether any such patterns relate to observed longitudinal salinity gradients throughout the inlet, and iv) how species composition in St. Pauls Inlet compares with other regional locations. Zooplankton species composition was primarily marine cyclopoida and calanoida, with some brackish-water cladocerans. Zooplankton density was not high, possibly as a result of limited nutrient levels in the watershed. Longitudinal salinity gradients were noticeable mainly in the spring, likely due to snow melt. Cluster Analysis showed no strong patterns in species assemblages in 2010, although in the 2009 season there appeared to be a slight pattern related to salinity. Cluster dendograms indicated that St. Pauls' zooplankton fauna was only about 10% similar to Lake Melville (Labrador), another regional estuarine system. Although estuarine and tidal inlet environments are typically regions

that are of high importance to ecosystem productivity, St. Pauls does not appear to be a highly productive or diverse system, based on zooplankton data.

Oral CCFFR (General session)

A NEW APPROACH TO UNDERSTANDING THE SPATIAL REGULATION OF ZOOPLANKTON COMMUNITY STRUCTURE

St-Gelais*, N.F., P. del Giorgio, and B.E. Beisner
University of Québec at Montréal, Department of biological sciences, C.P. 8888, Succ. Centre-Ville, Montréal (Québec), Canada H3C 3P8 (nicolas.fstgelais@gmail.com)

Traditionally, zooplankton community structure studies have revolved around classical predictors of biodiversity in lakes such as morphometry and primary productivity. While the green carbon pathway (from phytoplankton to fish) is well established in trophic studies, recent work has demonstrated a significant contribution of terrestrial bacterial-mobilized carbon to sustain zooplankton communities. However, the relative effects of each pathway on zooplankton community stucture remains unclear and because it may have a complex dependence on lake characteristics, remains controversial. Moreover, because simple community properties, such as biomass and taxonomic diversity, do not capture the complexity of interactions of zooplankton with the environment (e.g. carbon acquisition), there is a need to develop community indices based on functional characteristics. Taking these aspects into account should allow the development of a more mechanistic understanding of the processes regulating communities. Toward this goal, we have integrated into the classical approach, variables associated with: (i) the provenance of carbon and (ii) zooplankton functional diversity. In our study of zooplankton communities across landscapes of lakes, we used the ratio of primary production to bacterial production (PP:BP) to represent the alternate pathways by which matter and energy are passed through food webs. Furthermore, we use functional diversity rather than taxonomically-based indices so as to identify the mechanistic basis for the observed community responses to the different food web structures. Our preliminary results show that zooplankton community structure (diversity, function and composition) differs most between lakes that are at the extremes of the energy and carbon flow pathways.

Oral SCL (General session)

EFFECT OF BROOK TROUT STRAIN AND TEMPERATURE ACCLIMATION ON CRITICAL THERMAL MAXIMA AND UNDERLYING PHYSIOLOGICAL MECHANISMS

Stitt*, B.[1], K. Burgomaster[2], J. McDermid[3], G. Burness[1], and C. Wilson[4]
[1]*Environmental and Life Sciences, Trent University, Peterborough, ON, Canada* (bradleystitt@trentu.ca). [2]*University of Ontario Institute of Technology, Oshawa, ON, Canada.* [3]*Wildlife Conservation Society of Canada, Peterborough, ON, Canada.* [4]*Aquatic Research Section, Ontario Ministry of Natural Resources, Peterborough, ON, Canada.*

Salmonids and other coldwater fishes are predicted to be highly vulnerable under global warming scenarios and changing thermal conditions threaten their future sustainability. Thermal stress and habitat loss from increasing water temperatures are expected to impact population viability, particularly for inland populations with limited adaptive resources. As an archetypal coldwater salmonid, the long-term persistence of brook trout (*Salvelinus fontinalis*) populations will depend on their ability to cope with and adapt to changing thermal conditions. Very little is known, however, about the scope and variation of thermal tolerances within and among brook trout populations and evolutionary lineages. We assessed the comparative thermal performance and physiology among three strains of brook trout with differing biogeographic origins and historical thermal environments that are used in fisheries management in Ontario. The three strains exhibited significant differences in their ability to tolerate increasing water temperatures, with significantly different critical thermal maxima (CTM) across acclimation temperatures ranging from 9^{O}C to 21^{O}C ($F_{3,191}$=624.5, $p<0.0001$) and among the three populations ($F_{2,191}$=51.1, $p<0.0001$). Heat shock protein (HSP) response was investigated as the underlying physiological mechanism behind these significant CTM differences. Expression of the inducible HSP 70 differed significantly between strains ($F_{2,89}$=10.5, $p<0.0001$) and across acclimation temperatures ($F_{3,89}$=12.6, $p<0.0001$) in heart tissue. There were no significant HSP70 differences within liver and white muscle tissues. This research provides insights into the physiological basis for differences in thermal tolerance, as well as management implications for wild and hatchery populations of brook trout in Ontario.

