CCFFR/SCL : Abstracts of Oral Presentations—alphabetical order

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ASSESSING GENETIC DIVERSITY OF SPAWNING RAINBOW TROUT IN TRIBUTARIES OF LAKE SUPERIOR ALONG THE ONTARIO SHORELINE.
Studies assessing the genetic structure of migratory Pacific salmonids within their native range have been vital to establishing effective management units. However, for Great Lakes populations, genetic assessment has been limited and population structure remains generally undetermined. Naturalized populations of migratory rainbow trout (*Oncorhynchus mykiss*) in tributaries between Thunder Bay and Marathon, Ontario, have had at least 85 years since initial colonization and limited influence from subsequent supplemental stocking, both of which have contributed to the opportunity for population divergence. Adults from nine tributaries will be used as a model system to study genetic diversity and to identify the most appropriate management units.

Rainbow trout were non-lethally sampled by angling during their spring spawning run. A 5mm circle of fin tissue was excised for genetic analysis and scales, length and sex taken to obtain life history information. Multilocus genotypes for 30-50 individuals from each tributary will be measured using 11 microsatellite loci. Results will be compared among fish from different tributaries to assess suitability of current management strategies.

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LONG-TERM TRENDS IN THE CHEMISTRY OF PRECIPITATION AND LAKE WATER IN SOUTH-CENTRAL ONTARIO, CANADA
North American agreements to reduce the emissions of acidifying pollutants have resulted in major changes in the deposition of sulphur across Ontario in the past 20 years. Long-term deposition and lake chemistry (~30 lakes) data for the period 1980–1999 were used to determine the response of surface waters in south-central Ontario to reductions in emissions. Trends in chemical parameters were estimated using the Mann-Kendall test. Results suggest a widespread reduction in sulphate concentration; however reduction in calcium concentrations appear to have partially offset the influence of sulphate reduction on lake acidity. Fluctuation in climatic factors over the monitoring period have led to significant inter-annual variability, emphasising the need for long-term monitoring if underlying trends are to be identified.

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MODELLING THE FUTURE WATER CHEMISTRY OF LAKES IN SOUTH-CENTRAL ONTARIO, CANADA
During the 1970s and 1980s, the acidification of surface waters by atmospherically deposited sulphur (S) became a major international concern. Major S emission control programs were implemented in North America, resulting in current emissions being ~30% less than in 1980. However, the level of acidic deposition remaining is still unlikely to promote widespread recovery of aquatic ecosystems. As such, there is an increased need to know whether future proposed reductions will be sufficient to promote ecosystem recovery, and when (chemical) recovery is likely to occur. To address these issues, dynamic soil chemical models, such as MAGIC (model of acidification of groundwater in catchments), are required. The predictive power of models is a crucial issue for determining their usefulness to support policymaking. MAGIC was used to predict recovery of lakes in south-central Ontario to proposed future emission reductions. Calibration of the lakes to the observed trends (1980–1999) considerably increased the robustness of the model predictions.

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STOCKING FISHLESS LAKES: INFLUENCE OF BROOK TROUT ON MESOZOOPLANKTON COMMUNITY STRUCTURE OF BOREAL SHIELD LAKES IN THE SAGUENAY REGION

Interactions between wild and stocked brook trout, *Salvelinus fontinalis*, as well as competing invertebrate predators like *Chaoborus* (Insecta: Diptera) have both positive and negative effects on the mesozooplankton structure of Boreal Shield lakes and the identification of such impacts is closely tied to analytical methods. In this study, three hypotheses were tested using univariate and multivariate analyses: (a) wild and stocked brook trout exert equally strong influences on Boreal Shield lacustrine mesozooplankton structure in eastern Canada (with significant differences expected between brook trout lakes (naturally present or stocked) and fishless lakes); (b) mesozooplankton species assemblages were expected to be different between individual lakes with fish and fishless lakes resulting from top-down control by fish and/or invertebrate predation; (c) species-specific body size was expected to decrease in the presence of fish. The study found that multivariate metrics are more sensitive than univariate metrics in identifying changes amongst mesozooplankton species assemblages related to fish stocking of fishless lakes. The strength of this response was somewhat unexpected since the diet of brook trout is thought to be primarily composed of zoobenthos in the absence of other fish species. Indeed, statistical analysis of the body size distribution of pelagic mesozooplankton revealed that inter-lake differences were most likely due to a combination of invertebrate and trout planktivory than correspondence with measured abiotic factors. *Chaoborus*, in particular, exerted a strong intermediary influence on the species composition and body size of mesozooplankton assemblages acting as both prey and predators in the system.

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THE COMMON CARP (*CYPRINUS CARPIO*) IN MANITOBA: IMPACTS AND EXPANSION OF AN EXOTIC BENTHIVOROUS FISH

The common carp is arguably the most successful exotic fish species worldwide and has been well established throughout North America for decades. Recent findings from Manitoba suggest that the common carp has now invaded the Churchill River system and is moving northward. Although there have been many studies which have examined the impacts of the common carp on aquatic ecosystems, only a few have been carried out at the whole ecosystem level. To determine the effects of the common carp on wetland ecosystems, 5 large (5 - 7 ha) experimental wetlands were stocked with increasing densities of carp (0, 150, 300, 600, and 1200 kg/ha) in 2001 and 2002. Additionally, as most studies examining the impacts of carp have used small mesocosm experiments, we conducted a parallel experiment in 2002 where carp were stocked in small (5m x 5m) wetland enclosures. Experiments conducted in the large experimental wetlands indicated that total suspended solids, rates of sedimentation, and concentrations of dissolved phosphorus increased in a linear fashion with increasing carp biomass. Conversely dissolved oxygen concentrations decreased with increasing densities of carp. Additionally, results indicated that sedimentation rates, measured over short time intervals (5-7 days) were much better at predicting the level of carp activity compared to measuring the concentration of total suspended solids which has traditionally been used to estimate the impact of benthivorous fish. Similar changes in water quality were observed in experiments conducted in small enclosures, with the exception that impacts were much more pronounced.

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CORRELATION OF FISH COMMUNITIES AND MULTI-SCALE ENVIRONMENTAL DESCRIPTORS IN WADEABLE STREAMS OF THE YUKON RIVER BASIN

We sampled fish at thirty wadeable stream sites in the Yukon River basin in Yukon Territory, Canada during July, 2004, to establish reference conditions for fish in Yukon River basin stream communities We also measured water quality (eg. temperature, dissolved oxygen, conductivity, pH), stream flow, substrate characteristics and riparian vegetation at each site. In addition, catchment area, catchment land cover, and distance of each site to major water bodies and stream barriers were determined through Geographic Information System and satellite photography analysis. Fish community structure and its relationships with the multi-scale description of the stream environment were quantified with non-metric multidimensional scaling, principal component analysis, and correlation analysis.

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ABUNDANCE AND SEASONAL DYNAMICS OF TRANSPARENT EXOPOLYMERIC PARTICLES (TEP) ALONG A GRADIENT OF LAKE PRODUCTIVITY: POTENTIAL SOURCES AND IMPLICATIONS TO THE CARBON CYCLE.

It is now recognized that primary production in aquatic systems is not only limited to the production of algal biomass but also includes extracellular products such as carbon rich dissolved organic matter. These simple organic molecules derived from algal and bacterial exudates may polymerize and coagulate to form Transparent Exopolymeric Particles (TEP). TEP have been extensively studied in marine systems, and are thought to play a major role as vectors in the burial of carbon, significantly affecting the fate and balance of marine carbon. There have been many fewer studies of TEP in freshwaters, and their distribution, regulation and biogeochemical and ecological role in lakes are largely unknown.

To quantify the significance of TEP in freshwaters, we carried out a large-scale comparative study of lakes in southern Québec, from May to August 2004. The aim of this study was to determine the basic seasonal pattern of TEP distribution in lakes of different productivity, dissolved organic carbon (DOC) content, algal community composition and microbial abundance. Results show that TEP formation and abundance are strongly linked to the trophic status of lakes. TEP are more abundant in eutrophic systems but the relative importance of TEP as a function of chlorophyll *a* concentration and of the particle load, is higher in oligotrophic systems. Thus the role of TEP as a structuring factor within the water column may be relatively more important in oligotrophic conditions. Moreover TEP are more abundant in high DOC content lakes confirming that they are formed by coagulation of DOC and colloids. Simultaneous *in situ* measurements of phytoplanktonic pigments allowed us to assess the links between the algal community structure and the TEP formation. Diatoms appear to produce a large amount of TEP relative to other algal groups.

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NOCTURNAL DENSITY PATTERNS OF ATLANTIC SALMON PARR IN THE SAINTE-MARGUERITE RIVER, QUÉBEC, RELATIVE TO THE TIME OF NIGHT.

The abundance of Atlantic salmon *Salmo salar* L. has been declining over the past century. As the time spent in freshwater is considered a critical phase of their life cycle, understanding the influence of physical attributes on the freshwater production of *S. salar* is a vital part of conservation plans for this species. A great deal of research has been directed at identifying freshwater conditions used by fish and developing models that predict the effect of perturbations on fish habitat quality. These studies are based on *S. salar* parr observed during the day because, in the summer, they are typically considered to be diurnal. Recent studies indicate that a comprehensive perspective of parr habitat requirements entails observations performed at night because they become more nocturnal as they grow. Habitat models developed during the night may be complementary to models developed during the day. However, relative fish abundance obtained at night may depend on the time at which observations are performed. Assessment of parr abundance during a period of the night when signals are stable may warrant the robustness of nocturnal fish habitat models. We snorkelled the shore and middle of two 40 m long sites on the Sainte-Marguerite River, Quebec. Sampling was performed every two hours between 20:30 and 4:30 during one full and one new moon. The number of visible *S. salar* parr increased between 20:30 and 22:30, remained relatively stable until 2:30 and decreased at 4:30. Moon phase did not appear to influence the number of visible parr.

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EPILIMNETIC PHYTOPLANKTON COMMUNITY RESPONSES TO INVASION BY *BYTHOTREPHES LONGIMANUS*

Invasions by exotic species provide natural experiments with which insight into the functioning of food webs can be determined. In central Canada, the invasion of the exotic zooplankton species *Bythotrephes longimanus* is currently underway as it spreads from one inland lake to another after a longer history in the Great Lakes. We studied the cascading effects of this invasion on the pelagic food web, in particular, on the phytoplankton community. As part of a larger study on the impacts of *Bythotrephes*, we collected biweekly phytoplankton samples across the depth of the epilimnia in 14 lakes in the Muskoka-Haliburton region of Ontario in the summer of 2003 using a tube sampler.

Four lakes were free of the invasive species and ten have been invaded since at least the mid-90`s. The two groups of lakes did not show statistically significant differences in terms of landscape position or size nor in terms of TP or TN. Sampling for *Bythotrephes*, macrozooplankton, rotifer and phytoplankton were all done simultaneously. Here we report on the responses of the phytoplankton communities. In general, we find that for lakes with *Bythotrephes*, abundances of chrysophytes and diatoms are reduced, there are fewer species of cryptophytes and there is a trend towards a reduction in total phytoplankton abundance (density of cells and chlorophyll a). Across all lakes, where invader density increases, dinoflagellate abundances increase significantly. Species richness of phytoplankton is unaffected by invasion, but diversity (Shannon-Weiner) is significantly higher in lakes with *Bythotrephes*. Discriminant analyses show that overall, invaded lakes are characterized by phytoplankton assemblages where dinoflagellates and diatoms dominate, while uninvaded lakes are dominated by chrysophytes and cryptophytes. *Bythotrephes* direct influence on the macrozooplankton community through predation is the likely driver of these indirect changes in the phytoplankton. Predation by *Bythotrephes* on macrozooplankton enhances the growth of small heterotrophic groups like the colonial rotifer *Conochilus* (joint study by Hovius et al.), and as shown here, the dinoflagellates - likely from competitive release. Growth by these small herbivorous species may in turn increase predation pressure on small chrysophytes, leading to their decline in invaded lakes.

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EVIDENCE OF SELENIUM ANTAGONISM ON MERCURY ASSIMILATION IN SUDBURY LAKES FOODWEBS.
Historically the metal smelters in Sudbury, Ontario released as much as 2 tonnes of Se per day, creating some of the highest known lake water concentrations of Se in North America. Samples of water, zooplankton (250-1000 um), mayflies (Stenonema femoratum), amphipods (Hyallela azteca) and y-o-y yellow perch (Perca flavescens) were collected for Se and Hg analyses in 10 lakes at increasing distances (5-100 km) from the smelters. Total dissolved Se declined significantly with increasing distance from the smelters. There were strong inverse relationships between lake water Se and tissue concentrations of Hg in all groups of biota. It is not yet clear what mechanisms are responsible for the reduced Hg assimilation. Se inhibition of in-lake Hg methylation or altered Hg bioassimilation processes are two possibilities. With regard to this conference's theme session, high levels of Se would certainly confound the use of Hg as a tracer for bioenergetics studies.

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CONSERVATION GENETICS OF ATLANTIC AND LAKE WHITEFISH IN THE MARITIME PROVINCES
From 1878 to 1901, ~42,000,000 lake whitefish (*Coregonus clupeaformis*) fry of Lake Ontario origin were stocked in lakes across Nova Scotia, and during the same interval, ~38,000,000 fry were stocked in New Brunswick. This was done without regard for, and perhaps in ignorance of, the presence in both provinces of native lake whitefish populations, and in Nova Scotia, of Atlantic whitefish (*Coregonus huntsmani*). Atlantic whitefish are endemic to Nova Scotia, are currently restricted to three semi-natural lakes in a single watershed, and are highly endangered. Lake whitefish are presently widely distributed in both provinces, and exhibit extensive phenotypic variability. Whether the phenotypic diversity of lake whitefish in the Maritime provinces is the product solely of local divergence, or whether it derives in some part from the introduction of the non-native stock, is a matter of evolutionary interest and a practical concern for conservation. For Atlantic whitefish, genetic diversity and species integrity are major concerns in light of the extremely limited range of the species, habitat disturbances, and the widespread introduction of non-native coregonids. We investigated all of these issues in a survey of microsatellite DNA variation across populations of lake and Atlantic whitefish in New Brunswick and Nova Scotia. Our results support a native origin for all surveyed lake whitefish populations, indicate that introgression of lake and Atlantic whitefish has not occurred, and reveal very low levels of genetic variability in Atlantic whitefish. The implications of these results will be discussed.

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OVER-WINTER MORTALITY IN FRESHWATER RAINBOW SMELT: A NORTH-SOUTH COMPARISON

Rainbow smelt is an important forage fish for many predators such as the landlocked Atlantic salmon. Consequently, inter-annual variability of smelt populations is a key factor affecting the production of many important game fish. Inter-annual fluctuations may be driven by climatic factors at the northern distributional limits of freshwater rainbow smelt populations. Our objective was to evaluate the effect of the length of growing season on lipid accumulation and otolith growth of YOY rainbow smelt. Samples were collected in three lakes located between 45°02'N and 48°20'N in the province of Quebec with annual degree-days ranging from 990 and 1980. Lakes were sampled in late autumn 2002 and 2003 and in early spring 2003 and 2004. Thirty fish from each lake and from each sampling period were used for lipid extraction and a sub-sample of ten fish were selected for otolith microstructure examination. A growth index was measured using the otolith radius at age 75 d. Preliminary results suggested that smelt from northern lakes accumulate more lipids than fish in the south (mean of 2.09% vs. 0.75% of body weight in lipid respectively). Similar results have been found with the otolith radius at age 75 d (mean of 705 µm in the north vs. 546 µm in the south). Results indicated different patterns of selective over-winter mortality between the north and the south.

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DEVELOPING ENVIRONMENTAL INDICATORS OF STRESS AT GREAT LAKES COASTAL MARGINS

Simple measures of community composition such as species richness and abundance are seldom sensitive enough to assess subtle differences of environmental condition. Fish communities are often used to assess health of a water body, most commonly using multimetric analyses to generate Indices of Biotic Integrity (IBI). However, the general applicability of IBI scores across regions is limited by the need for a priori classification of ecological zones. Multivariate grouping of reference sites based on similarity of species composition allows novel combinations of taxa to be evaluated as potential indices of condition. We sampled fish at over 170 sites along the U.S. Great Lakes coastline using 24-hour fyke nets, set during the summers of 2002 and 2003. Indices of biotic integrity were developed for each of the 6 Great Lakes ecoregions (sensu Omernik 1987). Metrics were evaluated against environmental stress scores summarizing population density, land cover, atmospheric deposition, agricultural intensity, point source pollution, and shoreline modification. The scores were relativized, integrated values obtained for second order drainage basins. Metrics were also evaluated against stress scores based on the wetlands sampled and their adjacent land use. The results of these two approaches were compared to identify the scale at which indicator species respond. Ultimately we will compare the multimetric approach of developing indicators to multivariate indices based on groups of co-occurring taxa that exemplify specific suites of structural habitat features.

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THE ROLE OF PREDATORS IN STABILIZING WILD SALMONID POPULATIONS AGAINST INVASION BY DOMESTIC STRAINS.

We use a simple behavioural theory, combined with life-history knowledge of domestic and wild trout, to (a) predict the initial success of invasion of wild trout populations by domestic strains and, (b) test those predictions in replicated whole-lake experiments. As predicted, the domestic strain (selected for high growth rates) used food-rich, but risky, habitats to a greater extent and subsequently grew faster than the wild strain. The survival consequences for greater growth rates depended upon the predation environment; domestic trout experienced greater survival when risk was low, but lower survival when risk was high. This suggests that domestic fish with

high intrinsic growth rates are more likely to invade wild populations possessing few predators, such as in exploited/disturbed ecosystems. For instance, escapes of domestic Atlantic salmon from net-cage aquaculture will likely have negative effects where predator populations are disturbed by overexploitation This study demonstrates that it is possible to predict the invasiveness of an exotic fish introductions using behavioural theory. We also present premlimary data on relative growth and survival performance of age-0 wild and domestic trout in relation to risk of predation.

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THE INFLUENCE OF CULTURE HISTORY ON GENETIC VARIATION AND POPULATION STRUCTURE FOR TWO STRAINS OF CULTURED ARCTIC CHARR (*SALVELINUS ALPINUS*) IN EASTERN CANADA.
Management of genetic resources in captive populations of fishes has become a major concern both for restorative and domestication purposes. We investigated the relative influence of culture history on decreased gene flow, increased genetic drift and/or artificial selection in two strains of aquaculture Arctic charr. Using data from 6 microsatellite loci, we measured and contrasted levels of genetic variation, tested for evidence of bottlenecks, discerned differentiation patterns within and between strains, and determined population relationships within strains. No evidence was found to suggest that bottlenecks had occurred in the creation of subsequent broodstock populations although there were decreases in allelic diversity and rare allele frequencies noted within particular hatcheries. The only measure that showed significant decline in populations further removed from the wild was observed heterozygosity. This was substantiated with a large number of deviations from Hardy-Weinberg proportions caused by heterozygote deficits. However, global F_{ST} estimates showed that those populations further removed from the wild were similarly differentiated. Analyses of molecular variance (AMOVA) revealed that twice the variation was preserved among populations in one of the strains yet most of the variation was maintained within populations for each strain. Differences in the levels of differentiation were supported by phenograms generated using genetic distances as the topology for one strain was give higher bootstrap support. Taken collectively, our data suggest that drift and/or selection are acting to reduce genetic variation and promote structure in these closed hatchery systems. This research reinforces the need for genetic inventories as an initial step in broodstock management.

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THE RESPONSE OF NATIVE FISH TO FRESHWATER AQUACULTURE OPERATIONS
The farming of salmonids in freshwaters generally occurs in oligotrophic systems and therefore policy is aimed at controlling the added nutrients and by-products of feed assimilation (primarily P and N) to avoid eutrophication of water bodies. The lack of information on the role that native fish play in the binding and dispersion of phosphorus through consumption of waste feed and faeces presents a fundamental research gap that needs to be resolved if we are to successfully predict the impact of P inputs into aquatic ecosystems. We reared 10 tonnes of rainbow trout (*Oncorhynchus mykiss*) in a small boreal lake at the Experimental Lakes Area to quantify the overall impacts of freshwater aquaculture. Through a combination of manual tracking and automated telemetry, we examined the spatial and pelagic distribution of native lake trout (*Salvelinus namaychush*) prior to (2001-2002) and during (2003-2004) the experimental aquaculture operation, as well as compared to a reference lake. We monitored cyprinid distribution and growth during this same time period. In the fall of each year of intensive cage-culture, we released rainbow trout into the study lake and monitored their movements by telemetry to examine the mobility and dispersion of "escapees", as well as their potential for interaction with native fish species. Here we discuss our findings in relation to current understanding of the impacts of aquaculture in Canadian freshwaters.

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ENERGETICS AND LOCOMOTION IN FISHES
Bill Beamish began his career with the study of physiology of fishes, especially locomotion and energetics, under the supervision of Fred Fry at the University of Toronto. Bill's original papers from his doctoral research are still regularly cited and widely recognized as classics in the field. During his long career with Fisheries and Oceans, at the University of Guelph and now at Burapha University in Thailand, Bill continued to emphasize energetics as a

central theme in his teaching and research, using fishes as diverse as lampreys, sturgeon, tilapia, bass, trout and whitefish and tropical species in Thailand. Bill's research provided the intellectual and empirical basis for what continues to be a very active and productive area of research in both the laboratory and the field.

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RELATIVE CONTRIBUTIONS OF SPAWNING STOCKS OF LAKE STURGEON TO POPULATIONS IN LAKE MICHIGAN

Historically, lake sturgeon were abundant throughout the Great Lakes, but populations have declined in both abundance and distribution due to habitat loss, water quality degradation, barriers to migration, and overexploitation. The lack of knowledge regarding their abundance, population structure, reproductive status and genetic diversity hinders rehabilitation efforts. An important issue facing managers is identifying the size and stock characteristics of remnant populations, as well as movement and habitat use of different stocks in open waters of the Great Lakes during non-reproductive periods. Spawning populations of lake sturgeon still remain in four tributaries to Green Bay in northeastern Lake Michigan. Previous genetic analysis (microsatellite loci and mitochondrial DNA) revealed that populations are genetically distinct, likely due to a high degree of philopatry. This genetic structuring allows individuals sampled from open-water habitats to be assigned to both a lake basin and a breeding population of origin with a high degree of confidence. Using mixed stock analyses, we determined the most likely population of origin for individuals captured throughout Green Bay, as well as a fall harvest on the Menominee River. This information can be of great use to managers interested in furthering restoration and conservation efforts for lake sturgeon, as it can provide information on relative recruitment rates from all lake sturgeon stocks contributing to the Green Bay mixed population, and of potential stock-specific differences in risk of mortality.

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THE INFLUENCE OF LOCAL VARIABLES AND SPATIAL CONTEXT ON HABITAT QUALITY MODELS IN RIVERS

Habitat quality models in rivers are often developed using a description of the environmental conditions used and avoided by fish. Environmental conditions are generally quantified in an area of few m^2 around fish. Application of such microhabitat models to predict habitat quality for a complete river is subjected to two difficulties. First, collecting environmental data at a fine scale over entire rivers is laborious. Second, at the scale of the complete river, variables that refer to the spatial context of sampling sites could influence habitat quality. The purpose of our study was to assess the effect of local and contextual variables on fish habitat quality. Local variables employed were substrate composition, water depth and flow velocity. Variables of spatial context assigned to each sampling site were either longitudinal (the distance to the closest spawning site or the closest tributary) or lateral (shore characteristics, slope and area of watershed). During summer 2003, 32 segments of 200m in the Sainte-Marguerite River were sampled. Parr density, which was adopted as a measure of habitat quality, and environmental conditions were estimated at 10m intervals in each segment. We used a "K-means" partitioning method to classify each of the sampling sites in a habitat type. We then grouped all adjacent sites belonging to a same habitat type in a series of habitat patches. Average fish density and environmental variables were estimated for each habitat patch. These values were used to assess the effect of local and contextual (longitudinal and lateral) variables on fish density.

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COMPARING DAY AND NIGHT HABITAT QUALITY INDICES FOR JUVENILE ATLANTIC SALMON (*SALMO SALAR*)

Recently, models were developed to aid in conservation by predicting juvenile salmon (parr) habitat quality. One of the most powerful, the habitat probabilistic index (HPI), uses a description of the physical conditions (depth, flow velocity, substrate grain size) that are used and avoided by parrs. HPI have typically been developed using day data alone; this assumes that diurnal and nocturnal habitats are comparable. Here we test that assumption by developing

day and night HPI with data collected on the Sainte-Marguerite River in the Saguenay region of Québec during summer 2003. By comparing the two sets of HPI, we found that a day HPI retains its predictive value at night, and vice versa. As a result, it is possible to sample during only one of these two periods to study the summer habitat of parrs.

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THE USE OF STABLE ISOTOPES TO ELUCIDATE FEEDING RELATIONSHIPS IN KEY FISH SPECIES IN THE BAY OF QUINTE AND ONEIDA LAKE
Recently, introduced invertebrates have disrupted Great Lakes food webs and threatened fisheries. Among introductions to the Great Lakes are zebra mussels (*Dreissena polymorpha*), which are thought to disrupt fish communities through impacts at lower trophic levels that have consequences for higher trophic level fish communities. This research examines the impacts of zebra mussels on fish communities, in two representative lake ecosystems, the Bay of Quinte, Lake Ontario and Oneida Lake, New York on populations of walleye (*Stizostedion vitreum*) and yellow perch (*Perca flavescens*) using stable isotope analysis of scale samples. Historical samples were taken from archived scale collections for the years 1974 to 1999. Specifically, it was hypothesized that between the late 1970s and the present, key fish species in the study lakes shifted relative trophic positions in the lake food webs as a result of changes in the pattern of energy pathways and/or changes in nutrient cycling associated with zebra mussel introductions. Results of the scale analysis indicated coincident temporal trends in carbon and nitrogen isotope signatures for walleye between lakes and coincident trends between species for nitrogen isotopes. Temporal trends were furthermore significantly altered by the presence of zebra mussels. Changes in relative trophic position, as measured by nitrogen isotopes, tended to be less than associated changes in carbon. Taken together, changes indicate significant disruptive effects of mussels at higher trophic levels to the foodweb positioning of key fish species.

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THE ROLE OF DROUGHT-INDUCED RE-ACIDIFICATION AND ELEVATED METAL CONCENTRATIONS IN THE IMPAIRMENT OF BENTHIC MACROINVERTEBRATE COMMUNITIES IN DORSET-AREA STREAMS
The mechanisms by which acid stress impair benthic macroinvertebrate communities include changes in ion balance and respiration, behaviour, or timing of life history events that result from elevated hydrogen or metal concentrations. Previous research suggests acid and metal toxicity associated with drought-induced re-acidification may be delaying stream benthic macroinvertebrate recovery in Dorset-area streams. When reduced sulphur stored in wetlands is exposed to air during El Niño-related drought, it is oxidized and released during subsequent wet periods causing pH depressions and elevated metal concentrations in streams. Analyses of long-term stream-flow and water-quality data showed increases in metal concentrations were associated with decreases in pH that occurred after drought periods. Impairment of benthic macroinvertebrate communities was attributed to low pH (4.3-4.8) in some streams, and high metal concentrations (500 µg/L aluminum) in other streams. The rate of biological recovery from acidification is dependent on the interactive effects of stream catchment properties, acidification and climate change.

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THE AGGREGATION PATTERNS OF JUVENILE ATLANTIC SALMON (*SALMO SALAR*) IN THE CONFLUENCE OF CATAMARAN BROOK, NEW BRUNSWICK, DURING HIGH WATER TEMPERATURE
During the summer, rivers can reach temperatures (>23ºC) that are potentially lethal for cool-water fishes. In the Little Southwest Miramichi River (NB), Atlantic salmon parr have been observed to abandon territorial behaviour and aggregate at cool water sources (e.g. springs and confluence of cooler brooks). In the inflowing cooler water of Catamaran Brook, a temperature gradient of approximately 260m is created. Along the thermal gradient (longitudinal and transverse) of the confluence, 1+ and 2+ juvenile salmon aggregate into many small groups. While both 1+ and 2+ aggregate, each aggregation is composed predominantly of a certain age class. This study quantified the aggregation patterns of wild juvenile Atlantic salmon along a thermal gradient during high water

temperatures. We examined whether particular physical habitat characteristics attracted the salmon to these locations (water temperature, water depth, water velocity, substrate). To understand the aggregation patterns observed, a model was developed to unravel the possible mechanism leading to the formation of many, small aggregations rather than one large aggregation.

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THE EFFECT OF THE SPATIAL ARRANGEMENT OF HABITAT PATCHES ON THE DEVELOPMENT OF FISH HABITAT MODELS IN THE LITTORAL ZONE OF A CANADIAN SHIELD LAKE
We developed fish habitat models using three approaches: i) a sampling-site approach built on a pre-defined analytical unit equivalent to the sampling site (~ 200 m^2), ii) constant-multiple approach where the analytical units constitute groupings of the same multiple of the sampling sites, and iii) a habitat-patch approach in which the analytical units represent merged contiguous sampling sites with similar environmental characteristics. Our objectives were to test the effect of the three approaches on the predictive power of fish habitat models developed for the littoral zone of a lake and to test the effect of variables that refer to the spatial arrangement of sites on these models. Comparison of the three approaches showed that merging of sampling sites, either with the constant-multiple or the habitat-patch approaches resulted in a 15%-35% increase in the predictive power of the habitat models. The relative contribution of the variables related to the spatial arrangement of habitat increased with the analytical size. Ordination diagrams based on species abundance and environmental variables, distinguished two main species-habitat assemblages: cyprinids and benthic-oriented species. We conclude that the integration of variables describing the spatial arrangement of habitat within the littoral zone of the lake, likely enhances the understanding of fish-habitat relationships. Patches of habitat represented appropriate analytical units for modelling fish-habitat relationships in comparison to the other approaches. From a conservation perspective, our study supports the belief that adjacent areas to those highly productive should be considered in conservation actions. (GS)

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SPATIAL VARIABILITY OF STABLE ISOTOPES AND FOSSIL PIGMENTS IN SURFACE SEDIMENTS OF TWO ALASKAN SALMON LAKES: CONSTRAINTS ON QUANTITATIVE ESTIMATES OF PAST FISH POPULATIONS
Sockeye salmon (*Oncorhynchus nerka*) effectively transport marine-derived nutrients (MDN) from the ocean to coastal freshwater ecosystems where they die following spawning. Previous studies suggest that the energy and nutrients transported by migratory salmon can sustain historical levels of primary production in coastal rearing lakes and that high algal production may support production of fry the year following spawning. Further, changes in sedimentary $\delta^{15}N$ have been used in paleoecological analyses to quantify past salmon escapement. However, to date no study has examined the degree of spatial variability of these relationships across an entire lake basin. Because sub-populations of sockeye vary in local density within a lake, it is conceivable that levels of MDN and fossil pigments in lake sediments may vary substantially among different locations within the basin. To address this question, we examined spatial patterns of stable isotopes of N and C ($\delta^{15}N$, $\delta^{13}C$) and fossil pigment concentrations in the uppermost 10-cm of sediment from Lake Nerka (n=75) and Little Togiak Lake (n=20), southwest Alaska. Our results showed that $\delta^{15}N$ varied minimally across Lake Nerka (mean = 4.27, SEM = 0.08) and Little Togiak Lake (mean = 3.47, SEM = 0.17). Further, sedimentary $\delta^{15}N$ showed values that were statistically and negatively correlated to fossil pigment concentrations in both study lakes. As well, depth of deposition was positively correlated with $\delta^{15}N$ and negatively correlated with $\delta^{13}C$ concentrations at both sites, although relationships were not statistically significant. We did not find any evidence that short-term sequestration of marine-derived N (as $\delta^{15}N$) was correlated to levels of primary production (as fossil pigments) during the past 20 years, nor that there was substantial spatial variation in isotope signature arising from local spawning habitats.

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DOES TOP-PREDATOR REMOVAL LEAD TO AN ALTERNATIVE STATE IN BROOK TROUT SPORT FISHERIES?

Using archival scale samples, historical creel records, and modern comparative studies we tested if top-predator removal from a system with strong intraguild predation resulted in alternative states in the dominant sport fish population. The study system consisted of brook trout, lake trout, yellow perch, white sucker, and cyprinid species. Brook trout and yellow perch exhibited an intraguild predation interaction with brook trout as the intraguild predator. Lake trout were a second predator on yellow perch. Results of a modern comparative study indicated that in the presence of lake trout, brook trout showed no ontogenetic shift in resource use and fed primarily on littoral derived resources. In the absence of lake trout, brook trout exhibited a significant ontogenetic shift from littoral to pelagic derived resource use. Historical records indicated that lake trout had been extirpated from one of the study lakes in the 1980s. Creel records indicated that following the extirpation of the top-predator, lake trout, maximum CPUE of brook trout declined significantly suggesting the fishery had shifted into a low-density brook trout state. We tested for the occurrence of alternative food web states in this altered system by reconstructing ontogenetic diet shifts of individual brook trout from the isotopic signature of scale samples collected before and after lake trout extirpation. The cultivation/depensation hypothesis suggests that alternative states may occur in fisheries characterized by strong intraguild predation. Our results will add to this discussion by testing a possible example of cultivation/depensation.

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THE EFFECTIVENESS OF PROTECTED AREAS IN ONTARIO AT PRESERVING AND MAINTAINING FISH SPECIES BIODIVERSITY

Ontario has the greatest diversity of freshwater fishes and inland aquatic habitats in Canada. Despite this, Ontario has no assessment framework for conserving aquatic biodiversity, and protection is generally focused on identified "at risk" species rather than communities or regional biota. For this project, fish species biodiversity inside and outside of protected areas will be compared throughout Ontario. It is important to know how much diversity is contained within the protected areas, and if these protected fish populations and species are representative of Ontario's fauna as a whole. This will help to generate informed conservation decisions in the future. Utilizing GAP analysis and comparisons of species presence inside and outside of protected areas it will be determined if the current protected area system is effective in providing representative coverage of aquatic biodiversity. Through correlation analysis between the category of protected area and amount of biodiversity, in relation to local and regional species pools, it will be ascertained which, if any category is most effective at protecting fish species. With this information it should also be possible to establish if the current protected areas will be able to safeguard species in the future. An assessment of this nature is pro-active and will lead to strategies that include protective measures as well as preventative ones. This study has significant potential to provide predictive insights into the ecological trajectories of aquatic species and habitats in Ontario, and provide direction to help ensure their sustainable future.

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ASSESSING FORAGE FISH AVAILABILITY FROM THE DIETS OF PUFFIN CHICKS AT AN INSHORE AND OFFSHORE COLONY OFF THE NORTHEAST COAST OF NEWFOUNDLAND.

During the 1990s in the Northwest Atlantic, capelin (*Mallotus villosus*) underwent major changes in their distribution and biology. These changes have been reflected in the diets of piscivorous seabirds. Previously, it was considered that Atlantic Puffins (*Fratercula arctica*) in the Northwest Atlantic required mature capelin to successfully rear chicks. Studies in the 1990s, however, revealed high variability in the diets fed to chicks. Puffins are capable of diving to ~40 m, therefore we hypothesized that when mature capelin is unavailable, parental puffins will supplement chick diets with immature sandlance (*Ammodytes* spp.) and other larval fishes. To test this hypothesis, parental prey deliveries were monitored at an inshore and offshore colony with similar populations in conjunction with a hydroacoustic and trawl survey within the puffins' foraging ranges during July-August 2004. Prey deliveries inshore consisted primarily of 1-3 pre- and post-spawning capelin or high numbers of small larval fishes. In contrast, ~90 % of the prey deliveries offshore consisted of loads of ~10 immature sandlance. Puffins

inshore apparently foraged on pre- and post-spawning capelin concentrated in < 30 m water and switched to larval fishes when mature capelin were unavailable. Hydroacoustic and trawl survey data showed concentrations of capelin at depths from < 50 m (dark) to > 200 m (daylight) that were unavailable to puffins breeding offshore. Trawling also revealed concentrations of sandlance within 6-10 km of the offshore colony. The integration of colony- and vessel-based studies of marine birds with other aspects of biological and physical oceanography will help improve understanding of meso-scale ecosystem processes. (GS)

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TRANSFER OF MERCURY AND OTHER METALS IN EASTERN LAKE ERIE: HOW DOES THE ROUND GOBY FIT IN?
The round goby *Neogobius melanostomus*, along with *Dreissena* spp, has altered the food web dynamics of the lower Great Lakes, particularly by competing for benthic resources with native fish species. It is hypothesized that in this changing food web, the round goby may now serve as a conduit for contaminants and nutrients from benthos to the upper trophic fish such as smallmouth bass *Micropterus dolomieui* in the eastern basin of Lake Erie. In the summer of 2002 and 2003, we collected fish (including smallmouth bass, rock bass, white bass, yellow perch, alewife, gizzard shad) and benthic invertebrates from the Port Dover area in eastern Lake Erie. Mercury and metal burdens were measured with ICP-MS techniques, and there are clear indications of biomagnification of mercury and rubidium through the food web. The trophic relationships of these fish and benthic invertebrates were assessed using $\delta^{13}C$ and $\delta^{15}N$, and a mass balance model for sport fish diet was estimated based on stable isotope data. The model indicates that round goby is an important prey item for smallmouth bass and other fish. The importance of round goby in connecting benthic production and trophic transfer of mercury and other metals to important fish species is discussed

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PREDICTION OF PERIPHYTON IN RIVERS: THE MORE WE LOOK, THE LESS WE KNOW?
A meta-analysis of 67 published models from the last 30 years that predict periphyton chlorophyll *a* in rivers was used to evaluate predictive power as a function of year of the study, geographic extent of the study area, and the type of predictor variables used. Model r^2 and residual mean square (RMS) values did not change over time, indicating no net improvement in our ability to predict periphyton chlorophyll *a* in rivers. Regression statistics (r^2 and RMS) did not differ among models that included physical, chemical, or both predictor variables or with type of physical (hydrology, drainage basin, light) or nutrient (total versus dissolved) variable. Models that included nitrogen had slightly higher r^2 values than models that included only phosphorus. The theoretical limit of model precision, determined from estimates of pure error due to instantaneous, spatial heterogeneity and also due to temporal variability, appears to have been reached for models predicting temporally averaged chlorophyll a concentrations. The implication for temporal mean models is that higher predictive power is not likely to be achieved until more effort is expended obtaining precise estimates of temporal means. In contrast, RMS values of models predicting instantaneous mean chlorophyll a were, on average, 4.5 times higher than theoretical pure error. We suggest that models predicting instantaneous chlorophyll *a* could be made more precise by including variables that better reflect the recent site history, such as the time since last flood or accumulated irradiance prior to the sampling date.

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OTOLITH GROWTH OF FISHES IN RELATION TO THERMAL REQUIREMENTS, ENVIRONMENT, AND CLIMATE

To understand the importance of parental growth on recruitment, otoliths of warm-water (summer-spawning), cool-water (spring), and cold-water (fall) species were examined from temperate waters of the Great Lakes Basin. Quantitative and qualitative growth history was examined in relation to thermal requirements, environment, and climate. Cross-sectional area described otolith growth more precisely than single radial measurements. Growth history of 2000 to 2003 spawning stocks was examined in relation to temperature and changes in prey abundance for species typical of the three thermal guilds. Otolith growth of walleye, a cool-water fish best adapted to this temperate thermal environment (midsummer 23.3 C), was highly significantly positively correlated with summer temperatures ($P = 0.002$, $r^2 = 0.43$), which followed global climate and alewife prey abundance ($P = 0.018$, $r^2 = 0.27$). Growth was significantly less in cold Pinatubo and La Niña years (1992 and 2000) and greater in El Niño years (1998, 1987, and 1991). The opposite was true for lake whitefish, a cold-water fish. Otolith growth was negatively correlated with summer temperatures ($P = 0.038$, $r^2 = 0.24$) and positively with body condition ($P = 0.034$, $r^2 = 0.25$). Growth was significantly greater in Pinatubo and La Niña years and lower in El Niño years (1991, 1995, and 1998). For both species, otolith growth was negatively correlated with recruitment from the preceding spawning (walleye: $P = 0.003$, $r^2 = 0.39$, whitefish: $P = 0.035$, $r^2 = 0.25$). Otolith area more precisely describes growth and physiological and environmental conditions and climate extreme and change.

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EARLY DEVELOPMENT OF ANADROMOUS AND FRESHWATER-RESIDENT BROOK TROUT (SALVELINUS FONTINALIS): SPAWNING, INCUBATION AND EMERGENCE PARAMETERS
Anadromous and freshwater-resident morpho-types of brook trout (Salvelinus fontinalis) exist in sympatry in several watersheds throughout Canada. It is not well understood why some individuals within a population have adopted an anadromous life-history strategy and why others remain in freshwater their entire lives. Our research compares early developmental characteristics of the offspring of both forms in an attempt to better understand why some go to saltwater and others remain in freshwater. Traps were placed on the redds of anadromous and freshwater-resident trout in fall 2003. Recently-hatched trout were collected from the traps the following spring. Parameters we are comparing for anadromous and freshwater-resident offspring include fertilization date, emergence date, incubation period, incubation temperature and size-at-emergence. Preliminary results suggest the anadromous offspring are approximately 20% longer than the freshwater-resident offspring when they emerge from the gravel in the spring. We will present the remainder of our results and we will discuss the evolutionary significance of our findings and implications for responsible management of this species.

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HABITAT, FOOD AND SOUTHWESTERN ONTARIO POPULATIONS OF GREENSIDE DARTER (*ETHEOSTOMA BLENNIOIDES* RAFINESQUE)
Habitat and food preference of southwestern Ontario greenside darter (*Etheostoma blennioides* Rafinesque) populations were studied. Johny darter (0.82, 0.63, and 0.74 – Eramosa, Nith and Connestogo rivers) and sculpins (0.72, 0.70 – Speed and Eramosa rivers respectively) showed notable habitat overlap with greenside darter. Despite the overlap, distinctive habitat preferences of johny darter (slower but deeper water) and sculpin (fast and shallow) suggest the adaptability of greenside darter to different depths, substrate sizes and velocity. Notable dietary overlap was observed with fantail darter – *E. flabellarei* and johny darter – *E. nigrum*. Prey items found in rainbow darter – *E. caeruleum* showed no significant dietary overlap for the Speed, Nith and the Thames-Sydenham populations except for the Eramosa River populations. Among the other groups of species, higher dietary overlap was seen with sculpins – cottidae (Speed and Nith), suckers – catostomidae (Speed River; Eramosa River; Nith River, and Thames-Sydenham Rivers), and catfish – ictaluridae (Nith River). Diptera was found negatively correlated to other prey items in the stomach contents e.g. coleoptera ($r = -0.596$, $p<0.01$), ephemeroptera ($r = -0.304$, $p<0.05$), and trichoptera ($r = -0.407$, $p<0.01$). This indicates a strong preference of greenside darter to diptera (specifically chironomidae) over the other prey items when available. Also, worth noting that the only other prey item preferred by greenside darter when diptera was in abundance was crustacea ($r = 0.463$, $p<0.01$). Our analysis of prey populations at different locations also suggests a strong relationship of the density greenside darter population size to the density of diptera and crustacea populations.

(GS)

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BILL BEAMISH – SCIENCE AND SEA LAMPREYS – APPLYING KNOWLEDGE TO PROTECT GREAT LAKES FISHES
Bill Beamish provided decades of leadership to our efforts to suppress sea lampreys in the Great Lakes. His leadership most often came in the form of a question. A question posed to a graduate students toiling in the laboratory. A question asked of researchers preparing to explore the unstudied. A question asked of biologists preparing to treat a stream with lampricides, construct a trap, or build a barrier. A question asked of the bureaucrats hiding behind colourful slides. A question asked to challenge politicians to make good on their commitment to the Great Lakes. Bill was involved in most of the successes of sea lamprey control. Bill participated as an active researcher, as a consultant to the control agents, as member of innumerable boards and panels, and as commissioner and chair of the Great Lakes Fishery Commission. He was involved in research into the damage caused by sea lampreys on fishes, population dynamics and estimation of age of sea lampreys, the environmental safety of lampricides, and the biology of native lampreys in the Great Lakes. Bill participated in and led the development of alternative controls, quantitative assessment, and ecological modeling in sea lamprey control. Bill asked his questions of everyone involved in the program; from details of sampling gears with the technician in the field to strategies for international resource management with fellow commissioners. Bill asked the questions that led to good science and ultimately to good management. In this talk, we will attempt to finally answer some of his most pressing questions.

Christie, G.C.* and C.I. Goddard.
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IMPLEMENTING A SEA LAMPREY CONTROL PROGRAM IN THE GREAT LAKES
The invasive sea lamprey (*Petromyzon marinus*) is successfully controlled in the Great Lakes and the control program has contributed to the successful restoration of native fishes and achievement of management objectives for the fish community. Lessons learned from the successes and challenges faced during the 50-year history of this integrated control program may be applicable to other large-scale species efforts to manage invasive species.

Successful suppression of sea lampreys requires an ongoing control effort that integrates a variety of techniques. Removal of larvae with selective lampricides on a 3-5 year cycle remains the main method of suppression. Selection of streams for these treatments has evolved from qualitative evaluations to quantitative comparisons of cost effectiveness. Alternative control efforts include: construction of barriers to block the spawning migration enhanced trapping to remove animals from spawning runs, and the release sterilized males to reduce spawning success. New research suggests that pheromones can be used to modify sea lamprey and affect control. Application of these alternatives requires measurement of their effectiveness and their efficiency.

Sustaining sea lamprey control requires options that maximize suppression, while minimizing economic and environmental costs. Quantitative information and predictive models are needed to evaluate these trade offs. Long-term success depends on research to improve the effectiveness of existing techniques and to find new control techniques.

Sea lamprey control is an example of successful management of an invasive species that has met the requirements of a complex ecosystem and complex institutional arrangements.

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POTENTIAL DISTRIBUTION CHANGES IN LAKE TROUT, WALLEYE AND SMALLMOUTH BASS WITH CLIMATE CHANGE.
Climate change will ultimately affect the supply and quality of freshwater lakes and rivers throughout the world. This study examines the potential impacts of climate change on lake trout, walleye and smallmouth bass distributions in Canada. Climate normals data (means from 1961-1990) from Environment Canada were used to map the current climate found throughout the tertiary watersheds of Canada. Logistic regressions based on these climate data were used to develop predictive presence-absence equations at the tertiary watershed level. The

Canadian Centre for Climate Modelling and Analysis Global Coupled Model 2(IS92a) provided forecasts of Canada's climate in 2020 and 2050. The data from these scenarios and the logistic regressions provided a ready framework for predicting the likely distributions of the fishes. The potential distributions were then filtered using geographic boundaries, watershed boundaries and lake size to produce more accurate predictions of distribution changes with climate change. Changes in the overlap between lake trout, walleye and smallmouth distributions were also examined. Generally, coldwater species may be extirpated from much of their present range while cool- and warm-water species expand northward. These results suggest that different management strategies are required for these species and present management strategies should incorporate the future impacts of climate change.