ORAL CCFFR (Population dynamics, health, and ecology of salmonids)

THE ADAPTABILITY OF SUBARCTIC TUNDRA PONDS TO ENVIRONMENTAL STRESSORS

Symons*, C.C.[1], S.E. Arnott[1], and J.N. Sweetman[2].
[1]*Department of Biology, Queen's University, Kingston ON.* [2]*Parks Canada, Winnipeg, MB*
(email: c.symons@queensu.ca)

Understanding how ecosystems will respond to environmental change is particularly important in northern regions, as climate change is predicted to have profound effects in this area. Higher temperatures are expected increase nutrient loading to ponds and increase salinity. The response of biota will depend on changes in the local environment as well as regional processes such as dispersal. We conducted a mesocosm experiment in Churchill, MB to determine the importance of regional dispersers, and the timing of their arrival in the response of the community to increased salinity and nutrients. Using 150L enclosures, we performed a fully-crossed 3 factor design experiment: Nutrients (ambient, +nutrients), Salinity (ambient, +salinity) and Dispersal time (dispersers added in 3 9-day intervals). The effect of dispersal changed throughout the season as the invasibility of the communities decreased. Dispersers added shortly after the creation of the environmental treatments had high establishment in both the Nutrient and Salinity treatments. When dispersers were added 9 days later they only established in the Salinity treatments, and there was low establishment in all treatments when added 18 days after disturbance. With dispersal the communities changed significantly in both Salinity and Nutrient treatments for all dispersal times; however, dispersers provided limited 'rescue effects', in

species richness, diversity or abundance. Ecosystem functioning, using Chl-*a* as a proxy, was maintained when regional dispersers were added. Overall, the results suggest regional dispersers will help communities to adapt to changing environmental conditions, and that the effect of dispersal will depend on the arrival time of dispersers.

Oral SCL (Migration, mixing, and dispersal)

DROUGHT-INDUCED FLUXES OF METALS AND NUTRIENTS TO LAKES FROM PEATLANDS IN CATCHMENTS VULNERABLE TO EXTREME EVENTS

Szkokan-Emilson*, E.[1], S. Watmough[2], and J. Gunn[1].
[1]*Cooperative Freshwater Ecology Unit, Living With Lakes Centre, Laurentian University, Sudbury, ON.* [2]*Environmental Resource Science, Trent University, Peterborough, ON* (Ex_SzkokanEmilson@Laurentian.ca).

The Boreal Shield contains a vast area of peatlands connected to one of the world's largest stores of freshwater. This area continues to experience disturbances related to mining and forestry while adapting to a changing climate, where extreme events of drought and flash rain events are expected to become more prevalent. Peatlands are an important regulator of water quality in lakes, and previous studies have demonstrated that drought events can severely degrade water quality. Heavily disturbed areas are particularly susceptible to drought, and currently experience extreme drying / rewetting events that may become characteristic of the entire Boreal Shield in this changing climate. Biogeochemical cycling within six peatlands located in catchments with varying degree of disturbance (past and present) are being studied to determine how the cycling of nutrients and metals differs, and investigate differences in the loads of these materials across their outflow streams. The outflows from two of the catchments are monitored at a high frequency (every 8 hours with ISCO automated samplers) to assess the impact of summer drought and short-term re-wetting events on stream water quality during the fall. Changes in chemistry and its implications to lakes will be discussed. This research will provide a better understanding of the interaction between peatland biogeochemical cycles and nutrient and metal fluxes in Boreal Shield catchments under a changing climate, where episodic hydrologic events could become a major regular of lake water quality.

Oral SCL (Impacts of climate change)

THE RELATIVE INFLUENCE OF FOOD WEB POSITION AND GROWTH RATE ON INTERSPECIFIC VARIATION IN MERCURY CONCENTRATIONS OF BOREAL PISCIVORES

Tang, R.W.-K., A.D. Stasko*, T.A. Johnston, and J.M. Gunn.
Cooperative Freshwater Ecology Unit, Department of Biology, Laurentian University, Sudbury, Ontario (ax_stasko@laurentian.ca).

In boreal fish communities, piscivores usually have much higher mercury concentrations than other feeding groups. However, even within the piscivore trophic guild, mercury concentrations can still vary among species at a standard body size. We examined the relative roles of food web position and growth rate in accounting for variation in mercury concentration among four co-habiting, native piscivore species (walleye, northern pike, lake trout, burbot) in boreal shield lakes of northern Ontario, Canada. Linear models relating total mercury concentration (THg), to carbon source (inferred from $\delta^{13}C$), trophic position (inferred from $\delta^{15}N$) and growth rate in a standard size of fish (1 kg) were compared using Akaike's Information Criterion (AIC). In general, variation among lakes was higher than variation among species. Following adjustment for lake effects, the piscivores divided into two groups – those with higher growth rate and lower $\delta^{15}N$ (walleye, northern pike), and those with lower growth rate and higher $\delta^{15}N$ (lake trout, burbot). Models containing either growth rate or food web variables all ranked higher than a model where species was defined as a categorical variable. But, models containing growth rate generally ranked better than those containing $\delta^{13}C$ or $\delta^{15}N$. Much of the interspecific variation in mercury concentration among boreal piscivores can be accounted for by differences in growth rate.