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LAKE ERIE TROPHIC STATUS COLLABORATIVE STUDY: INVESTIGATING MECHANISMS AND EXTENT OF INTERNAL PHOSPHORUS LOADING
Monitoring of Lake Erie has revealed recent increases in nutrient and chlorophyll concentrations and an increase in the frequency, duration, and extent of central basin hypolimnial oxygen depletion and summer hypoxia. Yet, loadings of total phosphorus have apparently not risen. Such patterns seem inconsistent with predictions and dynamics of models of internal lake function developed to guide management of Lake Erie=s nutrient budget. Similar situations may have naturally occurred at times prior to those for which we have monitoring data. Alternatively, this may reflect the consequences of novel environmental and biological pressures on the ecosystem. Possible explanations of observations that involve key trophic compartments/ pathways are: **A**) reduced size and/or increased persistence of central basin hypolimnion, possibly accompanied by increased BOD or changed autotrophic:heterotrophic carbon fixation ratio; **B**) reduced benthic/planktonic primary production caused by grazing pressure, limited nutrients, trace metal limitation and/or, UV/contaminant-induced photosynthesis inhibition; **C**) increased net rates of hypolimnetic organic carbon accumulation. We report on research undertaken by 23 scientists to evaluate the relative likelihood of explanations **A-C** by characterizing the distribution and flux of biomass and materials (phosphorus, carbon, oxygen) to clarify the mechanisms and extent of internal phosphorus loadings especially as it may relate to oxygen depletion in central Lake Erie. Although nutrient dynamics appear to be changing, possibly reflecting altered food web structure, central basin oxygen depletion patterns can largely be explained by environmental factors regulating the timing of hypolimnion formation, its thickness, and persistence.

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REDHORSE SUCKERS IN THE GRAND RIVER, ONTARIO: HOW DO SIX ECOLOGICALLY SIMILAR SPECIES COEXIST?
The Grand River is home to six species of redhorse suckers (*Moxostoma* spp.), large bodied, benthic insectivores. The need to learn more about these fishes is pressing as two of the species, the black redhorse (*M. duquesnei*) and river redhorse (*M. carinatum*) are listed by COSEWIC as Threatened and Special Concern, respectively. We hypothesize that these ecologically similar fish partition resources to facilitate coexistence. We carried out a radiotelemetry study on 15 black, 15 silver (*M. anisurum*) and 15 greater redhorse (*M. valenciennesi*) in the Grand River between Paris and Brantford Ontario to quantify habitat preferences for these species. We found significant differences in home ranges and preferred habitat (depth, flow) between species. In addition, we analyzed digital images of all six species using both traditional morphometrics and thin plate spline analysis (geomorphometrics) to describe morphological variations between the species. The six species exhibited significant shape differences likely related to preferred position within the river. This study has contributed to our knowledge of habitat utilization in redhorse suckers and furthered our understanding of these often overlooked fishes.

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ENVIRONMENTAL AND ECONOMIC COSTS OF INVASIVE ALIEN SPECIES IN CANADA
In October 2000, the Minister of the Environment created a national multi-stakeholder Task Force to provide advice to him on the design and implementation of a Canadian Information System for the Environment (CISE).

To assist the CISE secretariat in making decisions around the structure of a proposed Biodiversity Network, the Secretariat required an economic analysis of the costs of invasives in Canada.

There are only two aggregate cost estimates of the impact of invasive alien species at the national level anywhere, both for the United States (OTA, 1993 and Pimentel et al., 2000). These reports were essential for generating support for the coordinated policy approach adopted by the U.S. National Invasive Species Council Management Plan. While our understanding of the environmental and economic impact of invasive alien species on Canada's environment is increasing, no national overview exists.

RNT Consulting was asked to gather available information on the costs of invasive alien species in Canada, summarize information retrieved and note the existing gaps. In addition, we developed a three step path forward to improve our knowledge of the economic and environmental costs of alien invasive species in Canada. This presentation presents our findings.

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INVASION GENETICS OF THE EURASIAN SPINY WATERFLEA: EVIDENCE FOR BOTTLENECKS AND GENE FLOW USING MICROSATELLITE DATA
The study of the genetic structure of nonindigenous populations (i.e., invasion genetics) can help to improve our understanding of invasion sources and vectors of gene flow, as well as the relationship between genetic diversity and invasion success. We isolated five microsatellite DNA loci for the spiny waterflea (*Bythotrephes longimanus*) to identify: (i) the severity of bottlenecks (i.e., founder effects) in introduced (North American) populations; (ii) the Eurasian source region of the North American invasion; (iii) patterns of gene flow between and among North American and Eurasian populations; and (iv) evidence for gene flow from other European sources. Average heterozygosity of native (European) populations ranged from 0.310 to 0.599, and was higher than that of introduced (North American) populations (0.151 to 0.220), consistent with a founder effect. However, low mean M ratios (ranging from 0.108 to 0.412), and abnormal allele frequency histograms support recurrent bottlenecks for both native and introduced populations. Pairwise F_{ST} estimates among introduced (0.002 to 0.063) populations were much lower than among native populations (0.208 to 0.474). Pairwise standard genetic distances (D_s) showed the same pattern, suggesting high gene flow among introduced populations relative to that of native ones. Genetic distance measurements and neighbour-joining analysis support an invasion source genetically similar to samples from Finland and the Netherlands. Assignment tests identified several recent genetic migrants from a population near Italy. Together, our results support a substantial bottleneck for North American populations, followed by subsequent introductions from other European populations and high gene flow among North American populations.

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CONTINENTAL-SCALE VARIATION IN AGE AND SIZE AT MATURITY OF LAKE WHITEFISH (*COREGONUS CLUPEAFORMIS*): PHENOTYPIC OR GENETIC?
On a continental scale, Lake whitefish populations are known to differ genetically and to exhibit substantial life history variation. Recently a portion of the life history variation has been explained by forming two groups of populations dubbed “Great Lakes” and “Inland Lakes” stocks by Beauchamp et al (2004. JGLR 30(3):451-460). These two groups exhibit different patterns of covariation between average age and average length at maturity, and the implication is that they have evolved differently. However, substantial variation in the maturity-size relationship is also associated with differences in latitude, and Great Lakes populations in the dataset are from lower latitudes than most of the Inland Lakes populations. Is the classification of whitefish into Great Lakes and Inland stocks just a proxy for a plastic response to environmental differences associated with latitude? This paper will evaluate the maturity-size relationships in lake whitefish using probabilistic reaction norms, which should remove the confounding effects of developmental responses to environmental influences, and allow us to see whether the differences have a significant genetic component.

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LIVE FISH POST HARVEST TECHNOLOGY: AN ENTRY POINT FOR COASTAL RESOURCES MANAGEMENT

Keeping live fishes in natural marine or freshwater areas and transporting alive in non-aquatic conditions or without water present a paradigm shift for the live food fish trade. In March 2004, the pioneering technology was successfully presented and defended by Boni Comandante among a panel of scientists from Silliman University, Dumaguete City, Philippines. Conditioning techniques and temperature manipulations were done on BROWN GROUPERS *Epinephelus tauvina* Forsskål to arrive at optimum parameters that would allow live fish transport without water. Individual fish experiments for aquatic and non-aquatic conditions were done at room temperatures while loading density experiments were performed at 25°C to simulate plane transport. Low temperature and zero pressure may have prevented the collapse of fish gills enabling direct assimilation of oxygen due to a temperature gradient between fish gills and its external environment. Kruskal-Wallis test for experiments indicated significant differences in survival between low (2-3 kg) and high (4-6 kg) loading densities. Low loading density experiments exhibited 100% survival while high loading density experiments showed 58.3% survival for nine hours. It is covered by Philippine Patent Application No. 1-2003-000494 dated October 2003 (International Application is being done through the Patent Cooperation Treaty, Geneva, Switzerland). Transport of live fish without water can serve as an entry point for environmental resources management. Marketing of live fishes will serve as a tool for conservation efforts and sustainable harvesting. As a prerequisite for the new marketing method, environmental protection and proper harvesting will form part of the Information, Communication and Education plan.

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COUPLING NON-INVASIVE PHYSIOLOGICAL AND ENERGETIC ASSESSMENTS WITH TELEMETRY: AN ASSESSMENT OF A NOVEL APPROACH FOR EXAMINING MIGRATION MECHANISMS IN SOCKEYE SALMON
We conducted several large-scale field experiments to assess the effects of non-lethally sampling un-anesthetized adult migrating salmon for physiological and energetic variables. We focused on Fraser River sockeye salmon (*Oncorhynchus nerka*) during their coastal and river spawning migration. About 150 fish were gastrically implanted with radio transmitters in the ocean 200 km from the mouth of the Fraser River. Subsets were biopsied which included drawing blood from the caudal peduncle, removal of gill tissue, and quantification of energetic status using a microwave fat meter. We tested the hypothesis that the biopsy had a negligible effect on the subsequent survival and migratory behaviour of telemetered fish. In a series of independent assessments, we determined that our handling and biopsy methods produced similar levels of mortality and/or tag retention as the telemetry treatment alone and that any changes in behaviour between the two treatment groups did not adversely affect migration time. We then used data collected in this study to evaluate the physiological and energetic correlates of migration timing and migration success. Collectively, our results begin to provide a mechanistic understanding of the patterns in migration timing and mortality observed in some stocks of Fraser River sockeye salmon. Non-lethal physiological biopsying provides a robust approach for understanding inter-individual variation in behaviour and survival of migrating adult fish.

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LAKE-WIDE DISPERSAL OF A JUVENILE SALMONINE COHORT IS COMPATIBLE WITH DENSITY-INDEPENDENT DIFFUSION
A density and size-dependent ability to secure territorial space is viewed as a key mechanism driving dispersal in juvenile stream salmonines leading to population regulation. This study examined twelve dispersal distributions of a lake-dwelling brook charr (*Salvelinus fontinalis*) cohort collected from first emergence until over 75% of fish moved to small summer refugia habitats with groundwater discharge. Spread through time, statistical form of the movement distributions, and signs of intraspecific competition were more consistent with density-independent diffusion than density-dependent dispersal driven by competition. Spread was not gradual and decelerating. Instead, initial dispersal rates around the lake margin were rapid and accelerating, and subsequent rates of spread remained

constant over the two-month dispersal period. Variance of the movement distributions increased linearly with time and the diffusion coefficients of the distributions remained relatively stable. Distributions were never platykurtic with uniform and abrupt boundaries, but instead showed a transition from leptokurtosis to mesokurtosis, and the redistributing cohort showed no consistent directional bias. Contrary to predictions of density-dependent competition, emigration rates from the small lake were insignificant and constant, emigrants were not smaller than fish remaining at the site of emergence, and the frequency of aggressive encounters was not negatively correlated with distance from the point of origin or positively correlated with local fish density. Compatibility with density-independent diffusion suggests estimates of mobility obtained from field-observed movement distributions can be extrapolated to broader spatiotemporal scales. Simple mathematical dispersal models may thus be applicable and useful for predicting the redistribution of juvenile cohorts.

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EXAMINATION OF SIMPLE MATHEMATICAL DISPERSAL MODELS USING A JUVENILE SALMONINE COHORT SUPPORTS THEIR USE AS STANDARD PREDICTORS
Dispersal is a fundamental ecological process and has become critical to conservation efforts as human disturbances amplify the importance of movement for species persistence. As a result, there has been a recent surge of interest in quantifying dispersal rates and distances as well as predicting patterns of population-level redistribution. An important hindrance to our understanding of dispersal is that a general framework for quantifying observed movements has not yet been adopted. Much progress is being made to develop theory predicting the spatiotemporal distribution of dispersers. However, predictions of even the most basic dispersal models remain insufficiently tested in field situations. This study examined dispersal of a cohort of lake-dwelling brook charr (*Salvelinus fontinalis*) soon after emergence. Multi-model comparative analysis was conducted to assess the applicability and usefulness of diffusion and exponential frameworks to describe the frequency distribution of dispersal distances. Models were fit to 12 dispersal distributions collected over a two-month period, and a cross-validation approach was used to assess their generalisability. Both frameworks provided accurate and useful estimates of mobility and redistribution, but models considering intra-population heterogeneity in movement were not as robust to outliers in the dispersal distributions and performed relatively poorly in cross-validation. No single model appeared as most likely, but the simplest diffusion and exponential forms disregarding asymmetry and intra-population heterogeneity in movement performed well. These models accurately predicted lateral mean displacement of the YOY cohort and the proportion of long-distance dispersers over the entire dispersal period after calibration using only the first two dispersal distributions.

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POTENTIAL CONTROL OF ROUND GOBIES USING PHEROMONES
The success of the invasive fish, the round goby (*Neogobius melanostomus*), may be due in part to its pheromonal communication between males and females during reproduction. We hypothesize that reproductive males secrete pheromones into the water that attract females to the nests of males. Our histological and biochemical studies showed that specialized glandular tissue in the testes of the round goby produce androgen steroids, two of which (11-oxo-etiocholanolone (ETIO) and 11-oxo-ETIO-sulfate) are novel compounds in teleosts. The presence of pheromones in reproductive male conditioned water was implicated by electro-olfactogram (EOG) responses in which EOG levels exhibited by reproductive females (RF) were significantly higher than non-RF when exposed to reproductive male (RM) odours. Our behavioural experiments showed that RF exposed to odours of RM spent more time near the odour source ($P<0.05$), exhibited elevated swimming velocities ($P<0.05$), and directed movement to the odour source when compared with responses to control water. Non-reproductive females exhibited EOG responses to RF and spent significantly more time near the odor sources of RF compared with control water. Mature males move shoreward in spring and occupy nests. Odour plumes from colonial nesting males likely guide RF to them and the non-RF play “follow-the-leader”, tracking RF. We plan to use pheromone traps baited with blends of male steroids to capture round goby females at specific locations where native fish spawn. This technique would

decrease reproductive success of round gobies while enhancing recruitment of native species by decreasing goby predation on native embryos and fry.

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USE OF LONG-TERM DATA TO ASSESS EFFECTS OF ENVIRONMENTAL STRESSORS ON DIATOM COMMUNITIES IN ACID-SENSITIVE LAKES
Recent evidence has shown that chemical recovery of Precambrian Shield lakes in central Ontario has been delayed or reversed as a result of interaction between the products of acid deposition stored within lake catchments and recent climatic variability. Alterations between drought and non-drought years have been identified as causing re-acidification of lakes in regions with high atmospheric sulfate loading, due to mobilization of stored sulfur from adjacent wetlands. The key factor responsible for the delay in chemical recovery of some acidified lakes is the ability of catchments to release sulfur stored within wetlands following drought periods. Lakes with wetlands in their catchments and in regions of high sulfur deposition (e.g., central Ontario Precambrian Shield lakes) have been found to be most at risk. Changes in diatom assemblages in 20-year-long sediment cores from three lakes with similar basin characteristics but different wetland area (0% of catchment at Blue Chalk Lake, 4.4% at Chub Lake, 13.9% at Dickie Lake) were compared to evaluate the role of wetland-mediated interactions on algal communities. Variance partitioning analysis of approximately annually resolved sedimentary diatom communities (1977-1997) identified that unique effects of water chemistry, independent of climate and acid deposition, explained 25% of variability in diatom assemblage at Chub Lake and 15% at Dickie Lake and only 6.4% at Blue Chalk Lake. Climatic factors (22% Chub, 10.9% Dickie) and acid deposition (24% Chub, 14.7% Dickie) explained similar amounts of variation in diatom communities within each lake. Covariation among water chemistry, climatic factors and acid deposition, which are attributable to wetland-mediated drought-induced re-acidification, explained 1% of the variation in diatom assemblage in Blue Chalk Lake, 9.2% in Chub Lake and 15.0% in Dickie Lake. Thus, drought-related re-acidification effects on water chemistry appears to be an important mechanisms regulating algal community responses in acid-sensitive lakes with wetlands, but not in lakes without wetlands. Three additional lakes with varying degrees of percent wetland coverage in their catchments will also be presented as well as analysis of how catchment to lake area might influence these results.

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DISTRIBUTION AND DYNAMICS OF EXOPOLYMERIC SUBSTANCES (EPS) IN THE LITTORAL SEDIMENTS OF AN OLIGOTROPHIC LAKE.
Bacteria and algae release exopolymeric substances (EPS), which influence a number of important processes in shallow benthic systems (e.g. they can stabilize sediments, affect sediment-water exchanges of nutrients, provide food for invertebrates, sequester contaminants and facilitate their transfer to foodwebs). Many factors affect the chemical composition, and properties, of EPS such as which organisms produce them, their physiological state, nutrient conditions and light levels (for algae). In this study we compare the concentration and composition of EPS in natural sediments from different portions of the littoral zone of an oligotrophic lake. EPS carbohydrate and protein concentrations were measured along depth transects (0.5-8 m) at 3 sites in Lake Opeongo in May, July and September 2003. The concentrations of EPS carbohydrates were highest in May and decreased through the summer, with faster declines in the deeper portion of the littoral zone. In contrast, the concentration of EPS proteins increased with increasing depth, but did not change through the summer. Proteins were an important and comparatively stable component of the EPS in these sediments. We found clear trends in the distribution and dynamics of EPS that provide clues to their role in the shallow littoral zone of lakes.

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SEASONAL PATTERNS IN WATER QUALITY AND ABUNDANCE OF *BARBUS* FISHES IN THE MNEMBO RIVER, SOUTHERN AFRICA.
Endorheic Lake Chilwa is one of the most productive lakes in Africa, contributing up to 24% of total fish production in protein-starved Malawi. High population density and agricultural practices in the Chilwa catchment

have been linked to observed declines in the number and size of the commercially fished *Barbus* species. The Mnembo River is a major inflow into Lake Chilwa which has received little scientific study to date. In 2003/04, water quality and *Barbus* migration were monitored monthly at 3 sites over one year in the Mnembo to provide data for a lake management plan. Studies on smaller inflows into Lake Chilwa have implicated river flow, conductivity and total suspended solids (TSS) as influences on *Barbus* migration. *Barbus* catch in the Mnembo was highest in the dry/hot season (Aug. to Oct.) while fish spawning condition was highest in the wet/hot season (Nov. to Jan.). River flow ranged from 0 to 0.47 m/s and was highest in February, while conductivity ranged from 80 to 697 mS/cm and was highest in October. The site nearest the lake had the highest mean TSS (2.6 mg/l) and lowest mean oxygen content (3.4 mg/l). The influence of land use on water quality is currently under investigation.

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LINKING BACTERIAL RESPIRATION, CARBON CONSUMPTION AND DISSOLVED ORGANIC CARBON LABILITY IN LAKES, RIVERS AND ESTUARIES
The biological reactivity or lability of organic matter is a key aspect of the carbon cycling in all aquatic ecosystems. Lability is generally determined using bioassays that follow the changes in DOC concentration with time, typically days to weeks, in the absence of light and of any new sources of DOC or nutrients. This DOC consumption thus represents the minimum long-term level of microbial metabolism that can be supported by the ambient DOC pool. Here we compare DOC lability measurements from estuaries and salt marshes, rivers and lakes, determined with similar protocols, and we compare these data with the actual in situ bacterial carbon respiration. We show that in most freshwater systems surveyed, the long-term rates of DOC consumption are low and fall within a relatively narrow range, in spite of large variations in total DOC, chlorophyll, and nutrient concentrations among systems. In most freshwater ecosystems, the proportion of labile DOC is below 5%, and this labile pool generally represents a small fraction of the measured in situ rate of bacterial respiration, suggesting that these freshwater lability bioassays only capture a remnant pool of organic matter and not the pool that fuels most of the heterotrophic microbial metabolism. The proportion of labile DOC is on average much higher in estuarine and marsh ecosystems, and also represents a larger proportion of the total in situ microbial metabolism. These results point to fundamental differences in the patterns of DOC sources and cycling between brackish and estuarine systems on the one hand, and lakes and rivers on the other. Although the metabolism supported by the remnant DOC pool is small in most freshwaters, it can nevertheless play an important role in determining the baseline microbial respiration, particularly in the more unproductive aquatic systems. Our results suggest that there is a very weak coupling between this baseline metabolism represented by long-term DOC consumption, and the level of in situ bacterial metabolism, suggesting different modes of control of these two aspects of ecosystem metabolism. This baseline respiration may in turn determine the role of freshwaters as sources or sinks of CO_2.

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DOC RELEASED BY MACROPHYTES IN SOUTHESTERN QUEBEC LAKES.
Dissolved organic carbon (DOC) release by living submerged macrophytes has been shown in laboratory experiments for some freshwater and marine species. In *in situ* incubations of a marine community *(Fucus serratus)*, a net release of 0.26 $gC/m^2/h$, corresponding to 15% of the gross primary production, has been observed (Barron *et al.* 2003). However there are no *in situ* studies of this phenomenon for lacustrine macrophyte communities and it is not known what factors influence the DOC release in natural systems. Our preliminary study aims to estimate DOC release in eight eastern Quebec lakes of various trophic status and to establish its contribution to the global metabolism of the lakes. *In situ* incubations with benthic chambers show a net DOC production for several different submerged macrophyte communities. Measurements of total dissolved phosphorus, total dissolved nitrogen and nitrate indicate that these nutrients are not released by macrophytes. We present evidence of the coupling between DOC release rate and the photoperiod. In addition, our dissolved oxygen measurements suggest that the communities are heterotrophic. Therefore, the DOC released by living macrophytes in these lakes represents a significant source of carbon for heterotrophic organisms living not only in macrophyte beds, but also in the pelagic zone.

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DISTURBANCE HISTORY AS A SELECTIVE FORCE FOR EVOLUTION OF ACID TOLERANCE: IMPLICATIONS FOR COLONIZATION AND BIOLOGICAL RECOVERY IN HISTORICALLY-DAMAGED LAKES

As freshwater ecosystems are faced with unprecedented rates of stress from human activities, it is critical to evaluate processes by which damaged lakes can rebuild biological diversity. Despite having an essential role in biological recovery, the capacity of aquatic organisms for adaptation of environmental tolerances is poorly understood. This project utilized field transplant experiments with zooplankton to address whether acidification history of lakes has altered acid tolerances among populations of persisting taxa in an acid-impacted region (Killarney Provincial Park, ON). Zooplankton communities from locally-occurring (Killarney, ON) buffered (n=3) and acid-recovering (n=3) lakes, and from more regionally-distant (Dorset, ON) un-acidified lakes (n=3) were stocked in 72 separate 10-L cubitainers that were incubated in acid-recovering Carlyle Lake as a common garden experiment. The experiment was designed with a 3 (acidification history: buffered vs. acid-recovering vs. regionally-distant and un-acidified) x 3 (pH treatment: ambient, circumneutral pH (6.2 to 7.6) vs. pH 5.2 vs. pH 4.7) x 2 (water treatment: home lakewater vs. lakewater from acid-recovering Carlyle Lake) factorial design. We hypothesized that although all study lakes are now circumneutral (≥ pH 6.2), zooplankton communities from lakes that have had a history of acidification stress decades ago will demonstrate greater acid tolerance than lakes with minimal prior exposure in spite of high dispersal potential among locally distributed habitats. It is expected that zooplankton from the more regionally distant Dorset lakes will have the least resilience at the low pH treatments if broad acid tolerance has evolved in the heavily acid-impacted Killarney region. Further, in addition to differences in acid tolerances, local adaptations to home water and food conditions could play a role in limiting effective spatial dispersal among lakes. Variability in acid tolerance among zooplankton populations and species resulting from differences in lake stress history on local and regional scales has implications for effective migration among aquatic habitats across pH gradients, and for the re-establishment of taxonomic diversity in previously stressed environments.

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HIERARCHICAL ANALYSIS OF RELATIONSHIPS BETWEEN BROOK TROUT DENSITY AND STREAM HABITAT FEATURES

Ecological data often have clustered or nested structure, in which observations are made on units that are grouped at different hierarchical levels. Hierarchically-structured data allow one to pose interesting questions about units at different levels of aggregation as well as to examine cross-level interactions. However, in clustered samples, units within a group usually tend to be similar and thus individual observations are not entirely independent as required by conventional regression models. We used hierarchical linear regression, which explicitly accounts for intra-group correlations and allows for modelling of variation at lower levels as a function of higher-level effects, to examine relationships between brook trout density and habitat features nested at different hierarchical levels (sections nested within reaches nested within streams) in the Cascapedia River basin, Quebec. Trout density and environmental variables were quantified at 600 sections distributed among 120 sites and 31 streams, from June to August in 2000, 2001, and 2002. Variance decomposition showed that variance in trout densities was greater at the section (35%) and reach (60%) levels than at the stream level (5%). Trout density was related to several habitat variables defined at the section level (current velocity, woody debris, cover), but the presence of cross-level interactions in the model indicated that section-level variables had "contextual" effects that varied predictably across reaches as a function of reach-level characteristics such as entrenchment and sub-basin area. Examination of contextual effects by use of hierarchical models can enhance our understanding of how habitat features influence fish distributions at multiple spatial scales.

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LONG-TERM TRENDS IN EXPORT AND RETENTION OF DISSOLVED ORGANIC CARBON, PHOSPHORUS and IRON IN THE DORSET STUDY LAKES, 1978-1998.

Annual export of total phosphorus (TP), dissolved organic carbon (DOC), total Fe and dissolved organic nitrogen (DON) to seven lakes in central Ontario was measured between 1978 and 1998. Fluctuations in annual runoff and

DOC load over the 20 year period were similar in the seven study lakes indicating that DOC export responds proportionally to changes in runoff. There were similar but less accentuated variations in annual DOC lake concentrations. There were no clear regional trends evident during the 20 year period towards drier or wetter conditions, less DOC load, clearer lakes, etc. that could be interpreted as signaling a shift towards a different equilibrium state. TP and Fe export decreased more than DOC export during the extended dry period, perhaps due to the presence of more oxidizing conditions in the surface layer of peatlands and the sensitivity of Fe to redox levels. Hence, permanently drier conditions may lead to slightly clearer lakes that are less productive. Most of the decline in DON during the dry period was due to the decline in organic matter export with other factors of secondary importance.

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BILL BEAMISH'S CONTRIBUTIONS TO LAMPREY RESEARCH AND RECENT ADVANCES IN THE FIELD
Since his first lamprey papers in 1973, Bill Beamish has published more than 40 papers on numerous aspects of lamprey biology, studying several native lamprey species as well as the Great Lakes sea lamprey. Bill and his colleagues have contributed to our knowledge of the basic biology of larval lampreys (e.g., abundance, habitat, feeding, growth, and gonadogenesis), helped refine techniques to determine age in larvae (using statoliths, structures analogous to the teleost otolith), and studied the process of metamorphosis and the feeding and bioenergetics of juvenile (parasitic) lampreys. Current research continues to build on Bill's contributions, and makes many advances that were probably not even anticipated in 1973. This exciting current research includes: the use of high-resolution ultrasound to study gonadogenesis and evaluate sex ratio in live larval lampreys; the elucidation of some of the exogenous and endogenous triggers of metamorphosis; examination of the neuroendocrine control of reproduction and the role of unconventional sex steroids in male lampreys; the discovery of migratory and sex pheromones and their potential use in sea lamprey control; the use of molecular markers to study lamprey mating systems and phylogeny; and the renewed interest in the conservation of native lampreys.

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VULNERABILITY OF FRESHWATER COASTAL WETLAND FISH ASSEMBLAGES TO CLIMATE CHANGE AND AN ASSESSMENT OF CULTURAL ADAPTATION STRATEGIES
The objectives of this project were two-fold. One, to predict the biotic response of fish guilds to habitat changes that result from anticipated water levels and temperatures under climate change. Two, to assess the fish response in wetlands to adaptation strategies (such as water level regulation by dams and dyking) compared to unmanaged situations under climate change. Initially, we assessed probable changes in fish habitat availability and suitability, including changes in wetland vegetation, for nearshore fish assemblages under climate change scenarios. (Vegetation changes due to fluctuating water levels were predicted as part of a larger study, in conjunction with Environment Canada and the University of Waterloo, on the vulnerability of coastal wetlands.) Secondly, a fish habitat supply analysis in Lake Ontario for different thermal guilds, which prefer vegetation for spawning, was conducted. Proposed water regulation schemes at the Moses-Saunders dam in Cornwall, which regulates Lake Ontario levels, were assessed under climate change conditions (International Joint Commission's Lake Ontario-St. Lawrence Study). Also, in selected wetlands of the lower Great Lakes, a site-specific assessment of dyking effects on fish assemblages and fish habitat was undertaken. The sampled fish assemblages were divided into thermal guilds and a habitat supply analysis for different life stages was conducted based on a compilation of species-specific habitat requirements. The response of current and potential future fish assemblages in coastal wetlands was compared across the three scenarios (climate change, dyking, regulation) to determine which guild or life stage is most affected and which adaptation strategy might be most effective.

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NON-DESTRUCTIVE ESTIMATION OF POPULATION CHARACTERISTICS IN FISH SPECIES AT RISK

Estimating distributions, demographic characteristics, and habitat associations are necessary but difficult in species at risk (SAR) evaluations. Information on abundance, growth, fecundity and mortality is necessary to modelling population dynamics, while distributions and habitat associations linked to population rates are important for defining critical habitat. Gathering this information in the most non-destructive manner possible is essential to protecting SAR while conducting much-needed research. Two small species at risk (<15cm TL), the eastern sand darter (*Ammocrypta pellucida*) in the lower Thames River and the pugnose shiner (*Notropis anogenus*) in the Old Ausable Channel are used as case studies for non-destructive population assessments. Both areas are included in SAR recovery strategies. Non-lethal techniques for sampling the SAR were employed to get an estimate of spatial and size distributions. A mark-recapture study using visible implant elastomer (VIE) tags is used to estimate local population sizes, and potentially mortality rates. This technique has been successfully used on very small fish with no additional tag-related mortality and minimal tag loss. Low recapture rates indicate that the populations are larger than expected. Recaptures indicate that movement between preferred habitats within a stream is negligible. Other non-lethal techniques to determine life history parameters are being developed using closely related species that are more abundant. For example, blackchin shiner (*Notropis heterodon*), greenside darter (*Etheostoma blennioides*), and johnny darter (*Etheostoma nigrum*) otoliths and scales are being evaluated for ageing and growth analysis for validating scale results in the SAR.

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THE EFFECT OF VISUAL ISOLATION ON THE POPULATION DENSITY OF ATLANTIC SALMON (*SALMO SALAR*): A GIS APPROACH
We examined the effect of visual isolation as a potential low-cost method for increasing the density of territorial fish such as Atlantic salmon (*Salmo salar*). We first tested Kalleberg's (1958) hypothesis that the density of salmon can be increased by adding boulders to a stream. We then used GIS to assess whether the increase in density was consistent with the hypothesis of an increase in visual isolation. Eight study reaches were established in Catamaran Brook and the Little Southwest Miramichi River, New Brunswick. Each reach was divided into three sites of 3 by 2 m, and received one of three treatments: boulder-added, 36 boulders (D_{50}= 0.21 m) were added to increase visual isolation; boulder-removed; and a control. The density of salmon increased by three-fold in the boulder-added treatment compared to the boulder-removed and control, but no effect was observed in non-salmonid fishes. A GIS viewshed analysis showed that the visible area and the distance-to-nearest neighbour were also significantly smaller in the boulder-added treatment than in either the control or boulder-removed treatments. However, current velocity at the "nose" of each fish did not differ among treatments, suggesting that the boulders were not providing a velocity refuge. Our results support Kalleberg's hypothesis that visual isolation is a key factor controlling salmon density.

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STOCK-YIELD MODEL FOR A FISH WITH VARIABLE ANNUAL RECRUITMENT
A stock-yield model was developed to assess sustainability of the commercial catch of goldeye (Hiodon alosoides) from western Lake Athabasca of north-eastern Alberta. Goldeye have irregular annual recruitment, with many failed year-classes and with dominant year-classes appearing an average of 1.7 times per decade. In the late 1990s, mean annual commercial catch from this population was about 11,500 goldeye. These were primarily fish from the 1982, 1989, and 1994 year-classes. A best-fit, stock-yield model was developed for this population that incorporated: 1) the restrictions of the catch from a historic fishery that depleted this population during the 1950s and early 1960s, 2) the restrictions of the known total stock size in the early 1970s obtained from mark-recapture studies, 3) long-term annual estimates and patterns for stock-recruitment (1972 to 2004), and 4) a natural annual mortality rate of 20%. The model suggested that an annual commercial catch of 18,000 goldeye, was sustainable over all years and conditions (1948 to 2004). This small modelled catch, about 3 % of the long-term mean stock number of 525,000 goldeye, ensured that at least a few thousand goldeye would survive to spawn through periods of at least 17 years with poor stock-recruitment.

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STOCKING FISHLESS LAKES: EFFECT OF BROOK TROUT ON THE STRUCTURE OF INVERTEBRATE COMMUNITIES IN THE LITTORAL ZONE OF BOREAL SHIELD LAKES

Fish stocking is known to have a negative effect on native fishes by means of intraspecific and interspecific interactions, impacting ecosystems. Stocking of fishless lakes may actually be used to create fish habitat as a compensatory measure for alteration of suitable niches or productivity brought about by large infrastructures (such as a hydro-electricity power plant) projects. Accordingly, native fish can be protected with these measures, but interactions such as competition and predation in fishless lakes are still not clear. The exact impact on biological integrity and diversity is largely unknown. Furthermore, fishless lakes could be an important element involved in the conservation of the eastern population of Barrow's goldeneye (*Bucephala islandica*), a threatened population. This bird species apparently preferentially occupies fishless lakes during their breeding period. Our objective was to compare the species composition of littoral organisms between fish-present and fishless lakes, within the summer season. Five fishless lakes and five lakes containing allopatric populations of brook trout (*Salvelinus fontinalis*) where sampled at four different times between June and September 2003 in the Saguenay region. Nektonic and benthic organisms where sorted, counted, identified to species level and analysed using univariate and multivariate approaches to compare species assemblages within communities. Subsequent comparison between fish and fishless lakes revealed that findings were highly dependent on the chosen analytical methods. Adequate analytical methods of biotic variables are necessary to achieve a better understanding of these ecosystems and to eventually develop adequate management tools.

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SELECTIVE MORTALITY AND EVOLUTION IN INTRODUCED SMALLMOUTH BASS POPULATIONS

We examine the potential for selective mortality to influence the population dynamics, growth, and evolution of maturation in introduced populations of smallmouth bass, *Micropterus dolomieu*. Using an individual-based stochastic model, we show that high mortality on newborns can cause reduced population density, increased individual growth, but no evolution in the position of the maturation reaction norm. Alternatively, high mortality on individuals above a minimum size limit does not influence population density or growth but does cause evolution of the maturation reaction norm. Specifically, high mortality on larger sized individuals causes evolution towards younger ages and smaller sizes at maturation in only a century. Our results show that the lake environment into which a population invades can shape patterns of life history variation and cause rapid genetic divergence. The range of smallmouth bass has been increasing over the past century due to both natural and artificial introductions and the present study has implications for managers interested in controlling the impact and spread of this predatory species.

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PREDATION RISK AS A PREDICTOR OF COD RECRUITMENT IN THE NORTHERN GULF OF ST. LAWRENCE

Recruitment in marine fish stocks is usually described as a function solely of spawning stock biomass (SSB). Though stocks at high SSB are more likely to produce good recruitments and poor recruitments at low SSB, SSB fails to describe most of smaller scale variance in recruitment for many stocks. This is can be troublesome as most marine fisheries in developed countries survive on recruitment events and stocks need recruitment events to recover though we can only roughly predict them. We have developed an index of predation risk for pre-recruit cod sizes using allometric consumption rates, predator/prey body size ratios and multispecies survey biomass estimates of predator abundance for the Northern Gulf of St. Lawrence. We use this predation risk index as a predictor of recruitment rate (recruitment standardised by SSB) in the N. Gulf cod. We found that recruitment rate decreases with predation risk suggesting that varying pre-recruit predation mortality on cod could be an important factor affecting recruitment variance. Additionally, temporal autocorrelation in recruitment rate is not apparent when predation risk is used as a predictor as opposed to SSB alone suggesting that predation risk may be an important unaccounted process in predicting recruitment for this stock.

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POPULATION DIVERGENCE, INNER LAKE DISPERSAL, AND CONSERVATION GENETICS OF LAKE MISTASSINI'S WALLEYE (*Sander vitreus*).
Northern Québec is well known for its pristine lakes offering unsurpassed fishing. Lake Mistassini is the largest of these lakes and is exploited both by sport fishermen and a first nation Cree community. Our objectives consisted of determining the fine scale genetic structure of Lake Mistassini's walleye populations and evaluate their relative contribution to the sport fishing industry and traditional fisheries. A second objective was to understand the dispersal patterns of each source population (i.e. the way these populations are spatially distributed in the lake), and to associate dispersal with individual characteristics. Extensive sampling was performed during spring (5 different spawning grounds) and summer (exploited stocks) of 2002 and was repeated in 2003 in order to assess temporal variability of our results. Overall, more than 2200 fish were genotyped. Genetic structure and population assignment analyses were established using 10 microsatellite loci. So far, our results show low to intermediate levels of pairwise genetic differentiation (range of F_{st} values = 0,01 to 0,1), with the strongest dichotomy being found between northern and southern populations, separated by more than 180 km. These results suggest that our ability to distinguish source population and the way these populations use the lake should be considered to avoid overexploitation of specific stocks.

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POTENTIAL EFFECT OF EXTREME WEATHER AND SEASONAL CHANGES IN PRECIPITATION ON CHEMICAL EXPORTS FROM CATCHMENTS
Hydrology affects the mobility and chemistry of a number of important nutrients, including carbon (as dissolved organic carbon (DOC)), sulphur (S), nitrogen (N) and phosphorus (P). Extreme weather events and altered seasonal distribution of precipitation may therefore influence the chemistry of water draining catchments and entering downstream surface waters, with subsequent negative/positive effects on biota. This study investigated long-term (>20 year) changes in the frequency and intensity of extreme precipitation, temperature and stream flow events at catchments in the Muskoka-Haliburton region of central Ontario, and assessed their potential influence on stream chemistry. In addition, because of the importance of the snowmelt period for hydrologic and chemical export in this region, temporal changes in the ratio of rain-to-snow, and the onset of snowpack development and snowmelt were also considered. Climate change projections for milder winters in Ontario could have a marked effect on the export of important nutrients such as N, which are sensitive to changes in snow pack thickness and freeze-thaw events. In contrast, summer droughts may be more important controls on S export and high intensity storms modify DOC and P export from catchments. Extreme climate events can influence both the quantity and quality of stream water, and therefore must be considered when evaluating the response of catchments to anthropogenic stresses, such as acid deposition, eutrophication or harvesting.

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DEEPWATER ANGLING CAUSES TISSUE DAMAGE IN SMALLMOUTH BASS (*MICROPTERUS DOLOMIEU*)
For several decades, catch-and-release angling has become a well-practiced conservation measure among anglers. Although catch-and-release has increased in popularity, the success of this conservation tool requires that fish are released in good condition. When fish are angled from deep water, however, decompression may pose an additional physiological challenge for sport fish, possibly decreasing fish survival. Previous research has demonstrated that decompression can result in bass mortality, but the sub-lethal impacts of decompression in fish captured from deep-water are largely unknown. The present study examines the physiological disturbance caused by angling smallmouth bass (*Micropterus dolomieu*) from depth. In this study, smallmouth bass were angled from 3 depth ranges (Shallow <2m, Intermediate 5-8m, Deep 15-22m), placed in a livewell for an 8 hour holding period, examined for external signs of decompression (blood hemorrhaging and bloating), and sampled for physiological parameters. Relative to control values and additional depth treatments, smallmouth bass angled from the deep depth range exhibited significant changes in the plasma levels of intracellular enzymes (LDH, CPK, AST), red blood cell lysis and a larger anaerobic disturbance following the 8 hour livewell holding period. This study provides insight into critical depths where angling causes increased physiological disturbance for important sport fishes.
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DISSOLVED ORGANIC CARBON, HYDROGEN PEROXIDE AND BACTERIAL PRODUCTION TRENDS IN FORTY MACKENZIE DELTA LAKES NEAR INUVIK, WESTERN CANADIAN ARCTIC.
Increased attention has been placed on the effects of climate change on arctic aquatic ecosystems. One obvious stressor is the depletion of stratospheric ozone and increase in ultraviolet radiation (UVR) at high latitudes lakes such as those found in the Mackenzie Delta. A series of forty-lake surveys were conducted during the open water season of 2003 and 2004. Hydrogen peroxide levels were measured across lakes of varying DOC compositions near Inuvik, NT. DOC can be photochemically broken down to yield hydrogen peroxide (H2O2), which can remain in surface waters for up to 24 hours and may also act as a negative feedback on bacterial processing of DOC. Therefore, bacterial production in the presence and absence of grazers was also measured using a tritiated thymidine-uptake method. The lakes chosen represent a range of flooding frequencies and mixtures of colored- and non-colored-DOC. Survey results showed highly variable DOC concentrations across the flood frequency gradient. H2O2 levels measured at three times ranging from the artic summer solstice (24 hour sunlight) to late summer conditions were higher around the solstice than later in the summer. Peroxide levels were also higher in intermediately-flooded lakes with a mixed composition of both coloured and non-coloured DOC. Bacterial results suggest that in the presence of grazers, bacterial production per cell was considerably higher than in the absence of grazers. A 'competitive release' on bacterioplankton may be occurring where bacterial metabolism is heightened when being actively preyed upon and dampened once grazers are removed (no clear relation with DOC or peroxide levels).

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DISPERSAL, NUTRIENT ENRICHMENT, AND DIVERSITY OF A CRUSTACEAN ZOOPLANKTON COMMUNITY
Productivity has long been recognized as a determinant of species diversity in many community types, including freshwater zooplankton. Recently, there has also been increasing interest in the effects of dispersal on community attributes such as species composition and diversity. However, the importance of dispersal-limitation in zooplankton communities – particularly limnetic communities – is still a matter of debate, and the way in which dispersal might interact with nutrient enrichment is unknown. We conducted a six-week mesocosm experiment in George Lake, Killarney Provincial Park, Ontario, to test the independent and interactive effects of increased immigration and a nutrient pulse on microcrustacean diversity. Colonists from six lakes representing the regional species pool were added weekly to established zooplankton communities in mesocosms, and nutrients (N and P) were added at one time early in the experiment. Three levels of immigration (none, low, high) and two levels of nutrient addition (nutrients added or not) in a full factorial design with four replicates per treatment gave a total of 24 mesocosms. Zooplankton, phytoplankton, and water samples were taken weekly. Preliminary results suggest a positive effect of nutrient addition on microcrustacean species diversity and a weaker (but also positive) effect of dispersal, as well as an interaction between the two variables. Effects on species composition, richness, and evenness will also be discussed.

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FERTILIZATION SUCCESS, EGG PREDATION, DEPOSITION AND POST EMERGENT SURVIVAL IN THE LAKE STURGEON (ACIPENSER FULVESCENS): THE RELATIVE IMPORTANCE OF POTENTIAL BARRIERS TO RECRUITMENT
Lake sturgeon were once historically abundant throughout their range but have experienced dramatic declines in population numbers and abundance due to overharvest, destruction of spawning habitats and barriers to migration. Management activities have resulted in some improvements to spawning habitats and restoring natural flow regimes. However, many extant populations continue to show little evidence of natural recruitment. High rates of

predation on eggs could be one explanation for the low rates of recruitment. Lake sturgeon may also be subject to an Allee effect, where low recruitment is attributed to low fertilization rates due low spawner numbers. We currently lack quantitative information on factors that may be barriers to natural recruitment in lake sturgeon. The objectives of this study were to 1) estimate fertilization rate as a function of spawner number and sex ratio, 2) characterize egg deposition and 3) determine the sources and magnitude of egg predation prior to larval emergence. Results over two field seasons revealed a large amount of heterogeneity in egg deposition, high invertebrate predation, and inter-annual variability in post-emergent recruitment to the larval stage. Quantification of the relative importance of factors affecting recruitment is vital to the recovery of this species.

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LANDSCAPE CHARACTERISTICS TO DEVELOP HABITAT QUALITY MODELS FOR JUVENILE OF ATLANTIC SALMON IN RIVERS.
Most fish habitat quality models in rivers are developed using local characteristics like water depth, flow velocity, and substrate composition. However, numerous studies have argue that habitat quality in rivers is also determined by the spatial arrangement of different habitats and by attributes observable at the scale of pool-riffle, reach, segment, and complete watershed (landscape characteristics). It has also been hypothesized that habitat characteristics that determine habitat quality may vary with the spatial scale of observation. Atlantic salmon represents an ecologically and economically important species in most circumpolar countries of the North-Atlantic Ocean. During the last decade, their abundance have declined steadily over its complete distribution. Habitat loss has been identified as one of the causes of this situation. Improving our knowledge about Atlantic salmon and his freshwater habitat may contribute to better management and conservation strategies. The objective of this study is to assess the effect of the spatial arrangement of different habitats and of landscape characteristics on fish habitat quality. The abundance of juvenile salmon was estimated at 20 m intervals over 15 km of Sainte-Marguerite river (Saguenay region of Québec). Principal coordinates of neighbor matrices is used to identify the spatial scales and the environmental variables that best explain variations in parr abundance and hence habitat quality. Results confirm that numerous variables perceived at different spatial scales contribute to fish habitat quality.

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TEMPORAL TRENDS IN MERCURY AND ORGANIC CONTAMINANTS IN COHO AND CHINOOK SALMON FROM LAKE ONTARIO
Over the past 3 decades, the Ontario Ministry of Environment has monitored environmental contaminants in sport fish from over 1,700 sites across Ontario. The data have been used to determine fish consumption guidelines for people consuming Ontario fish and published in the "Guide to Eating Ontario Sport Fish". We analysed a subset of this large database to determine contaminant trends in coho salmon (*Oncorhynchus kisutch*) and chinook salmon (*Oncorhynchus tshawytscha*) from Credit River, Lake Ontario. Credit River flows through Mississauga and is an important sport fishing destination. Overall trends indicate that mercury, total PCBs, mirex and DDT congeners have declined consistently over time. No significant relationships were found with size, condition factor (k) or sex ratios, so we suggest that the decline in mercury and the "legacy" organic contaminants in fish are linked to stronger environmental legislation and increased awareness of the potential risk of those contaminants.