Oral CCFFR (Role of top predators)

RIVER-WIDE MOVEMENTS AND FINE-SCALE HABITAT USE OF ATLANTIC STURGEON DURING SPAWNING MIGRATION IN THE SAINT JOHN RIVER, NEW BRUNSWICK, CANADA

Taylor*, A., and M.K. Litvak.
Department of Biology, Mount Allison University, Sackville, NB (adtaylor@mta.ca).

Movement patterns and habitat use of Atlantic sturgeon, *Acipenser oxyrinchus*, were investigated using ultrasonic telemetry during 2010 and 2011 in the lower Saint John River, New Brunswick, Canada. Twenty and 18 Atlantic sturgeon were captured and internally tagged with Vemco V16 ultrasonic coded pingers (27 V16-6X; 5 V16TP; 6 V16P) in summer of 2010 and 2011, respectively. Each fish captured was measured (TL, FL, Girth), digitally imaged, blood sampled, and identified for gender. Tagged individuals were passively tracked using stationary Vemco VR2 receivers located at strategic points throughout the Saint John River. We also manually tracked tagged fish from a boat using a Vemco VR100 receiver equipped with a directional hydrophone that allowed us to determine precise locations of fish through triangulation. Depth, temperature, oxygen concentration, salinity and substrate type were recorded at each directionally triangulated GPS position. Atlantic sturgeon selected mean depths (1±SEM) of 6.4±1.0 meters in 2010 and 5.5±1.0 in 2011 and were most commonly found on sandy substrate. Few fish exhibited upstream migration as the tagged sturgeon were primarily located between river kilometers 23-55 throughout the summer. Fish initiated downstream migration and exit from the river primarily between late July and September. Four fish tagged in 2010 were detected in the Minas Basin following exit from the river. One of these fish was detected in September 2010 and the other three were detected in Minas Basin in June 2011. This work provides information that can be used to create effective management strategies and protection for this species.

ORAL CCFFR (Species at risk)

GENETIC MONITORING OF CO-DISTRIBUTED SALMONIDS IN THE PEACE RIVER "SITE-C" HYDROELECTRIC DEVELOPMENT AREA

Taylor*, E.B., and M. Yau.
Department of Zoology and Beaty Biodiversity Research Centre and Museum, University of British Columbia, 6270 University Blvd, Vancouver, British Columbia V6T 1Z4 (etaylor@zoology.ubc.ca)

The Peace River drainage is the largest drainage system in British Columbia and extends into Alberta and the Northwest Territories. In British Columbia, two major hydroelectric facilities already exist on the Peace River (the W.A.C. Bennett and Peace Canyon dams) and a third proposed dam is currently in the environmental assessment phase (the so-called "Site-C" development). The development area is home to approximately 40 species of freshwater fishes representing a mixture of species of Great Plains, Bering, and Pacific origin, including bull trout (*Salvelinus confluentus*), Arctic grayling (*Thymallus arcticus*) and mountain whitefish (*Prosopium williamsoni*). We assayed variation at between six and 10 microsatellite DNA loci in samples from each of these three species collected from multiple years and localities to: (i) establish a baseline database for measures of genetic diversity, differentiation, and effective population sizes (EPS), and (ii) use genetic data to complement estimates of connectivity obtained from radio-tagging. Expected heterozygosity ranged from 0.50 – 0.72, EPS from 70 to 500 individuals, and pairwise F_{ST} ranged from 0.032 to 0.053 among species. An estimated 5 to 9% of individuals were identified as migrants between localities. Genetic estimates of inter-locality dispersal were generally consistent with those observed from radiotagging. Our data establish baseline conditions to enable genetic monitoring of future changes associated with hydroelectric development, demonstrate the importance of migratory connectivity to the life history of each species, and aid in compensation initiatives within the watershed.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

IS EGG SURVIVAL OF ATLANTIC SALMON A FUNCTION OF HYPORHEIC WATER QUAILTY AND/OR FLOW REGULATION?

Thoms*, P.A., R. Cunjak, T. Linnansaari, and A. Fraser.
Canadian Rivers Institute, Department of Biology, University of New Brunswick. P.O. Box 4400 Fredericton, New Brunswick, Canada E3B 5A3 (paula.thoms@unb.ca).

Atlantic salmon (*Salmo salar*) populations have been declining in recent years, particularly in regulated systems. Hydroelectric activities provide renewable energy but have a physical impact on salmon habitat and form barriers for salmon migration. An unanswered question is, to which extent is egg survival impacted by hydroelectric activities. To determine the effect of flow regime changes on hyporheic water quality and the repercussions on incubating salmon eggs a

pilot study in 2010 for four streams was conducted in Newfoundland. During which DO (dissolved oxygen) levels and temperature were monitored over winter in conjunction with discharge to assess the hyporheic water quality on regulated and unregulated rivers. The data obtained warranted further investigation using salmon eggs to understand the implications of the variance between habitats during the incubation period. In the Tobique river system, NB, salmon eggs will be placed in the streambed at 100, 200 and 300mm below the streambed at three sites downstream of dams in two regulated rivers; the Dee and the Serpentine and in an unregulated control river the Gulquac. Separate controls for base survival rate and transport/time taken to deposit the eggs will be used. Egg survival rate in the rivers will be monitored in conjunction with flow, DO and temperature data to assess the implications of hyporheic water quality and/or flow regulation.

Poster CCFFR (Population dynamics, health, and ecology of salmonids)

DISPERSAL INCREASES NEGATIVE CO-OCCURRENCE PATTERNS IN EXPERIMENTAL ZOOPLANKTON COMMUNITIES

Turner, K., S. E. Arnott*, and B. Schamp.
Department of Biology, Queen's University, Kingston, ON, K7L 3N6 and [1]Department of Biology, Algoma University, Sault Ste. Marie, ON, P6A 2G4 (arnotts@queensu.ca)

Community structure is determined by local environmental conditions as well as regional factors that influence the dispersal of individuals among habitats. The arrival of individuals to a habitat can rescue local populations from stochastic extinction, increase the local adaptive capacity of populations/communities, maintain sink populations, and potentially alter species interactions. Patterns of species co-occurrence across landscapes have been used to assess the strength of species interactions, and variation in habitat preference within communities. However, recent theoretical work suggests that non-random co-occurrence patterns can also result from high dispersal rates of individuals among sites. To test this prediction, we established replicate mesocosms (fifteen in each of four regions) and experimentally examined the influence of dispersal on species co-occurrence patterns. Mesocosms (380 L) were setup in Killarney Provincial Park, Ontario, filled with 50-µm filtered water and stocked with zooplankton from George Lake. Four species-neutral dispersal treatments were established; 0.1%, 1.3 %, 2.5% and 9.6% ambient concentration of zooplankton from 5 disperser lakes. Dispersers were added every 11 days for 88 days. Rotifer and crustacean zooplankton diversity, abundance, and species co-occurrence patterns were examined at the end of the experiment. We found that richness increased with dispersal, but evenness and total zooplankton abundance were similar among treatments. Species co-occurrence patterns were unimodal with significant non-random patterns in the 3 highest dispersal treatments. Our finding of negative co-occurrence patterns in the absence of environmental heterogeneity supports the notion that neutral processes, such as dispersal, can be a significant determinant of co-occurrence patterns.

Oral SCL (Migration, mixing, and dispersal)

A COMBINED STABLE ISOTOPE AND GUT CONTENT ANALYSIS OF SHORTNOSE STURGEON DIET IN THE SAINT JOHN RIVER, NB, CANADA

Usvyatsov*, S.[1], M. Power[2] and M. Litvak[1]
[1]Department of Biology, Mount Allison University, 63B York St, Sackville, NB, E4L 1G7 (sima.usvy@gmail.com). *[2]Department of Biology, University of Waterloo, 200 University Avenue West, Waterloo, Ontario, N2L 3G1.*

The shortnose sturgeon, *Acipenser brevirostrum*, is a protected species found along the Atlantic coast of Canada and the United States. In this study, colon contents of shortnose sturgeon were used to provide a snapshot of foraging habits, recovering only recently ingested items. In addition, stable isotope signatures of sturgeon blood plasma ($\delta^{13}C$, $\delta^{15}N$) were used to examine movement during the foraging season, as plasma isotopic values provide an account of diet integrated over a longer time frame. The contents of sturgeon guts were used to identify the dominant prey items in both freshwater and brackish environments throughout the Saint John River. Stable isotope samples of shortnose sturgeon blood plasma and 3-4 predominant invertebrate prey groups were obtained from 5 sites, covering both brackish and freshwater habitats, in summer, early fall and late fall. Two estimates of the trophic position of sturgeon were calculated, using 1) isotopic values of sturgeon plasma and benthos, and 2) gut contents and literature-based information on the diets of identified prey. The spatial and temporal variation in isotopic signatures of benthos and sturgeon plasma was examined to determine differences in feeding patterns between sites. In addition, the isotopic signatures were used in mixing models to characterize likely prey reliance, which was compared to the results obtained from sturgeon colon contents. This study addressed the knowledge gap concerning short-term and intermediate-term variation in the dietary habits of shortnose sturgeon across a range of habitats, and provided the first record of shortnose sturgeon isotopic signatures.