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STOICHIOMETRY OF SUSPENDED ORGANIC PARTICLES IN NORTHERN MICHIGAN STREAMS: EFFECTS OF WATERSHED LANDCOVER AND GEOMORPHOLOGY

Suspended particulate organic matter is an important food source for filter-feeding invertebrates in stream ecosystems. We examined how C:N:P ratios of suspended particles relate to landscape characteristics (e.g., geomorphology and land cover) in 35 streams located in the Ontonagon River watershed of northern Michigan. Across seven sampling dates in 2002 and 2003, suspended particulate C:N, C:P, and N:P ratios in these streams displayed a wide range of values (molar ratios: 6.4-51, 50-706, and 2.5-57 respectively) comparable to ranges found in lake and marine ecosystems. Particulate molar C:N ratios were negatively related to % lake area and positively related to % evergreen forest. Particulate C:P and N:P ratios were positively correlated with % woody wetlands in the watershed but negatively correlated with watershed area. No seasonal patterns were found either in suspended particulate C:N or C:P ratios or in their relationships with landscape predictors. Our results suggest that N- and P-poor particles dominate in small watersheds rich in wetlands or upstream of lakes, whereas streams downstream of lakes carry a lentic signature in their particle chemistry. Organic particles appear to become P-enriched as they are transformed during downstream transport in this large watershed.

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LONG-TERM HYDROLOGY OF CENTRAL ONTARIO STREAMS
We present an analysis of daily stream flow data from 1976-2002 for 23 streams in six catchments in the Muskoka-Haliburton region of central Ontario. Seventeen of these streams are lake inflows while six are lake outflows. We examine patterns of inter-annual and seasonal variability, as well as inter-and intra catchment coherence of stream flows.

We found no evidence of a trend towards earlier dates of maximum flow and limited evidence of a trend towards decreasing stream flow. These observations are in contrast to those from other parts of Canada and the north-eastern United States.

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30 YEARS OF TROPHIC STATUS MONITORING AND MODELING AT THE DORSET ENVIRONMENTAL SCIENCE CENTRE
The Lakeshore Capacity Model (LCM) is a steady-state export coefficient model developed to predict the effects of shoreline development on recreational lakes in Ontario. The LCM predicts in lake phosphorus concentrations ([TP]) as a function of catchment, precipitation and shoreline development loads. Over the past thirty years, the LCM has been revised and expanded to better represent our knowledge of lake eutrophication processes.

Recently, the LCM has been used to model a large watershed in Muskoka, and a series of Nova Scotia lakes. We show how the LCM can be extended to model multiple basin lakes such as Charleston Lake in Eastern Ontario

Long-term monitoring has shown declines in [TP] in streams and precipitation in Muskoka-Haliburton. There is still considerable debate as to the long-term fate of septic system effluent on the Canadian Shield. We discuss the implications of these issues for management strategies based on steady-state models.

We present new research on improved estimation of mass transfer coefficients, model sensitivity and non-steady state extensions of the LCM.

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REMEMBERING JOHN KELSO
Like many people in his field of study, Dr. John R.M. Kelso shied away from public recognition. His very sudden passing on Tuesday, May 18th, 2004 has left a hole in the ranks of the fisheries community that won't be easily

filled. This talk will recognize the contribution that John made to the scientific knowledge base of fish ecology in the Great Lakes basin and beyond.

Beginning with a BSc and MSc under Dr. Hugh MacCrimmon at the University of Guelph and a PhD under Dr. Fred Ward at the University of Manitoba, John's professional career spanned over 35 years. After a short stint with the Ontario Ministry of Natural Resources studying the effect thermal effluent had on Great Lakes fish communities, John began a 30 year career with the Department of Fisheries and Oceans. Based out of Sault Ste. Marie, ON for most of his career, his main focus was perturbations affecting fish production and he examined various large issues such as acid rain, waste heat, habitat loss and restoration and the variables driving the productive capacity of fish habitat. John published more than 100 publications and books on fisheries science and was a valued editor for CJFAS for much of his career.

He leaves behind a wonderful legacy of published research and an enthusiasm for fisheries science that he instilled in dozens of well trained confident young researchers.

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MOVEMENTS AND HABITAT USE OF ADULT COPPER REDHORSES (*MOXOSTOMA HUBBSI*), A RARE AND ENDANGERED FISH SPECIES OF THE ST. LAWRENCE RIVER SYSTEM

The Copper redhorse (*Moxostoma hubbsi*) is a rare and endangered catostomid fish endemic to Quebec. Its distribution is limited to short sections of the Richelieu and the St. Lawrence rivers. In response to population decline and habitat loss, this species was added to the list of threatened species in Canada (1987) and in Quebec (1999). Despite this status, little is known about adult essential habitats. Distribution, movements and seasonal habitat use of 20 adult Copper redhorse were studied by using telemetry in the St. Lawrence River system, from April through December 2004. Most tagged fish migrated towards the Richelieu River from mid May to early June where they used the two already known spawning sites. Reproductive activities lasted over two weeks, from mid June to early July. While some fishes stayed in the Richelieu River after spawning, most of them migrated towards the St. Lawrence and showed a widespread distribution from Lake St-Louis to Lake St-Pierre, suggesting a similar St. Lawrence distribution than described about 50 years ago. Results also supported the hypothesis that the Richelieu and St. Lawrence rivers fishes represent a single reproductive population. During summer, Copper redhorse showed restricted movements, appeared solitary in their habits and used shallow near shore habitats characterized by high density of vegetation and molluscs. This study will permit (1) to define the species essential habitats, (2) to identify new regulation criteria of the St. Lawrence River, (3) to direct reestablishment efforts and (4) to enhance legal protection.

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HABITAT PATCHINESS AND FISH DISTRIBUTION: INFLUENCES OF SPATIAL SCALES ON PREDICTIVE MODELS

Habitat patchiness in the littoral zone of lakes contributes to the irregular distribution of fishes. Numerous environmental attributes may influence fish distribution around the perimeter of a lake. The objective of our study was to assess the effect of environmental attributes on the spatial heterogeneity of fish assemblages in the littoral zone of lakes. We quantified the abundance, the size composition, and the specific composition of the fish community in four lakes of the Laurentides region of Québec. In each lake, the fish community was described by sampling fifteen 200 m^2 stations located in the littoral zone. The data were collected during visual surveys in July and in August 2004. We also measured several physical and biological variables such as water temperature, depth, macrophyte cover, substrate composition (local scale) and number of habitation and hotel found around the lakes (lake scale). Several multiple regression models were tested to identify the dependent variable (total fish density, density per species or size classes, total biomass, biomass per species or biomass per size classes) most strongly related to environmental conditions. Our results indicate that 65% of the variations of total fish density can be explained by a combination of local and lake variables. Our analyses suggest that fish distribution is influenced by a combination of factors observed at different spatial scales.

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LITTLE FISH, WIDE DISTRIBUTION: PHYLOGEOGRAPHIC STRUCTURE OF LONGNOSE DACE IN QUEBEC

Fish species that show a wide geographic distribution repeatedly covered by glaciations, is a problem of interest into the comprehension of the postglacial colonisation. In this context, the longnose dace (*Rhinichthys cataractae*) distribution in North America is of particular interest. Its distribution covers almost the entire temperate habitats between Atlantic and Pacific coasts of Canada and United States, from the 28th to the 69th parallels. However, its absence on Gaspesia Peninsula and at the Basse-Côte-Nord in Quebec province remained unexplained. Using two mtDNA markers, we aimed to elucidate the colonisation of Quebec territory by longnose dace following the deglaciation and explain the particularities of its actual distribution. A total of 25 populations were sampled in all regions of Quebec province where longnose dace could be found. Alleles for the two markers were sequenced in all populations. Our results suggest that the populations sampled are coming from a single glacial refuge. Preliminary phylogenetic analyses suggest a colonisation road, on north shore of Saint-Lawrence river, from South to North and then from West to East toward Saguenay River. South shore of Saint-Lawrence river seem to be colonized from West to East. Overall, our results emphasize the impacts of historical events into the shaping of actual genetic structure within and among populations of native fishes.

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SPECIES RICHNESS OF FISH ASSEMBLAGES IN THAILAND STREAMS

The structure of fish assemblages in tropical streams has seldom been examined in an extensive quantitative manner. We examined the fish assemblages at 83 stream sites throughout central Thailand from 2000 through 2003, with several sites being sampled on a number of occasions. We identified a total of 139 species from all sites; more fish species than reported for any single Canadian province. At the catchment scale, species richness was directly related to basin area. At the reach scale, species richness was a direct function of stream width. At the site scale, species richness was a function of fish abundance. The median number of species at a site was 12, the maximum was 30. Fish assemblages at sites upstream of steep waterfalls, however, had a reduced number of species. There was little seasonal change (wet vs dry season) in species richness at the four sites sampled repeatedly throughout the year. Although species richness within a basin was higher than that observed in temperate basins, the richness at a site appears no higher than that observed in temperate streams.

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EXPERIMENTAL COMPARISON OF ACTIVITY MEASUREMENT MADE USING SPONTANEOUS SWIMMING MODELS AND CAESIUM BIOACCUMULATION IN FISH

Activity is an important and variable component of fish energetic budget. Previous studies on fish's energetic budget have highlighted that the amount of energy spent on performing mouvements may account for 0% up to 40% of total energetic budget (Boisclair and Leggett, 1989). Among lake variations in fish activity rate may explain differences in growth rates . Failure to correctly account for activity cost have also been reported by Rowan and Rasmussen (1996) as the cause of flawed predictions of consumption and growth rate using bioenergetic models. Two methods are commonly used to assess fish's activity rate. Activity could be estimated from the knowledge of fish swimming activity and spontaneous swimming models or by a mass-balanced bioenergetic model, using growth rate (difference in energy content of the fish in a given period) and consumption rate (measured with evacuation model or estimated using biotracer). In our experiment, 140 arctic char (Salvelinus alpinus) were stocked into six 90m² littoral enclosures located in a stable caesium (Cs-133) enriched lake. Tree experimental densities were used to increase activity variation: 10 (half natural), 20 (natural) and 40 (twice natural) fish / enclosure. Spontaneous activity was measured using videocameras and Boisclair and Tang (1993) spontaneous swimming model. Caesium analysis was carried on using ICP-MS, Rowan and Rasmussen (1995, 1996) equations and Elliott (1976) models. Both activity rate measurement technic showed good agreement whitin the range of conditions of this study. This study represent the first corroboration of estimates of fish activity costs obtained using isotopes.

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HABITAT VS EXPLOITATION EXPERIMENT REVISITED (O)
Fisheries managers have often attempted to improve fishing quality or to compensate for high fishing pressure or habitat loss by conducting or recommending "habitat enhancement". For example, a recent review article described more than 130 projects in which spawning sites were created or "improved" to increase the reproductive output of lake trout (*Salvelinus namaycush)* in North American lakes. However, the effectiveness of few, if any of these enhancement efforts have been assessed. The whole-lake experiment that we conducted, during 1992-2002, was a unique and quite controversial one, where we eliminated spawning sites (> 250 sites, 1600m2, by covering sites with opaque plastic sheeting) of a natural lake trout population in a 67 ha lake to determine the effects of habitat loss on spawning behaviour and recruitment. A contrast was created by comparing the effects of these habitat disturbances with the effect of uncontrolled angling exploitation in a newly accessed lake. The results of this experiment were last presented at CCFFR in 2000. Since then the plastic sheeting has been removed and the fish have been allowed to choose from all the previous spawning sites (including the 7 original sites from 1991). Quantitative NORDIC netting surveys, mark-recapture assessments, and age and growth studies have also been conducted to assess any lingering effects of the habitat manipulation. Results will be presented.

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RIVER WATER QUALITY AND AQUATIC PLANT BIOMASS IN SOUTHERN ONTARIO.
Southern Ontario is located in the western portion of Canada's smallest ecozone, the Mixedwood Plains. Two centuries of European development has created a fragmented landscape mosaic of agricultural, urban, and remnant natural areas. Urbanization along the shores of the Great Lakes has concentrated farming in the south-west and eastern sections of the province. Farms tend to be small and mixed and manure is applied to the land at some of the highest rates in the country. In an effort to investigate relationships between nitrogen (N) and phosphorus (P) and aquatic plant biomass for rivers located in the Mixedwood Plain, we analysed five years of Ontario Ministry of the Environment's water quality monitoring and published aquatic plant (periphyton, macrophyte and phytoplankton) biomass for rivers located in the Mixedwood Plains ecozone. River water quality in Southern Ontario showed no obvious association between increased N and P concentrations and urban areas, probably because of decades of efforts to minimize P inputs from municipal sources. Current provincial and national water quality guidelines for N and P were, however, commonly exceeded in the south-west and eastern corners of the province where agriculture is the primary land use. Aquatic plant biomass also tended to be high where nutrient guidelines were exceeded. We will present preliminary analysis comparing N and P concentration in reference (relatively undisturbed) stretches of the rivers of Southern Ontario to those stretches in agricultural or urban areas in an effort to scientifically evaluate current N and P guidelines in the ecozone.

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AQUATIC INVERTEBRATES AND THEIR SIGNIFICANCE IN STURGEONS BIODIVERSITY IN CONTINENTAL SHELF OF CASPIAN SEA (O)
Sturgeons are one of the most important & valuable species in caspian sea which belong to ancient species that call them live fossile. The objective of this study is to determine the major & minor feeds of sturgeons in continental shelf and their rule on biodiversity of sturgeons in caspian sea.To investigate feeding of sturgeons, carried out by cooperative seins in7 stations having various geographical length and width with 55 km distance from each other.Also , trawl net with 9m width &24m length with 8mm mesh size used and sturgeons caught by motor boats in different depth of 2-4 , 5-7and 8-10 m in these stations during various seasons in 1999 to 2000. The intesting of these fishes fixed in 4-10% formalin and transferred to ecology department of sturgeon research institute. Samples prepared by sturgeons .The average minimum and maximum of their total length was 10 to 40 cm which 281, 13, 12 and 9 pieces of them were *Acipenser persicus* , Huso huso *,Acipenser nudiventri* and *Acipenser gueldenstaedti* , respectively.Regarding the abundancy of sturgeons in regions 10m depth, high abundancy of polychatea stomach content of these fishes show the importance of this organism as the main food of sturgeon. their high abundancy were due to the following factors1) increase in the factors of oxygen reduction and resistance of polychatea

compared with other aquatic invertebrates 2) increase in water level of Caspian sea up to 2.2m in 1977 to 1992 which caused to transfer these animals to shallow regions. Finding show that crustacea used minor food for sturgeons of under one year and 2 years old.

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BIOACCUMULATION OF HG IN SIMULIUM SPP (DIPTERA, SIMULIIDAE) FROM 17 STREAMS IN ONTARIO, CANADA.
Aquatic systems are considered very sensitive to inputs of mercury (Hg) because the bioaccumulation rates of this element are greater than any other metal. We measured the relative amount of total Hg in black flies in 17 soft water streams from the District of Muskoka and Haliburton County (Ontario, Canada) during 2003 and 2004. Concentration of total Hg in *Simulium* spp (Diptera, Simuliidae) larvae ranged from 0.07-0.64 ppm dry weight (DW), while adult Simuliidae Hg concentration ranged from 0.08-0.75. This concentration of Hg is much higher than has been found in other filter feeding insects, and represents a significant potential source of Hg to fish and birds. Mercury concentrations between *Simulium* spp at different sites was strongly correlated with dissolved organic carbon and pH, however, no significant correlation was found with conductivity, Ca^{2+}, or Na^{+}.

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A MULTI-SCALE APPROACH TO PREDICTING THE EFFECTS OF SEA-LAMPREY BARRIERS ON NON-TARGET FISHES IN THE GREAT LAKES BASIN
Effects of in-stream barriers used in the control of sea lampreys in the Great Lakes basin on the diversity of non-target fishes is an important concern for fishery managers. Estimates of upstream species loss attributed to 24 barriers (relative to reference streams) across the basin were highly variable. We examined five hypotheses for this variation: sampling variability, variation in environmental variables across lake basins, variability in the resiliency of different fish assemblages, variation in environmental variables across watersheds and sub-watersheds within barrier-reference stream pairs, and variation in barrier design. A simulation model was used to test whether the observed variance in effect was greater than that expected from a null (sampling) model of fish assemblage structure. A large variance in effect size was predicted for our sampling design, but the predicted variance was smaller than the variance observed. Regression models and information-theoretic model selection methods were used to evaluate the remaining hypotheses. The variance in effect size was most strongly related to environmental variation at the watershed and sub-watershed scales. Our results will improve the precision of estimates of barrier effects on non-target fishes and assist managers with decisions pertaining to the placement of barriers and their anticipated effects.

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HIDING FROM THE JAWS: THE USE OF HYPOXIA FOR REFUGE FROM PREDATION
A refuge from predators can only exist if prey are capable of withstanding environmental conditions that their predators cannot. Good evidence exists from laboratory experiments of such variation, but the application of these results to field conditions is limited. Here, we sought to determine whether our laboratory observations of variation in tolerance to dissolved oxygen conditions would manifest itself in the predictable response that prey will preferentially seek low dissolved oxygen habitats in the presence of their piscine predators. We tested this hypothesis by monitoring the fish community in Delta Marsh, Manitoba from May to August of 2003 (gillnets, minnow traps) and 2004 (trap nets). Environmental conditions (temperature, dissolved oxygen (DO) and turbidity) were monitored using YSI 6920 data sondes and HOBO Water Temp Pro loggers. Changes in the fish community (both predators and prey) were observed coincidentally with dramatic changes in environmental conditions. Temperature and hypoxia sensitive species (northern pike, yellow perch, various shiners etc.) evacuated Blind Channel during late June as the water temperature rose and DO levels dropped, leaving only hypoxia tolerant species (bullheads, fathead minnows). In August, with only slightly lower water temperatures and higher DO levels, juveniles of both tolerant and sensitive species returned to Blind Channel. The environmentally related changes in the piscine community reduced predation pressure on the fathead minnows (the dominant forage species) from visual predators, though bullheads provided a persistent, and perhaps increasing, threat.

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AN ECOLOGICAL AND CONSERVATION CRISIS IN BRITISH COLUMBIA PACIFIC SALMON: ABERRANT MIGRATIONS AND HIGH NATURAL MORTALITY OF FRASER SOCKEYE
The 'late-run' sockeye stock complex is one of the major groups of salmon in the Fraser River, the most productive salmon river in Canada. Historically, these fish milled in the estuary for several weeks before initiating their September and October up-river spawning migrations. However, in 1996, they arrived to the estuary at normal times but commenced river migration immediately. Late-run sockeye, as well as some other salmon species, have entered freshwater progressively earlier each year and in recent years entered freshwater 5-6 weeks earlier than normal. Associated with this abnormal behaviour has been extraordinarily high mortality. In recent years, mortality during the migration ranged from 90-96%. Mortality of migrants that successfully reached spawning grounds but died without spawning was 10-30%. Prior to 1995, total freshwater mortality for late-run stocks rarely exceeded 20%. This high mortality phenomenon has caused the collapse of fisheries and led to the emergency listing of stocks by COSEWIC. The economic costs are enormous - $72 million (CDN) in lost production and harvest in 2002 alone. We initiated a large multi-year research project in 2002, collecting fish from various coastal and in-river locales, and at different times during the run. Preliminary findings suggest that abnormally behaving and prematurely dieing fish had unusual ionic, osmotic and energetic states. Lab and field experiments indicate that mortality is caused by increased number of accumulated degree days which accelerates disease, energy use and senescence.

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CASCADING EFFECTS OF BYTHOTREPHES LONGIMANUS ON ROTIFER POPULATIONS IN CANADIAN SHIELD LAKE FOOD WEBS
Trophic cascades are often revealed through large scale manipulations of the environment, including non-indigenous species invasions. *Bythotrephes longimanus*, a zooplankton predator, invaded North America in the 1980's and is currently a known inhabitant of over 70 inland freshwater lakes. *Bythotrephes* is recognized to change food web structure, eliminating or decreasing medium sized *Daphnia* from the zooplankton community. We investigated the prospect that the effects of *Bythotrephes* within the zooplankton community spread beyond the cladoceran population to influence rotifer densities. In order to examine possible cascading effects from *Bythotrephes*, ten invaded and four non-invaded Canadian Shield lakes located in the Muskoka region of Ontario during the summer of 2003 were sampled bi-weekly to determine *Bythotrephes* and rotifer densities. Rotifer populations showed a strong positive linear response in density with increasing *Bythotrephes* densities among lakes, particularly *Conochilus unicornis*, a colonial rotifer. We additionally looked at long term data for Harp Lake which was invaded in 1993. To determine if *Conochilus* densities increased due to *Bythotrephes*, pre and post invasion rotifer samples were counted. Post invasion densities of *Conochilus* significantly increased two-fold after the invasion of *Bythotrephes* in Harp Lake, compared to pre-invasion densities, as well as densities in a non-invaded lake, Red Chalk Lake. Finally, in a 24hr laboratory feeding experiment, *Bythotrephes* was shown to overlook *Conochilus unicornis, Keratella cochlearis,* and *Ploesoma* spp. individuals as a potential source of food, suggesting that there is little to no predation pressure occurring from *Bythotrephes* on the rotifer community. There are therefore, multiple lines of evidence to suggest that rotifer densities, particularly colonial species, are increasing owing to *Bythotrephes* invasion.

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THE RELATIONSHIP BETWEEN GROWTH, MORPHOLOGY AND DIETS OF LAKE TROUT IN GREAT BEAR LAKE, NWT
Stock assessment studies of lake trout in Great Bear Lake over the past 5 years have revealed a great deal of morphological variation coupled with divergent growth and dietary patterns within trout populations. Preliminary

comparisons among individuals using stomach content data have suggested that diet and growth are closely linked. To obtain a more complete understanding of diet and trophic status of trout in relation to growth we combined stable isotope analyses with analyses of stomach contents. We also captured digital images of trout sampled over the past 3 years with the intention of quantifying morphological variation and relating it to patterns of diet and growth. Our initial comparisons among digitized images suggest that there are two common morphotypes which made up 95% of the samples we collected and 2 or 3 rarer morphotypes that comprised the remainder of samples. The two most common types were a typical piscivore body form with a large curved jaw, small fins and a narrow caudal peduncle, and a typical invertebrate feeder body form with a short jaw, longer fins and a short, wide caudal peduncle. Stomach content and stable isotope data indicate that trout are opportunistic feeders with a highly varied diet however, individuals appeared to specialize on either large-bodied fish or invertebrates and small-bodied fish. The type of diet (large vs. small food items) and morphology (piscivore vs. invertebrate feeding body form) were good predictors of growth suggesting that gape limitation may largely determine the diet of individual trout within the lake.

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NEW APPROACH FOR MULTIPLE REGRESSION ANALYSIS IN LIMNOLOGY: AKAIKE'S INFORMATION CRITERION (AIC)
Multiple regression analysis is frequently used in limnology. Multiple regression analyses may produce many competing models to explain the variation in a dependent variable. The choice of models and the number of independent variables to include in these models is often unclear. Methods such as Akaike's Information Criterion (AIC), Empirical Information Criterion (EIC), Schwaz's Bayesian Information Criterion (BIC) and Monte Carlo procedures can be used to simplify and improve model selection. In this paper, we compare an already published multiple regression model, which examines long-term patterns in DOC, with a model developed with the aid of AIC. Specifically, we will present the advantages of AIC for model selection and parameter estimation.