Oral CCFFR (Species at risk)

COMPARITIVE ANALYSIS OF THE SPATIAL DISTRIBUTION OF FISHING EFFORT UTILIZING THE IDEAL FREE DISTRIBUTION AND DESCRETE CHOICE MODELS

van der Lee*, A., and D. Gillis.
Department of Biological Sciences, Faculty of Science, University of Manitoba, Winnipeg, MB. R3T 2N2 (umvan277@cc.umanitoba.ca)

The relationship between commercial catch-per-unit-effort (CPUE) and abundance has been demonstrated to not always be linear. Despite this, CPUE is still utilized in many fisheries models to approximate stock size. Effort distribution has been suggested as an alternative measure with some finding it superior to CPUE. As a result it is vital to examine fishing effort distributions to fully understand a fishery. This study takes two approaches to investigate the effort distribution of the groundfish otter trawl fishery on the Scotian Shelf: first, through the use of the ideal free distribution (IFD) as a distribution null model of weekly aggregate effort; and second, by development of a discrete choice model of individual location choice. The application of the IFD to the fishery is examined using a novel approach to fisheries research, isodars.

Isodars represent the expected distribution of foragers between two habitats when fitness is equal. In our case, fitness is defined with relative catch rates and cost differentials between habitats. Discrete choice models were constructed as a mixed logit model, commonly used in economics, using random utility theory to give the expected probability of fishing in a particular area based on a collection of generic and individual specific predictors. In sample and out of sample prediction were made for both the IFD and discrete choice models and correlated with observe values to evaluate the success of each models predictions.

Oral CCFFR (General session)

THE IMPACT OF RETROGRESSIVE PERMAFROST SLUMPS ON LAKE SEDIMENT CHARACTERISTICS AND CHIRONOMID ASSEMBLAGES

Vermaire[*], J.C.[1], S. Delaney[1], J.R. Thienpont[2], P. deMontigny[1], S.V. Kokelj[3], J.M. Blais[4], J.P. Smol[3], and M.F.J. Pisaric[1].
[1]Department of Geography and Environmental Studies, Carleton University, Ottawa, Ontario, Canada. [2]Paleoecological Environmental Assessment and Research Lab, Department of Biology, Queen's University, Kingston, Ontario, Canada. [3]Renewable Resources and Environment, Aboriginal Affairs and Northern Development Canada, Yellowknife, Northwest Territories, Canada. [4]Department of Biology, University of Ottawa, Ottawa, Ontario, Canada (jvermaire@gmail.com).

Climate warming in northern regions is thawing permafrost and increasing the rate of retrogressive permafrost slumps into lakes. Lake survey studies have shown that permafrost slumps reduce the dissolved organic carbon concentration of the water and alter benthic environments. Permafrost slumps could therefore have important consequences for the structure and function of aquatic ecosystems, increasing within lake primary production but reducing the terrestrial carbon subsidy to aquatic consumers. The effects of permafrost slumps on lake ecosystems, however, remains poorly understood. Additionally, few studies have examined the long-term (decades or longer) impact of permafrost slumps on lake systems. The objectives of this study are therefore to examine the impact of permafrost slumps on: 1) the physical characteristics of lake sediments through time and 2) chironomid community structure. Preliminary results indicate that large permafrost slumps reduce the grain size and the organic content of the sediment by (~50%). Furthermore, these slumps can increase the sediment accumulation rate by an order of magnitude, depositing as much sediment in a decade as would normally be deposited in a century. These shifts in sediment quantity and quality would likely have important consequences for benthic organisms such as chironomids and early results suggest a shift from more profundal types of *Chironomus* spp. to littoral associated *Cricotopus/Orthocladius* spp. Future work will quantify changes in within-lake primary production through the analysis of fossil pigments and the organic carbon sources of invertebrates (chironomids and Cladoceran) through stable isotope analysis.

Poster SCL (Impacts of climate change)

HISTORICAL STORM SURGE MAGNITUDE AND CHIRONOMID RESPONSE OVER THE LAST ~1200 YEARS IN THE MACKENZIE DELTA REGION OF THE NORTHWEST TERRITORIES, CANADA

Vermaire[*], J.C.[1], C.L. Steele[1], C.J. Courtney Mustaphi[1], J.R. Thienpont[2], S.V. Kokelj[3], J.P. Smol[2], and M.F.J. Pisaric[1].
[1]Department of Geography and Environmental Studies, Carleton University, Ottawa, Ontario, Canada. [2]Paleoecological Environmental Assessment and Research Lab, Department of Biology, Queen's University, Kingston, Ontario, Canada. [3]Renewable Resources and Environment, Aboriginal Affairs and Northern Development Canada, Yellowknife, Northwest Territories, Canada (jvermaire@gmail.com).

Climate warming in the Arctic is reducing sea ice extent and increasing storm frequency and strength. The combined effect of increased storminess and reduced sea ice is expected to result in larger, more frequent, storm surges. The Mackenzie Delta region of the Northwest Territories has been identified as a region at high risk of severe storm surges. Understanding the magnitude of past storm surges and the resultant impacts on freshwater coastal systems is necessary for the management of Arctic ecosystems in a changing climate. The objectives of this study are: 1) to reconstruct the magnitude of past storm surges in the Mackenzie Delta region; and 2) determine the impact of storm surges on a central component of freshwater food-webs, the Chironomidae. Particle size analysis on lake sediment cores indicated that storm surges have been a frequent occurrence in the Mackenzie Delta region over the last ~1200 years. During warmer time periods (present day and ~1200-800 years B.P.), however, larger particles were deposited, suggesting that increased storminess is positively related to temperature. In fact, diatom-based paleolimnological studies suggest that the large 1999 storm surge was unprecedented in at least the last millennium. Preliminary results indicate that larger storm surges resulted in a decline in both the abundance and diversity of Chironomidae. Further analysis will focus on the recovery rate and trajectory of Chironomidae communities following storm surges, allowing us to draw conclusions on how freshwater Arctic ecosystems may respond to the anticipated larger and more frequent storm surges.

Oral SCL (Impacts of climate change)

ASSESSMENT OF A TECHNIQUE USED TO DETERMINE THE FAT CONTENT OF FISH: BIOELECTRICAL IMPEDANCE ANALYSIS

Vue*, S., R.A. Cunjak, and K.M. Samways.
Canadian Rivers Institute/University of New Brunswick, Department of Biology, P.O. Box 4400, 10 Bailey Drive, Fredericton, New Brunswick, CANADA, E3B 5A3 (sherr.vue@unb.ca)

Traditional measurements of fat content in fish require lethal sampling and the extraction of fat using laboratory techniques that are time consuming. This method precludes the ability to monitor temporal changes in fat content because the individual fish is killed during the initial sampling. The use of a bioelectrical impedance (BIA) meter avoids lethal sampling by correlating electrical properties of resistance and reactance in body tissues to fat content.

However, the BIA method is a relatively new and previous studies have shown that BIA readings are affected by temperature, time since death (and onset of rigor mortis), location of the electrodes, user experience, and conductivity of the sampling surface. Using juvenile Atlantic salmon, we tested the BIA meter's precision by taking repeated BIA readings and determining if the readings changed over varying time intervals since the initiation of sampling. Preliminary data showed that estimated lipid contents can be affected by temperature variances between sampling times. Assessing and correcting for variances in BIA readings will give biologist a fast non-lethal means of assessing fat content in fish.

Oral CCFFR (Use of new technology)

TESTING ABIOTIC AND BIOTIC FACTORS THAT AFFECT COMPETITION BETWEEN BULL AND BROOK TROUT IN AN ARTIFICIAL STREAM

Warnock*, W.G., and J.B. Rasmussen.
Department of Biological Sciences, University of Lethbridge, Lethbridge, Alberta
(will.warnock@uleth.ca)

Bull trout population declines in Canadian Rocky Mountain streams are attributed to many reasons, and one commonly cited cause is displacement from introduced exotic brook trout competitors. Patterns of brook trout invasion are patchy and largely unpredictable, and successful local invasions probably can be attributed to a suite of underlying biotic and abiotic factors. We conducted competition trials between juvenile bull and brook trout in an artificial stream to determine which factors may affect competitive interactions between the two species. Aggression and foraging success were measured as indices of competition and observations were made in both night and day periods. Bull trout from a migratory population outcompeted brook trout for food resources. In contrast, bull trout from a resident population were less aggressive and did not outcompete brook trout for food resources. When fish density was increased, brook trout became more successful competitors; however, increasing water velocity and habitat complexity counteracted this effect and bull trout became the superior competitor overall. These results suggest that competitive interactions between brook and bull trout can be affected by a variety of biotic and abiotic factors, including fish density, competitive behaviour of the population and physical habitat structure. Considering multiple such underlying factors that influence invasion success may help explain some of the patchy and complex patterns of brook trout occurrence in Rocky Mountain bull trout streams.

Oral CCFFR (Invasive aquatic species)

PATTERNS OF FUNCTIONAL AND NEUTRAL DIVERGENCE AMONG POPULATIONS OF RAINBOW TROUT FROM BABINE LAKE, BC

Wellband*, K.W., J. Lough, and D.D. Heath.
University of Windsor, 401 Sunset Ave. Windsor, Ontario, Canada (wellban@uwindsor.ca).