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MEASURING MARINE FISH BIODIVERSITY
At the 2002 World Summit on Sustainable Development in Johannesburg, an international commitment was made by the Conference of the Parties to the Convention on Biological Diversity (CBD) to "achieve by 2010 a significant reduction of the current rate of biodiversity loss". Within this context, we measured patterns in marine fish biodiversity by quantifying temporal variation in rate of population change and abundance concomitant with long-term reductions in population abundance. Based on data for 178 populations (62 species) from four north-temperate oceanic regions, 81% of populations in decline prior to 1992 experienced reductions in their rate of loss thereafter. Species whose rate of decline accelerated after 1992 were predominantly top predators such as Atlantic cod, sole, and pelagic sharks. Combining population data across regions and species, marine fishes have declined 35% since 1978 and are currently less than 70% of recorded maxima. Demersal species are generally at historic lows; pelagic species are generally stable or increasing in abundance. Within regions, declines by demersal species have been associated with substantive increases in pelagic species, a pattern consistent with the hypothesis that reduced predator abundance can effect increases in the abundance of prey. Our results suggest that reductions in the rate of population decline (the 2010 CBD target), in the absence of targets for population increase, will be insufficient to effect a recovery of marine fish biodiversity, and that great care must be exercised when interpreting multi-species patterns in abundance.

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HABITAT AND DAYTIME ABUNDANCE OF ATLANTIC SALMON PARR IN THE SAINTE-MARGUERITE RIVER, QUÉBEC: A MULTISCALE ANALYSIS
The freshwater phase is an important period of the Atlantic salmon life cycle, because reproduction, early growth and survivorship during this phase determine the abundance of juveniles. The lack of conservation and proper management of the key freshwater habitats is thought to be one of the major factors that contributed to the decline of salmon populations. The objective of this study was to develop an empirical model of salmon habitat quality at a

watershed scale, because this is the spatial scale at which private and governmental agencies generally try to adopt management strategies. In the summer of 2002, daytime parr relative density was visually assessed by snorkeling in a 10 km stretch of the Sainte-Marguerite River, Québec. We collected data on various habitat descriptors including local variables such as water depth, current speed, substrate composition, water temperature, cloud cover, as well as distance to nearest tributary, island, pool, riffle, spawning site etc. While many of these variables have been previously employed at smaller spatial scales, this study is the first attempt to integrate this information and to model salmon habitat quality at the watershed scale. The relationship between parr relative density and habitat variables at several spatial scales (20 m, 60 m, 100 m, 200 m, 500 m and 1000 m) and its relevance to Atlantic salmon management will be discussed.

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VARIATION IN PREDATOR-INDUCED PLASTIC RESPONSES AND ITS CONSEQUENCES IN POLYMORPHIC PUMPKINSEED SUNFISH (*LEPOMIS GIBBOSUS*)
With the exception of fishes, the function role of inducible defenses have been well studied in many aquatic taxa. Little attention has been paid to how plastic responses contribute to biodiversity, local adaptation, population growth rate, and population subdivision. We examined whether inducible defenses have played a role in the divergence of littoral and pelagic pumpkinseed sunfish (*Lepomis gibbosus*) ecomorphs that coexist in many postglacial lakes. We tested 1) if cues released by walleye (*Sander vitreus*) influence the external body form and behavioural traits of juvenile pumpkinseed reared with and without predator cues, 2) whether plastic phenotypic responses differed between ecomorphs, and 3) if predator-induced phenotypic variation influenced survival under walleye predation. We found that predation cues predictably influenced both external morphological and behavioural traits in both sunfish ecomorphs. However, different phenotypic responses were also observed between ecomorphs indicating genetic divergence of plastic responses. In a performance trial we found that predator-induced phenotypic variation increased survival under walleye predation, but only under littoral conditions. Our results suggest that variation in predator-induced plasticity in sunfish provides further evidence of population subdivisions between coexisting sunfish ecomorphs and may have influenced the success of sunfish in both native and transplanted ranges.

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A GRAPHICAL METHOD FOR IMPROVING COMMUNICATION OF COMPLEX ANALYTICAL TECHNIQUES AND RESULTS AMONG FISHERIES SCIENTISTS, STAKEHOLDERS AND MANAGEMENT AGENCIES
With the rapid development and increasing complexity of modeling and risk assessment techniques in fisheries, communication of complicated methods and results among scientists, stakeholders and management agencies in an emerging problem in improving fisheries management. Using the example of Lake Erie walleye (*Sander vitreus*), and population dynamic modeling and stock assessment using a state-space production model, we presented one graphical method to show uncertainty and risk in fisheries status evaluation. Our estimation of the vital parameters and abundance of the walleye stock over time was found to be greatly influenced by the source of the observation data, i.e., the catch rates from the gillnet and sport fisheries and the abundance indices from the fishery independent partnership index survey. The sensitivity and retrospective analyses showed that the status of the stock as assessed using the composite risk assessment method was found to be highly uncertain. All of this information was graphically presented clearly showing the exploitation status of the fishery over time and the uncertainty related to that status. This graphical approach has been used in stock assessment and harvest discussions among management agencies, scientists, and stakeholders in several Great Lake fisheries. The early results of this empirical application suggest that this approach should greatly improve the communication of risk and uncertainty among scientists, stakeholders and management agencies.

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SEARCHING FOR CERTAINTY AMONG UNCERTAINTIES
Uncertainty in fisheries population dynamic modeling and stock assessment is regarded as one of the primary factors leading to fisheries overexploitation and collapse. Risk assessment that fully considers uncertainties is necessary to avoid the effects of uncertainties on fisheries population dynamic modeling and management. Using the example of Lake Erie's walleye (*Sander vitreus*) fishery we investigated uncertainties in status evaluation and management even risk assessment that fully considered uncertainties for both indicator reference points and management reference points used in harvest decision making. The estimates of vital parameters and abundance over time and their uncertainties estimated using the likelihood inference method were found to be greatly influenced by the source of the observation data which included catch rates of commercial gillnet fishery and angling (sport) fishery and the abundance indices from the fishery-independent Ontario partnership index fishing survey. The status of the walleye fishery, evaluated using the composite risk assessment method, was found to be highly uncertainty using sensitivity and retrospective analyses. We used these sensitivity and retrospective analyses to search for certainty among the uncertainties. The population dynamic trend and risk assessment trend were found to be consistent during the sensitivity analysis. The sensitivity analysis suggested that stock assessment using equilibrium fishing mortality resulted in a robust risk assessment result for the Lake Erie walleye fishery. The retrospective risk analysis showed that the use of fishery-dependent data yielded biased risk estimates, while the fishery independent data yielded random varied risk estimates. The fishery-independent data was suggested to be used in the population dynamics modeling and stock assessment of Lake Erie walleye. Further empirical and simulation studies are needed to explore the application of the equilibrium yield in fisheries management. This study suggests that it is important to searching for certainty among uncertainties to avoid mismanagement of fisheries in the face of ever present uncertainties.

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GREAT LAKES FISH AND FISHERIES AT RISK: EXPLORING ADAPTATION TO CLIMATE VARIATION AND CHANGE.
This paper presents a retrospective analysis of international and Canadian research on fish, fisheries impact and adaptation responses to climate variation and change, and explores future directions needed in fisheries research in the Great Lakes. The inadequacy of past and present knowledge regarding the ability of fisheries to "adapt" to future climate change is indicated by results that show >93 % of all studies have focused on impact rather than adaptation issues.
Climate impact and adaptation (CIA) issues are embedded within multiple domains of the human ecosystem. Climate change impacts register first on the physical environment defined by climate and geographic context, and second on biological processes which influence plant and animal communities. Climate change impacts rapidly multiply into human socio-economic domains because of the diversity of associations between human society and natural resources. At regional Great Lake basin fisheries perspectives, CIA issues are conditioned by properties of the biological resource and resource "users" and "managers". Human socio-economic systems have further created a "built" environment consisting of both "hard" (fleets, dams) and "soft" components (regulations) of unknown resilience to change.

Our discussion demonstrates a priority for future research, management and policy into fisheries CIA issues by interdisciplinary teams across multiple domains of the human ecosystems. As an immediate response, "adaptation" research should be supported to explore risks, vulnerabilities and benefits to fisheries and communities by assuming vulnerability to the adverse effects of climate change. Adaptation research can be used to adjust practices, processes, management and structures of systems based on projected social and resource vulnerability to climate change.

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THE RELATIONSHIPS BETWEEN BODY CONDITION INDICES AND THE LIPID AND MOISTURE CONTENTS OF TWO FRESHWATER FISHES

Condition indices calculated from fish length and mass are widely used to assess the general health of fish; a fish with a relatively high condition index is presumed to have greater energy stores available for growth and reproduction. But, how are these indices related to the proximate composition of the fish? We sampled mature, spawning males and females from nine walleye and two lake whitefish populations (> 1000 fish) from across Canada. For all fish, body condition was estimated from length and mass using several different indices, and the moisture and lipid contents of their tissues were determined. Body lipid content varied considerably both within populations with respect to gender and body size, as well as among populations with respect to climate and level of exploitation. As expected, body moisture content (% of wet mass) was negatively correlated with body lipid content (% of dry mass) but, the relationship differed among populations. Muscle lipid content was generally a good predictor of body lipid content but, liver lipid content was not. Both body moisture content and lipid content were positively correlated with the condition indices. However, the strength and nature of these relationships varied among indices, and in some cases among populations. Caution should be exercised when inferring proximate composition from body condition using relationships developed from other populations. The relative merits of the various indices will be discussed.

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THE ONTARIO BENTHOS BIOMONITORING NETWORK

Monitoring facilitates adaptive management by providing feedback on the status of resources and the performance of management activities. Biomonitoring is a type of monitoring that evaluates environmental condition using biological indicators; it is an important part of environmental management because both our legislation and management activities stress protection of biota. Benthos, which are commonly used as biomonitoring indicators, are invertebrates that live chiefly among the bottom sediments of aquatic habitats.

Recognizing that benthos exhibit many traits that make them excellent indicators of aquatic ecosystem condition, in 2003 the Ontario Ministry of Environment and EMAN co-founded the Ontario Benthos Biomonitoring Network (OBBN), a biomonitoring program that uses benthos to evaluate the biological condition of Ontario's lakes, streams, and wetlands. The components of the network — a standard protocol (with limited options to tailor procedures to available expertise and financial resources), training, a database, and automated analytical and reporting tools — equally empower trained volunteers and research scientists to do biomonitoring. The OBBN is being implemented according to three principles: balancing standardization with flexibility, partnership, and free data sharing. Current partners include Environment Canada, Ontario Ministry of Environment, Ontario Ministry of Natural Resources, many of Ontario's conservation authorities, provincial and national parks, universities, and several non-governmental organizations.

Significant OBBN progress was made in the program's first two years: more than 400 reference sites have been sampled, a protocol manual is available for internet download (and will soon be sent for printing), benthos collection methods have been synchronized with the Ontario Stream Assessment Protocol (a collection of habitat and water quality assessment procedures developed by Ontario's Ministry of Natural Resources), and a hypothesis testing procedure (which uses information contained in multiple, user-defined indices of benthos community composition) has been developed. We anticipate having a working model of the database and analytical tools late in 2004.

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FACTORS GOVERNING THE DISTRIBUTION OF A NONINDIGENOUS SPECIES, *ECHINOGAMMARUS ISCHNUS* STEBBING (AMPHIPODA: GAMMARIDAE), AT GREAT LAKES COASTAL MARGINS

Elton (1958) proposed that biotic resistance to nonindigenous species (NIS) establishment is greater in intact communities than those disturbed by human activities. However, Baltz & Moyle (1993) suggest that invasion is likely wherever abiotic conditions are appropriate, regardless of biota already present. Simberloff & Von Holle (1999) proposed that invaders facilitate subsequent establishment of new species. We tested these hypotheses by investigating co-occurrence of a widespread amphipod, *Gammarus fasciatus*, with the nonindigenous amphipod, *Echinogammarus ischnus*, at 150 sites located at Great Lakes wetlands or shorelines circumscribed by the bounds of second-order or higher watersheds influenced by varying degrees of anthropogenic stress. Samples were collected using cores, sweep nets (both employed for depths < 1m), and ponar grabs (depths > 1m) from a maximum of 24 points per site. Runs test and logistic regression analyses revealed that the NIS was distributed independently of disturbance gradients related to nutrient inputs and land uses, consistent with the expectations of Baltz and Moyle's hypothesis. Chi-square analyses indicated *E. ischnus* was highly associated with the nonindigenous bivalve, *Dreissena polymorpha*, which may provide necessary microhabitat for the amphipod. This novel finding at a large geographic scale suggests that dreissenids may regulate the distribution of *E. ischnus* at the landscape scale, as well as at the microhabitat scale, and may be an important predictor of *E. ischnus* distribution in the Great Lakes. Successful establishment in the Great Lakes by *E. ischnus* may require prior establishment of *D. polymorpha*, implicating invasional meltdown as an important invasion process.

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COMMUNITY BASED DIFFERENCES IN FISH ACTIVITY USING MUSCLE ENZYMES
Activity levels in walleye (*Sander vitreus*) and yellow perch (*Perca flavescens*) were tested in eight Sudbury lakes, four containing only small bodied prey, yellow perch, and four containing small bodied prey (yellow perch) and large bodied prey, lake herring (*Coregonis artedi*). Lake herring grow larger than yellow perch and therefore should provide optimal forage for larger predators. Walleye stomach content data from small prey lakes show that as walleye grow, perch remain their main prey. In lakes with small and large prey, as walleye grow they feed on less perch and more lake herring. Anaerobic capacity, measured by lactate dehydrogenase rates (LDH), increased with walleye length in both lake types. Overall, LDH rates were higher in lakes with only small prey. Aerobic capacity, measured by citrate synthase (CS), scaled negatively with length in small prey lakes only; there was no relationship with length in small and large prey lakes. There was no overall difference in the aerobic capacity of walleye in the two lake types. This suggests that walleye are more anaerobically active foraging when only yellow perch are available as prey. In yellow perch, LDH did not scale with size, but CS decreased linearly with size. Overall, both enzyme activities (LDH and CS) were higher when they were the only prey, suggesting higher predator avoidance activity. There appears to be physiological costs for both predators and prey when there are limited sizes of prey available.

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DOES SIZE MATTER? REPRODUCTIVE ECOLOGY OF THE SLIMY SCULPIN, *COTTUS COGNATUS*
The slimy sculpin, *Cottus cognatus*, is a small, benthic fish common to many areas of North America. In this species, males guard a nest rock; females, sometimes multiple females, deposit all their eggs into one nest. Nesting males were monitored in 6 small New Brunswick streams to learn more about the reproductive ecology of the species. Passive integrated transponder (PIT) tags were used to determine exact nest locations and individual movement throughout the breeding season. Microhabitat characteristics, such as depth and velocity, were considered at nest locations. The size of the male and his nest rock was considered in relation to his reproductive success, specifically, the number of females that deposited eggs in his nest. In total, 40 PIT-tagged, male sculpin with nests were monitored during the 2004 spawning period. Movement of all male sculpin was extremely low for at least a month before females spawned, suggesting that they commenced guarding early and most males did not leave the nest for more than a week after the young hatched. Males tended to select nest locations in shallow, fast-moving sections of riffles; nest sites were concentrated in these areas and were in close proximity to each other. The number of females clutches per rock varied from none to more than 10, but most males guarded 1 or 2 clutches. The number of eggs per nest observed ranged from 50 to more than 1000 eggs. There was a positive relationship between individual reproductive success and the length of the male sculpin, however, the nest site did not appear to be related to the size of the male or the number of eggs deposited in the nest.

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FOREST FIRE RESULTS IN INCREASED MERCURY ACCUMULATION IN FISH
A forest fire, in the catchment of Moab Lake in Jasper National Park, resulted in a 5-fold increase in whole-body Hg accumulation by rainbow trout (*Onchorhynchus mykiss*) within the lake. Smaller post-fire Hg increases were identified in dorsal muscle tissue of other fish species. The enhanced accumulation of Hg in fish is a previously unrecognised effect of forest fire. A large, short–term release of methyl mercury (MeHg) and total mercury (all forms of Hg; THg) to streams and the lake occurred during a post-fire rain event. Export from the burned catchment also increased lake water nutrient concentrations 2 to 9-fold, which enhanced lake productivity. Subsequently, the trophic position of fish species increased by a maximum of 2 positions. Food web restructuring was more important than increased Hg inputs to the lake with respect to the post-fire enhancement of Hg accumulation by fishes. Climate change and prescribed burning to compensate for past fire suppression are predicted to increase forest fire occurrence in North America during the next century, and increased mercury in fishes may be an unexpected consequence.

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AN ASSESMENT OF CURRENT REARING METHODS IN HATCHERY PRODUCTION OF LAKE STURGEON (ACIPENSER FULVESCENS): DO BLACK FLY LARVAE (DIPTERA: SIMULIIDAE) REPRESENT A MORE EFFICIENT FEEDING REGIME?
Artificial propagation is believed to be an effective means to increase depleted lake sturgeon (*Acipenser fulvescens*) populations and is included in most conservation strategies. Poor acceptance by larval fish to formulated feeds has warranted the use of a more costly and labour intensive rearing method including initial feedings of live brine shrimp, *Artemia* sp., with a later switch to frozen bloodworm, Diptera: Chironomidae. However, high mortalities have also been reported as a result of this diet switch. In this study, survival and weight of juvenile lake sturgeon switched to a diet of frozen bloodworm or black fly larvae, Diptera: Simuliidae, following one, two, three and four weeks of an initial diet of brine shrimp were assessed at the end of a seven week period. Mean survival was lowest when fish were switched to either bloodworm or black fly larvae following one week of exogenous feeding (36.3%+/-10.9 SE and 65.3%+/-3.5 SE, respectively) and highest for fish switched to either bloodworm or black fly larvae following four weeks of exogenous feeding (76.1%+/-4.3 SE and 90.4%+/-2.3 SE, respectively). Fish switched to a diet of black fly larvae maintained higher average survival rates and more consistent results among replicates than their counterparts switched to bloodworm at the same time. Despite fewer daily feedings of black fly larvae, weights of fish in these treatments were not compromised when compared to those fish fed bloodworm more often throughout the day. Future consideration should be given by hatcheries to the use of black fly larvae in lake sturgeon feeding regimes which could potentially represent a less labour intensive procedure leading to greater numbers of fish available for release.

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POTENTIAL IMPACT OF CLIMATE CHANGE FACILITATED INVASION BY NORTH AMERICAN FISHES ON THE GREAT LAKES FISH COMMUNITY
Climate change is predicted to increase temperatures and change precipitation patterns in the Great Lakes basin over the next century. Invasion of the Great Lakes, by thermally limited North American fishes, may be facilitated by climate change as northern thermal limits are expected to shift northward. Subsequent dispersal of many of these fishes may be further facilitated by existing connections between the Great Lakes basin and both the Mississippi (e.g. Chicago Sanitary Canal) and Atlantic Coastal (e.g. Erie Canal) drainages. We developed regression tree models to predict which species may successfully invade the Great Lakes, as a result of climate change, based on life history, reproductive and ecological characters. Three models correctly classified 92-100% of recent invaders as successful or failed on the basis of 2-4 variables. The models were then applied to species widely distributed in the Mississippi or Atlantic Coastal basins, with northern range limits south of the Great Lakes basin. Based on these analyses, the Great Lakes fish community is likely to be significantly impacted by climate change facilitated invasion.

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SCIENCE, POLITICS, DOUBT AND HOPE: THE FUTURE OF LIMNOLOGY IN CANADA
The Society of Canadian Limnologists (SCL) Société Canadienne de Limnologie is the Canadian national representative of the International Association ofTheoretical and Applied Limnology (Societas Internationalis Limnologiae, SIL). As such, SCL is responsible for promotion of freshwater sciences in Canada and represents national interests on the international stage. National activities include presentation of annual meetings in association with the Canadian Conference for Fisheries Research (CCFFR), liaisons with media to promote aquatic research, sponsorship of student travel awards (Clemens-Rigler Travel Fund) and transmission of scientific information (reduced journal subscription rates, job postings, email list-services). Further, members of SCL and CCFFR form the majority of grant and fellowship selection committees for aquatic sciences and occupy many of the key editorial posts at major aquatic science journals (CJFAS, L&O, Ecology). On the international front, SCL funds student participation in DIALOG (with ASLO), was a founding member of the North American Council of Aquatic Sciences and will be co-sponsoring forthcoming international meetings with the American Society of Limnology and Oceanography (ASLO; Victoria 2006) and SIL (Montreal 2007). As well, the Society is highly cost-effective, with both the lowest average membership and conference registration rates of any major society (ASLO, ESA, GSA). Despite these activities, participation in SCL has been unpredictable, a trend seen also in SIL and, to a lesser extent, ASLO. Further, unlike CCFFR, SCL does not normally serve marine scientists in Canada, despite obvious methodological, theoretical and conceptual overlap. To address these issues, a survey was submitted to all limnologists in Canada during November 2004 to poll opinions on the future of the Society. Results of this survey will be presented in this talk. The presentation will be followed with an open discussion period.

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POPULATION STRUCTURE AND INFLUENCE OF EVOLUTIONARY FORCES ON THE YELLOW PERCH POPULATIONS (PERCA FLAVESCENS) IN THE ST. LAWRENCE RIVER
Yellow Perch exploitation represents an important activity in the St. Lawrence River, particularly in lake St. Pierre, where historic high catches recorded before 1994 have never been observed since. The main objective of this project is to evaluate the way that evolutionary forces (genetic drift, mutation, selection and gene flow) influence the evolution of these populations at small and large scales based on variation at both microsatellite loci (10) and morphological traits (11). A total of 1028 individuals were sampled from Lake St. Francis to Quebec in 2003, with a temporal replicate in 2004. A moderate differentiation between populations from fluvial lakes (pairwise Fst between 0,02 and 0,09), and a finer structuring within the three fluvial lakes (pairwise Fst around 0,01) are observed in 2003. Spatial allelic segregation between eastern and western yellow perch populations suggests the existence of two glacial races within the St. Lawrence River, with lake St. Louis (Montreal area) representing a contact zone. This hypothesis is being verified from mitochondrial DNA control region sequencing. The intensity and asymmetry of dispersal and gene flow will be examined in a second objective at different levels of population structuring, with attention to age and sex-biased dispersal in the system. Analyses of morphological traits will contribute to assess the role of divergent natural selection in local adaptations to different habitats and diets. Altogether, this study will increase the general knowledge regarding the determinants of population structuring within a large river system and its relevance in producing conservation scenarios related to the different fisheries.

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IMPACT OF FOREST HARVESTING ON YOUNG-OF-THE-YEAR YELLOW PERCH (*Perca flavescens*) DAILY GROWTH IN QUEBEC BOREAL SHIELD LAKES.
Recent research has shown that forest harvesting can modify water quality, phytoplankton, and zooplankton production in boreal shield lakes. These changes may have an important effect on the first year growth of yellow perch via a bottom-up effect, and consequently, may affect the recruitment of *P. flavescens* populations. The objective of this study is to evaluate the impact of forest harvesting on YOY yellow perch growth in boreal shield lakes. For this purpose, a BACI approach was performed on 4 lakes (2 controls and 2 logged). Fish from these lakes were sampled twice per summer, for the year before (2003) and post (2004) forest logging. Daily increments were

measured on otolith microstructures and using an adequate back-calculation procedure, individual growth trajectories were built. To assess the effect of forest logging on early growth, we compared the growth trajectories of 15 fish per lake, between periods (before and after logging) and between group of lakes (controls and logged) by means of RM-MANOVA. These results will improve our understanding of the mechanisms by which anthropogenic alteration of lake watersheds from logging can influence fish populations as well as revealing the mechanisms that underlie recruitment of yellow perch populations in the freshwater boreal ecozone.