A fundamental question in the study of local adaptation is whether differential selection at functional loci drives divergence among populations in the face of gene flow. Salmonid populations experience differential selection across a gradient of environmental conditions and low rates of straying maintain low levels of gene flow among populations. A critical question in the management of these populations is whether neutral divergence is representative of functional divergence in natural populations. Neutral genetic divergence is widely used to delineate salmonid populations and for the conservation of at risk stocks. Investigations of the relationship between functional and neutral divergence have employed gene sequence data or phenotypic data to calculate 'functional' distance metrics, which are then compared with distance estimates from neutral markers. The resolution of these functional markers is often much coarser than that detected by neutral markers. Recently, gene expression has been demonstrated to be under selection and may provide a more sensitive measure for assessing functional divergence among populations. Functional divergence (Q_{ST}) based on gene expression profiles at functional loci will be compared with neutral genetic divergence (F_{ST}) for populations of Rainbow Trout native to Babine Lake, BC tributaries.

Oral CCFFR (Population dynamics, health, and ecology of salmonids)

THE IMPACT OF BOAT AVOIDANCE BY FISHES ON STOCK ESTIMATION FROM SMALL VESSEL HYDROACOUSTICS SURVEYS

Wheeland, L.
Centre for Fisheries Ecosystem Research, Fisheries and Marine Institute of Memorial University, 155 Ridge Rd., St. John's, NL (Laura.Wheeland@mi.mun.ca)

Hydroacoustics is a useful tool for collecting high-resolution data to quantify fish stocks and their distribution. However, for acoustic data to be reliable, the survey method must not initiate avoidance responses by fishes that would result in inaccurate stock estimates. The reactions of schooling fish in marine environments are well documented, with aggregations displaying a range of horizontal and vertical movement at various depths when a vessel passes overhead (e.g. Skaret et al., 2005; Mitson and Knudsen, 2003). Boat avoidance responses for individual fish and for freshwater environments have not received the same attention, with few studies focusing on these reactions (e.g. Draštík and Kubečka, 2005). In this study, a small vessel (17' Boston Whaler) was used to complete paired-transect experiments to determine avoidance reactions of non-schooling fishes in shallow freshwater. Assuming that a passive object does not initiate an avoidance response, the vessel was allowed to drift over an area, after which the same area was driven across at a constant speed. Fish counts from the paired tracks were compared to determine if a difference was detected in the driven track that would suggesting that fish were moving away from the path of the approaching vessel. The presence of this behaviour during acoustic surveys would produce artificially low stock estimates. We predict a speed dependent relationship of boat avoidance, which can contribute to the determination of an optimal survey speed for shallow water acoustic work.

Oral CCFFR (Use of new technology)

PHYSICAL HABITAT BELOW A HYDROPEAKING DAM: EXAMINING PROGRESSIVE DOWNSTREAM CHANGE AND THE ROLE OF TRIBUTARIES

Winterhalt*, L., B. Eaton, and M. Lapointe.
Department of Geography, University of British Columbia, 1984 West Mall, Vancouver, BC, V6T 1Z2 (lesley.winterhalt@geog.ubc.ca)

Hydropeaking dam operations often drastically alter natural flow regimes, to synchronize flow releases with consumer energy demands. These large alterations to natural flow regimes affect aquatic organisms and their habitats. This study assesses quantitative changes in physical habitat variables at progressive distances downstream from a hydropeaking dam, with particular attention given to the role of tributaries. A 40-km stretch of the Kananaskis River, Alberta, Canada, below a hydropeaking facility was used as the study site. The physical habitat properties examined were depth, velocity, total suspended solids, substrate size, and channel bed mobility. Depth loggers were installed, and the channel bed was surveyed at six sites downstream of the dam. An Acoustic Doppler Current Profiler was used to assess velocities at high and low flow releases. Velocities over larger river sections were calculated using RIVER2D (a 2D hydraulic modeling program). Preliminary results indicate that some, but not all, physical habitat traits are mediated by distance downstream of the dam and incoming tributaries. This research will aid in understanding how, and to what extent, hydropeaking dams alter instream physical habitat characteristics.

Oral CCFFR (Impacts of multiple stressors)

MORPHOLOGICAL RESPONSES TO VARYING WATER VELOCITIES IN NATIVE AND NON-NATIVE FISH

Yavno*, S. [1], and M.G. Fox[2].
[1]*Environmental & Life Sciences Graduate Program, Trent University, Peterborough, ON.*
[2]*Environmental and Resource Studies Program and Department of Biology, Trent University, Peterborough, ON* (stanyavno@trentu.ca)

The introduction and establishment of non–indigenous species is oftentimes facilitated when individuals exhibit a high degree of morphological plasticity. The pumpkinseed (*Lepomis gibbosus*), a North American centrarchid that was introduced to Europe over a century ago, is found in over 28 countries and is a particularly prolific invader in the Iberian Peninsula. We hypothesized that morphological traits, functionally significant for swimming, will differ by habitat (river or lake) and population origin (native or non–native) of pumpkinseed. Using flow–through raceways, we reared juvenile pumpkinseed from four populations under two water velocities (still and 4 cm/s sustained flow) for 80 days. Individual lanes were modified to ensure that fish held under lotic conditions were exposed to a continuous water current, and all morphometric measurements were taken using digital photographs based on established protocols. While caudal peduncle dimensions differed significantly by population origin, only non–native populations developed longer caudal peduncles with increased water velocity. Lotic

conditions induced more posteriorly located median and paired fins in all populations. Non–native populations continued to exhibit longer dorsal fins regardless of water velocity. Therefore, these European populations appear to be better able to adapt their caudal peduncles in a way that increases thrust and decrease drag. This may facilitate their ability to propel through inland waterways, and helps to clarify the dispersal potential of the species in the Iberian Peninsula.

Oral CCFFR (Invasive aquatic species)

ENERGETIC EFFECTS FROM CONSUMPTION OF *HEMIMYSIS ANOMALA* ON NEAR SHORE FISH SPECIES IN LAKE ONTARIO

Yuille[*], M.J.[1], T.B. Johnson[2], and S. Arnott[1]
[1]*Biology Department Queen's University, 116 Barrie St., Kingston, ON, K7L 3N6, Canada.*
[2]*Ontario Ministry of Natural Resources, 41 Hatchery Lane, RR#4, Picton, ON, K0K 2T0, Canada* (email: michael.yuille@queensu.ca).

Hemimysis anomala, a littoral freshwater mysid native to the Ponto-Caspian region, is the newest invader to the Laurentian Great Lakes basin. Discovered in 2006, they have since been found in all of the Great Lakes (except Lake Superior) and have the potential to offset the dietary energy sink caused by invasive dreissenid mussels (*Dreissena bugensis* and *D. polymorpha*) in the littoral zone. Studies have shown multiple fish species consume *Hemimysis* within the Great Lakes and European literature indicates in some lakes where *Hemimysis* have invaded, diets of *P. fluviatilis* are comprised entirely of *Hemimysis*. Stable isotope (^{13}C and ^{15}N) analyses on alewife, round goby and small yellow perch in Lake Ontario support results from fish diets and suggest the consumption of *Hemimysis* increases with *Hemimysis* density. As *Hemimysis* populations continue to establish and stabilize, fish may incorporate this species into their diets at a higher capacity. Our study models the effect of *Hemimysis* consumption by three fish species: alewife (*Alosa pseudoharengus*), round goby (*Neogobius melanostomus*) and yellow perch (*Perca flavescens*). Using bioenergetics modeling, we test multiple predictive scenarios of *Hemimysis* consumption and incorporation into these fish diets to determine the energetic cost/benefit of consuming this new invader. Preliminary results suggest the consumption of *Hemimysis* will not affect growth rates of alewife, will increase growth rates of round goby and decrease growth rates of yellow perch. Due to their limited seasonal availability, diel migration and predator avoidance behaviours, consumption of *Hemimysis* will reduce current fish growth rates in Lake Ontario.

Oral CCFFR (Invasive aquatic species)

ATLANTIC COD ESCAPES: MOTIVATION AND DISPERSAL

Zimmermann*, E., C.F. Purchase, and I.A. Fleming.
Department of Biology, Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, Newfoundland, A1C 5S7, Canada (ezimmermann@mun.ca)

The emerging Atlantic cod farming industry faces the common aquaculture problem of escapes. Cod are particularly prone to escape from sea cages because they bite holes in nets. The depleted populations of wild cod in the northwest Atlantic may be especially vulnerable to negative interactions with farmed cod. To try to reduce the number of escapes, we investigated what motivates cod to bite at the net based on four parameters: individual temperament, nutrition, cage enrichment, and net damage. We hypothesized that suboptimal conditions such as hunger, boredom, and damage, would encourage net biting. Our results indicate that hunger and boredom motivate cod to bite at the net, suggesting that nutrition and cage enrichment could be used to reduce cod escapes. The second part of our study used acoustic telemetry to understand behaviour patterns following a simulated escape from a sea cage. Preliminary results suggest that farmed cod remain near the cage for up to two days longer than wild cod. Following departure from the cage area, farmed cod seem to disperse along the coast, similar to wild cod. The results suggest that escaped farmed cod could be recaptured near the cage within a day of the escape event; however following dispersal, farmed cod could potentially interact with wild cod. The results of our study can be applied to the emerging cod aquaculture industry to reduce the number of escapes, streamlining the development of the industry before mitigation becomes too difficult and costly to implement.

Oral CCFFR (General session)