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IMPAIRMENT OF DAMAGE-RELEASED CHEMICAL ALARM CUES OF JUVENILE ATLANTIC SALMON (*Salmo salar*) IN WEAKLY ACIDIC STREAMS: ARE THERE POPULATION OR ONTOGENETIC DIFFERENCES IN RESPONSE?
Damage-released chemical alarm cues play a critical role in the detection and subsequent avoidance of predators in aquatic environments. These cues are typically released following damage to the skin resulting from a predation event, and translate into significant survival benefits for responding individuals. It has been shown in a series of laboratory and field experiments that two species of salmonids (rainbow trout and brook charr) are impaired in their ability to detect and respond to damage-released chemical alarm cues under weakly acidified conditions (pH ~ 6.0) but not under neutral conditions. These experiments, however, were conducted on a single population of a single age class (0+), thus the generality of the effects of weak acidification remain unknown. In this study, we quantified the alarm response of 0+ and 1+ juvenile Atlantic salmon (*Salmo salar*) resulting from exposure to damage-released alarm cues in six natural streams ranging in mean pH between 5.71 and 7.49. Our results demonstrated that salmon present in weakly acidified streams did not exhibit any overt response to alarm cues (i.e. not different from stream water controls), while those tested in streams of neutral pH exhibited a stereotypical alarm response. While ontogeny did influence the response patterns in neutral conditions, no difference in response intensity was observable in weakly acidic conditions. These data suggest that damaged-released chemical alarm cues are generally ineffective in systems of weakly acidified conditions (which includes pH that are physiologically suitable for salmonids, e.g.~6.0) demonstrating a sub-lethal effect of pH associated with behaviour.

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MOBILIZATION OF ENERGY AND CONTAMINANTS BY THE ROUND GOBY (Neogobius melanostomus) POPULATION OF LAKE ERIE
Round gobies, invasive fish from the Ponto-Caspian region of Eastern Europe, arrived in Lake Erie in 1993. Since their arrival, they have had numerous ecosystem impacts including predation on eggs and young, and competition for habitat with native fishes for habitat, and alteration of material flows from the benthos into the pelagic food web. Using a bioenergetics model developed and tested for round gobies, we quantified the movement of energy and contaminants mediated by round gobies within the Lake Erie ecosystem. Our base model represents the current situation in Lake Erie, utilizing field observations of size-at-age, diet, thermal habitat, and energy density. Total prey biomass consumed and uptake of contaminants (PCB 180 and mercury) was used to quantify material flows mediated by round gobies. In west basin of Lake Erie, the round goby population consumed more than 13×10^4 tonnes of benthic prey per year, of which about 36% is dreissenid mussels (Dreissena polymorpha and Dreissena bugensis). Contaminant uptake included 466 g PCB 180 and 2028 g mercury/y. Population parameters (abundance, sex ratio, and mortality rates) had the greatest impact on the magnitude of material transfer, followed by diet. Future research should focus on these sensitive parameters to improve estimates of round goby impact on invaded ecosystems.

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VARIATION IN PRECAMBRIAN SHIELD LAKE CHEMISTRY AND BENTHIC MACROINVERTEBRATE COMMUNITIES: A SUMMARY OF 15 YEARS OF BIOMONITORING AT DESC
Precambrian Shield lakes have a history of acidification from sulphur emissions. To measure the response of these lakes to reduced emission levels, the Ontario Ministry of the Environment began a benthic macroinvertebrate sampling program at the Dorset Environmental Science Centre (DESC) in 1988. This study was intended to

provide a summary of those data, focusing on water chemistry and littoral benthic macroinvertebrate community data from 17 lakes sampled from 1988 to 2002. Trend analysis, coherence analysis, and ordination were used to evaluate changes in community structure and chemical parameters on both a spatial and temporal scale. The study lakes displayed long-term trends consistent with recovery from acidification, including increasing pH and alkalinity, and a shift in community dominance from Chironomidae to Ephemeroptera. There was strong coherence evident in the variation patterns of both chemical and biological variables in the study lakes, indicating the presence of an external influence on the system. This synchrony may have been a result of climatic changes, particularly El Niño cycles, which have been shown to cause re-acidification events in these lakes. The effect of climate may have been visible in the increased community variability observed in concordance with El Niño cycles, but this relationship requires further investigation.

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CONSERVATION GENETICS OF THE ENDANGERED COPPER REDHORSE (*MOXOSTOMA HUBBSI*)
Species are often negatively affected by anthropogenic habitat destruction and fragmentation. Conservation genetics is increasingly providing the adequate tools needed towards the preservation of biodiversity. The copper redhorse (*Moxostoma hubbsi*) is an endangered species of Quebec with a restricted distribution limited to the Richelieu River and a short section of the St. Lawrence River. The Richelieu population, now composed primarily of old adults, has been divided by a weir since 1849. The main objectives of the project were: 1) isolation and characterization of 21 microsatellite loci, 2) determine the genetic diversity and population structure; 3) employ these markers as a tool to avoid inbreeding during a supportive breeding program. A total of 275 samples were collected between 1984 and 2003. DNA was extracted from fin tissues as well as bone and scale samples from historical collections. Despite a small census size (~600-800) that has declined significantly over the past 30 to 40 years, the ageing remaining population still exhibits a high degree of genetic diversity with an average number of 11.75 alleles per locus and an overall expected heterozygosity of 0.79 ± 0.08. Results suggest that the samples from the Richelieu and St-Lawrence rivers are representative of a single population, with an F_{ST} value of 0.00258. The degree of relatedness among potential broodstock captured for a supportive breeding program suggested that only four crosses among a possible hundred were to be avoided. Cumulatively, this project empirically demonstrates the potential of genetic data towards effective conservation.

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COMPARISON OF GROWTH OF LAKE WHITEFISH (*COREGONUS CLUPEAFORMIS*) IN LAKES ERIE AND ONTARIO
Lake whitefish (*Coregonus clupeaformis*) are a cold-water, benthic feeding fish native to the Great Lakes basin. Trends in lake whitefish abundance were similar in Lake Erie and Lake Ontario from the 1950s until 1990, when abundance began to decline in Lake Ontario while increasing in Lake Erie. Although both lakes have undergone similar environmental changes, from decreasing phosphorous loading to invasion by dreissenid mussels, declining growth and condition were more pronounced in Lake Ontario. Reduced size-at-age was clearly evident in Lake Ontario, but remained constant in Lake Erie until the late 1990s. Limited size-at-age data are available for earlier time periods in both lakes to evaluate growth responses to ecosystem change. We used archived scales to back-calculate length-at-age of lake whitefish during three distinct time periods: 1) pre-phosphorous abatement, 2) post-phosphorous abatement but pre-dreissenid invasion, and 3) post-dreissenid colonization. Bioenergetics models will be used to evaluate different hypotheses related to changes in growth, including changes in diet composition, prey availability, and spatial distribution of lake whitefish.

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SPREADING THE WORD, NOT THE SPECIES: PREVENTING THE INTRODUCTION OF INVASIVE SPECIES IN ONTARIO THROUGH PUBLIC OUTREACH
Introductions of aquatic invasive species pose a significant and increasing threat to Canada's aquatic resources. While many of these introductions have occurred unintentionally via pathways such as ballast, aquaculture, canals

and range expansions, many have been intentionally released or inadvertently spread by un-informed citizens. Information and education programs play a critical role in preventing unauthorized introductions by the public to Canada's natural waters. Outreach initiatives focused on specific pathways such as overland transfers by recreational watercraft have been demonstrated in several jurisdictions to be both cost effective and highly successful in preventing introductions. Over the last decade, the Ontario Federation of Anglers and Hunters in partnership with the Ontario Ministry of Natural Resources, industry stakeholders and a variety of Canadian and U.S non-governmental organizations have undertaken a variety of outreach initiatives focused on recreatonal watercraft, baitfish and unauthorized fish introductions in Ontario. This presentation will provide an overview of the issues associated with invasive species introductions and public outreach, the challenges in reaching specific audiences in different geographic regions, changing public attitudes and behaviors, and will detail some of the current initiatives to deal with the problem in Ontario.

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NATIONAL AQUATIC INVASIVE SPECIES NETWORK
Canada's freshwater and coastal marine ecosystems have sustained a series of high-profile biological invasions by nonindigenous species (NIS). Eastern coastal marine ecosystems have been invaded by tunicates, crabs, pathogens amongst others. The Great Lakes have been invaded by at least 170 species and continue to experience reports of new NIS invasions. Native biodiversity in mountain lakes in western Canada has been dramatically altered by introduction of sport fishes. Finally, western coastal waters host shipping and other activities that may predispose these regions to invasions by NIS. Once established, NIS undermine management efforts owing to the unpredictable ecosystem trajectories that these species may precipitate. Additionally, established NIS threaten production of natural and aquaculture-reared marine resources. To date, Canada had not developed effective programs to prevent or mitigate NIS invasions in any ecosystem. We are presently forming a network of 35 faculty from 8 provinces in conjunction with Department of Fisheries and Oceans to address four priority areas: 1) vectors and pathways; 2) factors affecting NIS establishment; 3) trophic disruption associated with NIS; and 4) prevention and mitigation. Our network will address common questions for each of three geographic nodes: Gulf of St. Lawrence and coastal Nova Scotia; Great Lakes - St. Lawrence River; and mountain lakes and coastal marine ecosystems in western Canada. We intend to integrate results from these studies to assist federal and provincial managers with policy development, and dovetail our efforts with those in the USA to provide continental coverage.

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SWIMMING IN UNCHARTED WATERS: THE ECOLOGY AND MANAGEMENT OF SMALL BROOK TROUT STREAMS IN ONTARIO'S BOREAL FOREST
Forest management in Ontario is restricted in areas adjacent to lakes and streams to protect aquatic habitat. Recent research has questioned the necessity of forested reserves along shorelines, suggesting that forest management may occur with minimal risk to aquatic habitat if appropriate management practice guidelines are followed. Unfortunately, current guidelines and policy apply only to mapped streams. In preliminary surveys we estimated that approximately 30% of the stream network in our study watershed was not mapped. These small streams, which provide habitat for brook trout and contribute water and nutrients to larger streams, may be physically disturbed during forest harvesting. Our research is focuses on locating, classifying (based on fish habitat) and developing guidelines to protect small streams. We have utilized hydrologic models to predict the location of small streams. Field validation of these models indicates that permanent stream channels can be accurately predicted based on upstream contributing area and local topography, particularly riparian zone dimensions. Of the 44 small streams (catchment area less than 1 sq km) we have surveyed, 20 contained young of year brook trout. We have developed and validated a model to predict the presence of brook trout using information on the stream's position in the watershed and proximity to a source population node. Finally, the results of this research have been used to revise Ontario's forest management guidelines and policy by increasing the level of planning and protection directed at small stream systems in order to improve their sustainability.

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A NEW METHOD TO MEASURE BENTHIC PRIMARY PRODUCTION

In the lower Laurentian Great Lakes, the biomass of the benthic filamentous green alga, *Cladophora glomerata,* appears to be on the rise. In summer months this alga, once a major impetus for phosphorus controls to the Great Lakes, covers areas of hard substrate with near total dominance, in some places exceeding biomass of 100 g DW· m^{-2}. *C. glomerata* is recognized as a nuisance because in midsummer large quantities detach and wash ashore. In recent years, there has been an increase in public complaints associated with detached *C. glomerata* fouling shorelines and clogging water intake pipes. The cause of this detachment is poorly understood, but possibly related to metabolic imbalance.

To better predict the distribution, growth dynamics and the detachment phenomenon of *C. glomerata*, we need to accurately quantify its potential primary production *in situ*. Traditional methods for measuring benthic primary production involve incubation chambers deployed for several hours with measurements of initial and final dissolved gas concentrations (generally O_2). With high metabolic rates, these methods are not favourable for measuring macroalgae productivity for two main reasons: (1) metabolic gas flux in chambers during lengthy incubations may be curvilinear due to feedback mechanisms resulting in an underestimation of photosynthetic rates and (2) containment of macroalgae reduces water flow over their surface, thereby inhibiting a potentially critical mechanism used to acquire dissolved CO_2, reducing measured rates of photosynthesis, particularly during long incubations.

Here we report a new technique to measure *in situ* benthic primary production by simultaneously measuring changes in CO_2 and O_2 concentration continuously in benthic chambers over short time periods. By continuously monitoring gas concentrations, the shape of the rate function is easily observable. Furthermore, because the incubation times need only be short (e.g. 15 minutes), artefacts related to decreased water velocity are minimized.

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RISK ASSESSMENT OF ASIAN CARPS IN CANADA

Four species of Asian carps (bighead carp, black carp, grass carp and silver carp) have been introduced worldwide for aquaculture purposes. Subsequent to introduction into the southern United States, all four species have become established in the wild. Two species, bighead and silver carps, have been dispersing rapidly up the Mississippi River, wreaking ecological havoc along the way. As there are numerous connections between the Mississippi basin and Canadian watersheds, including the Great Lakes, there is considerable concern about their potential ecological impacts if established in Canada. In addition to natural dispersal, these species may also be introduced into the Canadian wild through the live food fish trade. Canada represents over 50% of the market for bighead and grass carp cultured in the United States. The Canadian government conducted a risk assessment to determine the ecological risk of Asian carps in Canada. This assessment included evaluating the risk of introduction, survival, reproduction, spread and fellow travelers (e.g. parasites, diseases, other invasive species). These components were assessed in an experts workshop using best available information on their biology, potential vectors of introduction, and impacts in both native and introduced ranges. The assessment concluded that the risk was high in, at least, some parts of Canada including the southern Great Lakes basin.

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IDENTIFYING PRIORITY AREAS FOR PROTECTING FRESHWATER SPECIES AT RISK IN CANADA

Priority areas for protecting freshwater species at risk in Canada were identified by creating an index based on the biodiversity of fishes and mussels, and on the threats to these taxa. Of some 229 fish species and 55 freshwater mussel species found in Canada, the highest diversity is found in southwestern Ontario where many species are at their northern range limit. In this most southerly region of Canada, species diversity peaks at 102 fishes and 34 species of mussels at the tertiary watershed level. Patterns of species at risk listed by COSEWIC mirror this pattern with richness peaking at 16 fish species and 8 mussel species in the tertiary watersheds of southwestern Ontario. Such diverse aquatic communities in this region are primarily attributed to moderate climatic conditions and biogeographic history. Unfortunately, this ‘crossroads of freshwater biodiversity’ in Canada occurs in the Great

Lakes where threats from human impacts and aquatic invasive species are most severe. To ensure the preservation of aquatic diversity in watersheds of the Grand, Thames, Sydenham and Ausable rivers, an aquatic ecosystem approach to recovery planning is underway.

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HOW MUCH SAMPLING EFFORT IS REQUIRED TO DETECT FRESHWATER FISH SPECIES AT RISK?
There are 31 fish species at risk (SAR) present in the Great Lakes basin. They are found in a wide variety of habitats from small, headwater streams to the hypolimnion of the Great Lakes proper. It is important to conduct ongoing assessments of the distribution and abundance of fish SAR to accurately determine conservation status, identify threats, and evaluate recovery actions. However, by their very nature, fish SAR are often difficult to capture and even more challenging to enumerate. We are currently developing species-specific sampling protocols for the ongoing, standardized monitoring of fish SAR. Preliminary sampling studies have allowed us to identify the most efficient gear to detect specific species at risk in both wadeable and nonwadeable systems. We are now interested in determining how much effort is required to determine fish community composition, and to detect fish SAR, using these gears at regional and local scales. To determine the sampling effort required at the regional scale, data for multiple sites sampled within the Sydenham River watershed were used to construct species accumulation curves. To determine sampling effort required at the local scale, data for multiple sites or transects sampled within Point Pelee (sites), Old Ausable Channel (sites), Sydenham River (transects) were used to construct species accumulation curves. The results of these analyses will allow researchers to determine the gear and amount of effort required to detect fish SAR detection prior to conducting field research activities.

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PHYLOGEOGRAPHY OF A HIGH ALTITUDE COPEPOD: *HESPERODIAPTOMUS SHOSHONE*
The freshwater diaptomid copepod *Hesperodiaptomus shoshone* occurs in high altitudes of Western North America, in the Rocky Mountains ranging from British Columbia to Colorado and in the Sierra Nevada of California. We carried out a phylogeographic study using partial DNA sequences of the Cytochrome Oxidase I gene from 49 populations representing the current distribution range of the species. The nucleotide sequences were analyzed using parsimony, maximum likelihood and distance based phylogenetic reconstruction methods. The genetic divergence among populations was high, and indicates that mountain ranges significantly restrict gene flow in *H. shoshone*. Our data revealed presence of two geographically distinct deep lineages (North/South), with further genetic sub-structuring within each region. We hypothesize that the observed patterns of genetic diversity and structure reflect historical dispersal events and episodic range displacement due to Pleistocene glaciations.

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VERTICAL DISTRIBUTION PATTERNS OF CAPELIN (*MALLOTUS VILLOSUS*) IN THE NORTHWEST ATLANTIC
Capelin (*Mallotus villosus*) is the primary prey of vertebrate predators in the Northwest Atlantic. This species traditionally carried out diel vertical migrations, occurring in discrete schools at greater depths during the day and migrating up to disperse and feed at night. In the 1990s, these migration patterns became irregular and capelin distribution shifted closer to the seabed. As part of a larger project examining the bio-physical factors influencing habitat selection of capelin, we investigate the vertical distribution and migratory patterns of capelin in relation to time of day and temperature. A vessel-based survey (~ 1600 km) was conducted aboard the CCG Research Vessel *Templeman* during mid-August 2004 on the northeast coast of Newfoundland. The distribution and density of capelin were determined during hydroacoustic transects between 50 pre-determined stations. At stations, we characterized the thermo-haline properties of the water column and the biomass of zooplankton and pelagic fish. In the two areas where large concentrations of capelin were found, water depth was >200 m resulting in the availability of three distinct thermal habitats: the warm mixed surface layer (0-50 m; 0-17°C), the cold intermittent layer (CIL;

50-225 m; <0°C) and the warm bottom layer (> 225 m; 0-4°C). Capelin undertook diel vertical migrations consistently throughout the study area. Many schools remained in warm water below the cold intermittent layer during daylight, but migrated through this layer into warm surface water during dark, then dissipated into dispersed aggregations. Some schools, however, remained below the CIL throughout the night. Findings are considered in the context of habitat selection of capelin for foraging, predator avoidance and bioenergetic considerations.

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THE IMPORTANCE OF ENVIRONMENTAL FLUCTUATIONS FROM INTERNAL WAVES TO BENTHIC ALGAL COMMUNITY STRUCTURE
Theoretical models and laboratory experiments show that fluctuations of abiotic factors may influence the biomass and composition of communities. In lakes, the regimes of temperature variability differ between upwind and downwind littoral sites. These temperature fluctuations are linked to physical disturbance from the internal waves and possibly to fluctuations in nutrients from sediment resuspension. In this study we test whether there is a difference in benthic algal biomass, species richness, and community composition with different regimes of environmental variability at upwind and downwind sites in a 6 km long basin. We set out standardized substrate tiles at four upwind and four downwind sites in Lake Opeongo, Ontario. There was no difference in biomass or richness, but the Shannon Diversity Index was higher at downwind sites. Environmental variability has a subtle effect on the structure of benthic algal communities.

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A NOVEL METHOD TO MEASURE THE STABLE ISOTOPIC SIGNATURE OF RESPIRED BACTERIAL CO_2.
Delineating the source and biological fate of organic carbon (OC) in aquatic systems is a challenge to ecologist and geochemist alike. Historically it was accepted that secondary production was supported by autochthonous (algal) OC. However recent studies have suggested the inverse, that allochthonous OC sources are fueling both microbial and higher food webs in aquatic systems. Although bacterial respiratory carbon demands are the major carbon sink in lake ecosystems, methodological limitations have prevented an accurate assessment of the isotopic signatures and hence sources of carbon respired. Here we present a novel method to measure the stable isotopic signature of respired bacterial CO_2. In brief large volume (~20L) water samples from lakes in southern Quebec were returned to the lab, acidified to a pH of ~2.8 and sparged with ultra high purity He to remove DIC. Incubations were subsequently reoxygenated with volatile organic carbon free air and the pH adjusted to initial conditions. Incubations were maintained for approximately 48 to 100 hours and terminated during log phase growth. Upon acidification, the CO_2 was isolated cryogenically. Isotopic $\delta^{13}C$ values of respired CO_2 ranged from –28.35 to –32.5 per mil across an oligotrophic to meso-trophic gradient of lakes. We compare the isotopic values of respired CO_2 with those of potential organic matter sources within the lakes (POC, DOC, DIC and zooplankton). Preliminary results suggest a substantial portion of the respired CO_2 is terrigenous in origin. An understanding of potential selective respiration of different OC sources (e.g. algal, terrigneous) is critical for predicting how cross-system gradients in the relative importance of these OC sources may subsequently impact the metabolic balance (autotrophic vs heterotrphic) in freshwater systems.

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LAKE TROUT LIFE HISTORY VARIATION: GENETIC OR PHENOTYPIC?
Lake trout (*Salvelinus namaycush*) exhibit substantial life history variation across their range. Populations at the northern and southern extremes of their distribution are markedly different, but considerable local variation also occurs in response to differences in forage communities. It is not known, however, if these differences are due to phenotypic plasticity, heritable adaptive responses, or both.

To assess the relative importance of environmental and genetic influences on lake trout life history, eggs were collected from two neighboring lakes in Algonquin Park, Ontario with contrasting ecotypes and forage bases. Louisa lake trout are primarily planktivorous and achieve relatively small asymptotic sizes whereas Opeongo lake trout are piscivorous and achieve larger asymptotic sizes. Eggs from both populations and interpopulation hybrids

were reared in a common controlled environment to assess heritable (genetic) life history differences among ecotypes.

Prior to maturation lake trout from Louisa Lake were found to have faster growth and reached maturation earlier and at smaller sizes than Opeongo lake trout. Opeongo lake trout had greater post-maturation growth rates yet produced fewer eggs per gram despite their larger size. Hybrids were intermediate between the parent populations. These results provide evidence that lake trout life history characteristics are driven by both genetic and environmental influences, extending current lake trout life history models, and management practices.

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EFFECTS OF LOW-HEAD BARRIERS ON STREAM FISHES: CHANGES IN SPECIES COMPOSITION DO NOT ALTER TROPHIC SERVICES

The relative importance of taxonomic diversity versus ecological diversity is currently the subject of considerable scientific and management debate. Small low-head barrier dams used in the biological control of parasitic sea lamprey (*Petromyzon marinus*) in the Laurentian Great Lakes can alter the diversity and composition of stream fish assemblages. We used fish sampling data from 24 matched pairs of barrier (with barrier) and reference (without barrier) streams and published accounts of foraging behaviour to test whether corresponding changes in trophic services accompanied the changes detected in species diversity and composition. Contrary to expectation, we found no differences in the trophic services provided by fish assemblages sampled above and below barrier locations and between barrier and reference streams. Four trophic guilds were identified using cluster analysis. For some guilds, representation above and below barrier locations differed between barrier and reference streams, but the differences were smaller than those observed for taxonomic groupings. Our analyses suggest that species missing or under-represented in barrier streams may be ecologically redundant or of marginal ecological importance to the trophic structure of the assemblage.

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MERCURY IN THE ENVIRONMENT: EVOLUTION OF AN ISSUE

During the 1950's and 1960's mercury became recognized as an environmental toxin capable of serious harm to wildlife and humans. Environmental protection agencies successfully controlled large industrial sources, but many waterbodies remote from contamination sources were found with fish at high, potentially harmful levels of mercury. With no apparent source of mercury to these pristine areas it was generally assumed that the mercury in these systems was a natural phenomenon.

In the 1980's we began to investigate the possibility that mercury in pristine areas was not a natural phenomenon. Initial efforts were impeded by the difficulties of working at the ultratrace levels of mercury in background systems, but by the late 1980's our lab at the Dorset Environmental Science Centre was one of the few in the world that was able to produce reliable data on the levels of mercury in water from pristine areas.

The results from our studies were surprising, as they clearly demonstrated precipitation was a major, and very likely the dominant source of mercury to pristine systems. The water draining from watersheds was not enhanced with mercury as expected from geological sources, but was 5 to 10 fold less than the concentration in precipitation. Watersheds were sinks, not sources for mercury.

Over the past decade the full complexity of mercury transformation, transport, and bioaccumulation began to emerge through studies in our lab and others. Some traditional models of mercury accumulation were validated and extended to non-fish species, but discoveries about the nature of the methylation of mercury greatly altered our view of this important process. Other discoveries such as the photoreduction of mercury in lake water revealed new pathways for the removal of mercury from natural water. Traditional notions such as the importance of food chain biomagnification have been eclipsed by a new understanding of the rapid accumulation of methylmercury by phytoplankton. At the other end of the food chain, we now have evidence that threat of mercury to fish-dependent wildlife is quite real. My presentation will highlight our contributions to this field, and touch on future directions for our studies on mercury.

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DOES LIPID AVAILABILITY LIMIT REPRODUCTIVE EFFORT IN WALLEYE, *SANDER VITREUS*?

A key requirement of effective fisheries management is a better understanding of the mechanisms driving recruitment variability. Recent research suggests that reproductive effort (the quantity and quality of gametes produced) in fishes is closely linked to the availability of surplus energy, usually stored as lipid. The lipid status of the adult stock has even been used as a predictor of year-class strength in some species. Here, we test the prediction that adult lipid status is positively related to reproductive effort within and among seven walleye populations sampled across Canada. Populations were selected across gradients of climate and exploitation, and exhibited wide variation in growth rates, gonadosomatic indices, and body lipid content. Males and females were analyzed for body size, age, condition, gonad size, egg size, and the moisture and lipid contents of four tissues (gonad, liver, muscle, whole body). Preliminary results indicate that lipid availability may limit reproductive effort within some populations, but the trend is less clear among populations. Walleye in some populations exhibit relatively low fecundity and small egg size despite having very high body lipid contents; this suggests that other factors can limit reproductive effort in some stocks.

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FEEDING DETRITAL MATTER TO DAPHNIA PULEX: ENHANCED SURVIVAL WITH ALLOCTHONOUS ORGANIC CARBON

Numerous studies have reported that energy fixed by phytoplankton is insufficient to fuel pelagic and benthic food webs and that community respiration typically exceeds gross production in unproductive lakes. It follows that allocthonous dissolved and particulate organic carbon (DOC and POC) provides some of this fuel. We tested the ability of a zooplankter, *Daphnia pulex*, to utilize detrital matter. Adults repeatedly survived longer when incubated in aged, unfiltered, humic stream water at pH 6 compared to filtered water (0.2 um). Irradiation did not improve survival rates. Scanning electron micrographs show highly fibrous particles with high surface area/volume ratios, providing niches for microbial attachment and adsorption of DOC. The POC fraction contained several essential fatty acids: DHA (C22:6n3), EPA (C20:5n3) and ARA (C20:n46).

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DIATOM ASSEMBLAGES AND WATER DEPTH IN LAKE 239 (EXPERIMENTAL LAKES AREA, ONTARIO): IMPLICATIONS FOR PALEOCLIMATIC STUDIES

Diatom assemblages in surface sediments were sampled along three transects in Lake 239, from the Experimental Lakes Area (NW Ontario), and analyzed in order to explore the relationship between modern species distributions and water depth. Approximately 170 diatom species were identified in surficial sediments at lake depths from 2 to 30 m. The species composition varied with sample depth but remained highly similar across all three transects. The main patterns of variation in the diatom assemblages across transects, derived from a detrended correspondence analysis (DCA), showed that assemblages were highly correlated (r = 0.97 to 0.98). Around 8 m the pattern of predominantly benthic composition changed to a planktonic assemblage dominated by *Cyclotella stelligera*. This depth currently corresponds to the depth of 1% light penetration as assessed from extinction coefficient measurements. Diatom species diversity increases with the switch to the near-shore benthic taxa in all three transects. Additionally, there is a large decrease in the ratio of chrysophyte scales to diatoms starting at 8 m. Light transmission data from wet and dry periods over the last 35 years suggests that during dry periods the extent of the littoral zone should change by over 2 m. Hence, we suggest that cores along a transect from 8 to 14 m should provide a highly sensitive location for detailed paleoclimatic study.

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NORDIC BIODIVERSITY ASSESSMENT METHOD: APPLICATIONS FOR CLIMATE CHANGE AND INVASIVE SPECIES RESEARCH

Analysis of fish community structure is widely considered as an integrative indicator of the ecological status of water bodies. Aspects of the fish community that contribute to community structure are species composition, species abundance, size (or age) structure and trophic composition. To assess fish community structure and biodiversity we are testing and developing the Nordic method, a standardized gillnet fishing procedure, for use in Ontario lakes. The Nordic nets consisted of 12 panels (1.5 X 2.5m each) with mesh sizes from 5 to 55mm (knot to knot) based on geometric series with a factor 1.25. Between 1999 and 2004 over 140 lakes in Ontario had been sampled using the Nordic method. Tests of mesh selectivity, effects of water clarity, behavioural avoidance, seasonal variation, and calibration with mark and recapture experiments have been carried out. In addition the Nordic method has been compared to existing species-speecific sampling protocols (e.g., spring littoral index netting for lake trout and fall walleye index netting). There was evidence from these surveys that most of the fish biomass was concentrated in the littoral zone (<6m depth) of these lakes. Also, many water bodies had been recently invaded by percid and centrarchid species since the original lake surveys of the 1970s and 1980s. The Nordic method provides a valuable assessment tool to evaluate ongoing fish community changes related to climate change and invasive species.

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MARINE FEEDING (DIET) OF ANADROMOUS BROOK TROUT (*SALVELINUS FONTINALIS*) INHABITING THE ESTUARINE SAGUENAY RIVER, QUÉBEC

Anadromous brook trout, otherwise known as sea trout, naturally occur in northeastern North America in river systems that closely access the sea. They generally experience a short but seasonally determined sea residence. Sea trout, after life at sea, are significantly larger than residents of the same age class, suggesting better feeding opportunities at sea. In Quebec, sea trout of the Ste-Marguerite River, as young as age 1+, enter the estuarine waters of the Saguenay River passing through the Ste-Marguerite bay (BSM) in early May. Upon their entry at sea, the new migrants (first time migrants) acclimatize to new salinities and temperatures, staying relatively close to freshwater inputs. During the summer months they remain either within the bay or in its vicinity, or travelling throughout the Saguenay River (SR), allowing for an in-depth investigation of their marine feeding. New migrant sea trout were thus captured periodically throughout the summer immediately upon their entry at sea. Stomach contents, obtained both from personal sampling and local fisher captures, were analysed for the detection of diet shifts, and muscle tissue was removed for stable isotope analyses allowing for a time-integrated portrait of the trout's marine diet. As suggested by both stomach content and stable isotope analyses, new migrants initially feed on freshwater invertebrates upon sea entry, but quickly shift to marine prey items such as mysids and amphipods. This highlights the potential role that this diet shift may play in allowing for rapid growth rates immediately upon sea entry, as prey items found in the BSM are more abundant and larger than those in the river system.

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THE ENDANGERED MUSSELS OF ONTARIO'S THAMES RIVER WATERSHED – CAN THEY SURVIVE?

Freshwater mussels are the most imperiled group in North America with nearly 70% of the approximately 300 species considered at risk of extinction. Eleven of the 55 species which occur in Canada have already been assessed by COSEWIC as being at risk (1 extirpated, 8 endangered, 2 special concern) with additional listings imminent. Southern Ontario is the hot spot of mussel diversity in Canada and home to 41 species including all 8 of the species listed as endangered. The Thames, Grand and Sydenham rivers of the Lake Erie/Lake St. Clair drainage are the most diverse mussel rivers in Canada however serious declines have been noted in all three rivers during the last 2 decades. Eight of the 34 species, including 4 federally endangered species, historically known from the Thames River no longer occur within the watershed. The current project examined the distribution and population dynamics of mussel species at risk (SAR) within the Upper Thames watershed in an effort to determine the extent of current distributions and the likelihood that these species will persist within the river. Although one SAR, *Lampsilis*

fasciola, is still actively reproducing within the watershed the recent establishment and spread of zebra mussels in the upper reaches may further complicate the survival of this and other species.

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QUANTIFYING THE UNQUALIFIED: HABITAT
In the past 10 years, Bill Beamish was involved in several research projects that each had fish habitat as important components. These projects are diverse focusing on such topics as Atlantic salmon interactions with Chinook salmon, Lake Simcoe, lamprey, sturgeon and more recently, backwaters in south east Asia. Bill often challenged those working on these projects to first define habitat. As a physiologist he recognized that inter- and intra-annual and diel variations in factors such as alkalinity, dissolved oxygen, water temperature, and other limnological features of streams and lakes were important factors effecting the growth and development of fish and the quality or supply of their food. As a result, most field work required the collection or measure of several physical and chemical attributes at study sites and species specific definitions of habitat were developed. During Bill's long involvement with the Great Lakes Fishery Commission, agencies managing Great Lakes fish were encouraged to create environmental objectives. It is no surprise that these environmental objectives recognize the importance of the chemical, physical and biological components of habitat, and the larger scale hydrological processes effecting watersheds.

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ESTIMATING DAILY RATION IN FISH: WHAT REALLY MATTERS?
A simple model of the diel cycle of stomach contents in a fish (Atlantic cod, *Gadus morhua*) is developed from first principles using factors (predator weight, temperature, prey concentration, stomach contents, feeding periodicity and prey energy density) thought to be responsible for the majority of variation in food consumption estimates. Through comparing daily ration (DR) estimates using Pennington's (1985) method, it is shown that, beyond a simple designation of linear (*a=0*) vs. non-linear (*a=0.5*, *a=0.67* and *a=1*), the choice of the shaping parameter (*a*) of the stomach evacuation function is irrelevant. Furthermore, in a comparison to mean actual model DR, it is shown that the accuracy of the mean estimated DR is highest when using the exponential (*a=1*) form of stomach evacuation.

Determined through sensitivity analysis, the majority of variation in the DR estimates is due to predator weight and prey energy content. The Pennington method of estimating mean DR was found to be accurate when compared to both the mean actual model DR and actual consumption measured for trout in the lab (Elliott and Persson 1978). This accuracy was tested and maintained using two published simplifications of the Pennington (1985) method. The robustness of the results of this study was tested with different model forms and parameter error.

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EFFECTS OF THE SPATIAL CLUMPING OF FOOD ON AGGRESSION GRWOTH RATE AND GROWTH DEPENSATION WITH GROUPS OF CONCICT CICHLIDS
Aquaculturalists are interested in maximizing growth, while minimizing aggression, which leads to tissue damage, slower growth and growth depensation. Resource defence theory provides a theoretical framework for predicting the intensity of aggression and degree of growth rate variation in relation to the spatial clumping of resources. We tested for a dome-shaped relationship between the rate of aggression and degree of growth depensation versus the spatial clumping of food, which was manipulated via competitor-to-resource ratio (CRR), the number of potential competitors divided by the number of resource units. Groups of 10 convict cichlids (*Archocentrus nigrofasciatus*) were allowed to compete for a fixed amount of food in one of five CRR treatments (1, 1.43, 2, 5 and 10), created by varying the number of patches in which the food appeared (i.e. 10, 7, 5, 2, and 1 patch, respectively). As predicted, both the frequency of aggression and the coefficient of variation of body mass, a measure of the consequences of food monopolization and variation in a component of fitness within groups, increased significantly as CRR increased from 1 to 2, and then decreased significantly at CRRs of 5 and 10. In addition, mean growth rate

decreased in groups with high rates of aggression, suggesting an important cost of aggression. Our study provides insight into how food should be presented in an aquaculture setting to ensure low aggression, high growth, and low growth depensation.

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DIRECT AND INDIRECT IMPACTS OF THE *BYTHOTREPHES* INVASION ON *MYSIS RELICTA* IN ONTARIO SHIELD LAKES
Bythotrephes longimanus has rapidly spread from the Great Lakes and is making its way across the Canadian Shield. These lakes are highly valued for their support of natural populations and recreational use, including fishing. *Bythotrephe*s has changed zooplankton abundance and composition in lakes it has invaded (Michigan, Huron, Harp), and competes directly with *Mysis relicta* for cladoceran prey. *Mysis* is a large invertebrate, a glacial relict which inhabits the deeper regions of thermally stratified lakes. It provides an excellent food source for fish due to its size and high lipid content. We investigated the zooplankton community composition and the diet and lipid composition (total and essential fatty acids) of *Mysis* in seven lakes along a gradient of *Bythotrephes* invasion. Overall, we observed that: (1) cladoceran total biomass decreased in relationship to *Bythotrephes* abundance, (2) mysids ate *Bythotrephes,* especially when other preferred prey were not readily available, (3) total lipids were lowest in mysids from invaded lakes, and, (4) the composition of the essential fatty acids in mysids could be characterized by the invasion status of the lake.

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LONG-TERM PHOSPHORUS DECLINES IN CENTRAL ONTARIO LAKES
Over the past three decades, an examination of the trophic status of central Ontario lakes has been an important component of the lake monitoring program at the Dorset Environmental Science Centre. In particular, the collection of high-quality low-level nutrient data in lakes, inflowing tributaries, and atmospheric deposition has been used to calibrate and validate Ontario's Lakeshore Capacity Model. Consequently, a powerful dataset for evaluating long-term nutrient trends now exists for many lakes in central Ontario. We present thirty-years of nutrient data from eight headwater lakes in the Muskoka-Haliburton region. Our results indicate that lake concentrations of total phosphorus ([TP]) have declined by approximately 30% since the late-1970s, regardless of the initial concentration. A survey of several other waterbodies in the southern Canadian Shield suggests that this pattern is not restricted to small, headwater lakes. Furthermore, these trends are strongly correlated to a decline in phytoplankton biomass over the same time period. In an exploration of causes, analysis reveals that declines in lake [TP] are strongly linked to tributary loads. While climatic events such as drought and associated decreases in runoff provide a partial explanation for these trends, we explore other factors that may contribute to the gradual lowering of [TP] in lakes. Given the role of phosphorus in regulating algal populations in these nutrient-poor lakes, prolonged declines in [TP] will lower lake productivity, with possible implications for higher trophic levels, including recreational fisheries.

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SPATIAL AND TEMPORAL VARIABILITY OF PLANKTONIC FOOD CHAIN LENGTH: INFLUENCE OF LAKE SIZE, PRODUCTIVITY, DIETARY SHIFTS AND WEATHER CONDITIONS
Food chain length, or the number of intermediate consumers between primary producers and top consumers, is a basic property of ecosystems. In lakes, it can influence the biomass of piscivorous fish and the extent of contaminant bioaccumulation. Although the relationship between food chain length and ecosystem size and productivity have been well investigated, little is known of temporal variability, both seasonal and annual, of food chain length. Here, we present an isotopic analysis of the trophic position of four taxonomic groups of the

zooplankton community (*Daphnia*, calanoids, cyclopoids and *Leptodora*) in five chained lakes of the Canadian Prairies sampled fortnightly over a period of nine years (1994-2003). Trophic position of zooplankton taxonomic groups was measured as the difference in the nitrogen isotopic composition of primary producers (as particulate organic matter) and individual zooplankton taxa. Overall variability will be statistically decomposed into a lake, season, and year factor. We expect season to be the most important source of variability in food chain length, likely resulting from dietary shifts. This hypothesis will be tested by an examination of the carbon isotopic composition of algae and zooplankton, an indication of carbon sources. Finally, we will also quantify the importance of weather in accounting for inter-annual variability, and ecosystem size (lake volume) and productivity in accounting for inter-lake variability in food chain length.

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A COMPARISON OF BEACH AND DEMERSAL SPAWNING IN CAPELIN (*MALLOTUS VILLOSUS*) ON THE NORTHEAST COAST OF NEWFOUNDLAND
The biology and behaviour of capelin (*Mallotus villosus*), the focal forage fish in the Northwest Atlantic, has recently undergone dramatic changes. Capelin spawn both on and off beaches throughout their circumpolar distribution but are thought to spawn primarily on beaches in Newfoundland with the exception of the Southeast Shoal. Persistently used off-beach (demersal) spawning sites were recently discovered near-shore within a bay and on the exposed coast. Timing of spawning, length of spawning events and duration of egg incubation are compared among 3 sites in the Cape Freels North region: Capelin Cove Beach (0m; water temperature: 4.0 – 17.0˚C; air temperature: 6.0-28.5˚C), Turr Island (18 m; 2.9 - 15.6 ˚C) and Gull Island II (28 m; 1.9 - 6.1˚C). A 6.5 cm diameter steel corer was used to sample the beaches and demersal sites were sampled from a commercial fishing vessel using a 30 cm^2 Van Veen bottom grab system. Spawning commenced at the beach on July 11 and lasted for 3 days in contrast to ~12 days at the demersal sites which began 2 weeks later. Eggs appeared to develop at predicted rates and emergent larvae were observed near estimated hatching dates. Incubation periods were longer at demersal (23-32 days) relative to beach sites (~10 days), presumably due to a lower temperatures, but there were a higher proportion of dead and abnormal eggs at the beach (2-32 %) relative to demersal sites (0-11 %). Findings are considered in the context of the relative contribution of beach and demersal spawning to overall reproductive success in our study area.

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TROPHIC DYNAMICS IN THE ZOOPLANKTON COMMUNITY ALONG A DOC GRADIENT.
In light of changing dissolved organic carbon (DOC) in temperate lakes, we investigated how trophic dynamics within the zooplankton community will change. Specifically, we used $\delta^{13}C$ isotopic signatures to evaluate whether feeding patterns among different zooplankton taxonomic groups can change along a DOC gradient. We surveyed 15 lakes for zooplankton in the Dorset area with a wide range of DOC (1.7-9.8 mg/L) in July and August, 2004. Zooplankton $\delta^{13}C$ signatures ranged from -34.2 to -26.8‰ for *Daphnia*, -38.7 to -28.9‰ for *Holopedium*, -36.5 to -27.2‰ for cyclopoids, -35.6 to -27.2‰ for small calanoids, -33.6 to -25.3‰ for large calanoids and -33.9 to -27.3‰ for *Chaoborus*. Among lakes, $\delta^{13}C$ signatures of the zooplankton groups became more variable as DOC concentration declined. In a lake with a DOC concentration of 9.8 mg/L $\delta^{13}C$ signatures ranged from -35.3 to -31.6‰, whereas in a lake with a DOC of 1.7 mg/L $\delta^{13}C$ signatures ranged from -38.7 to -27.7‰. These results suggest that at high DOC levels there is much dietary overlap and the zooplankton groups are generally feeding on food derived from closely related carbon sources. In contrast, at low DOC levels different carbon sources are being utilized by various zooplankton groups leading to reduced dietary overlap. We therefore expect that trophic dynamics in the zooplankton community will be altered as DOC changes in temperate lakes.

Amber K. **Peters***, Michael L. Jones, Jim Bence, Dale Honeyfield (peter420@msu.edu)
ENERGY DYNAMICS OF LAKE MICHIGAN CHINOOK SALMON
Lake Michigan fishery managers seek tools to assess nutritional stress in Chinook salmon, *Oncorhynchus tshawytscha,* populations. We collected more than 300 Lake Michigan Chinook salmon, over a 4 year period, and analyzed them for water content, lipid content, protein content, caloric content, stomach content, and bacterial

kidney disease. These analyses were performed on muscle tissue, liver tissue, and a homogenized whole carcass sample for each individual. Data were analyzed to determine effects of size, sex, maturity, and season on nutritional status. In addition, values among tissue samples were analyzed to determine how effectively a tissue sample would predict values for the whole carcass. A concurrent winter-simulation study was performed in a laboratory to provide comparisons with the field data. Water content, caloric content, lipid content and *Renibacterium salmonarum* load were significantly different when compared between seasons. We found a strong negative correlation between water content and lipid content. We determined that muscle tissue provided the best estimate of whole fish nutritional status. Conclusions from this study were used to outline a monitoring program for Chinook salmon in Lake Michigan in which we recommend using water content in a dorsal muscle plug as an indicator of nutritional status, collection of samples in the late spring/early summer from immature fish, and documentation of the proportion of fish with over 78% water content in the muscle tissue.

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CHANGES IN CYPRINID HABITAT USE IN RESPONSE TO THE INTRODUCTION OF BROOK TROUT (*SALVELINUS FONTINALIS*) IN TWO OLIGIOTROPHIC LAKES IN NORTHERN ONTARIO.
The littoral zone of lakes contributes to fish community dynamics, as it offers diverse habitats through various depths, substrates, and macrophyte density gradients. Fish of various life stages and species are often found associated with particular habitat types. Habitat partitioning, and the high densities of fish most often found in vegetated areas have been attributed to two main factors: the availability of food and refuge from predation. The objectives of my research are to characterize patterns of cyprinid habitat use in the absence of predators and to observe if changes occur in these habitat use patterns after the introduction of predatory brook trout (*Salvelinus fontinalis*). Fish habitat use was observed via snorkelling line transects, and habitat specific population estimates were obtained by using distance sampling methodology. In the summer of 2002 and 2003 five lakes in northern Ontario were censused; two of these lakes were without predators. In the spring of 2004, brook trout were introduced to the predator free lakes, and during the summer of 2004 the five lakes were re-censused. Based on proportion of fish observed in a given habitat, and proportion of the littoral zone that the habitat encompasses, a measure of fish habitat use can be obtained. Preliminary analysis suggests that after the introduction of piscivores, cyprinids shifted habitat use: fish used habitats that were more structured, including emergent vegetation and beaver lodges, to a greater extent and did not use the more open habitats as frequently. However, habitat shifts observed appears to be species specific.

Popowich, R.C.*[1], E.B. Taylor[2], J.D. Stelfox[3], and J.P. Volpe[1].
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HYBRIDIZATION BETWEEN INVASIVE BROOK TROUT AND NATIVE BULL TROUT; GENETIC CONFIRMATION AND VALIDATION OF MORPHOLOGICAL AND MERISTIC IDENTIFICATION TECHNIQUES
Introduced brook trout (*Salvelinus fontinalis*) are causing concern for fisheries management where brook trout are invading waters inhabited by depauperate bull trout (*Salvelinus confluentus*) populations. In addition to increased resource (food, habitat, mate) competition, genetic introgression and hybridization represent a serious threat to native bull trout through loss of native gene pools, wasted reproductive effort, and the introduction of a potentially superior competitor (hybrid vigor). Management decisions are complicated by the fact that bull trout-brook trout hybrids are difficult to identify. Morphological characteristics (especially colour) are subjective and are distorted post mortem. Meristic characters can be useful but usually require lethal sampling. Genetic analyses are reliable but rarely available. In response to these problems, this study is attempting to i) implement genetic analyses to confirm the presence of bull trout-brook trout hybrids in Alberta, ii) determine the degree of introgression and sexually asymmetrical spawning events, iii) use genetic analyses to validate hybrid identification using morphological characteristics and meristic counts, and finally, iv) to develop comprehensive identification techniques for use in management. Contrary to most published findings, our preliminary genetic results indicate that introgression has progressed past the F_1 generation suggesting that bull trout-brook trout hybrids are viable. This further complicates identification efforts in that successive generations of hybrids may display diagnostic and parental hybrid traits to varying degrees, depending on their lineage (e.g. F_1 vs. F_2 vs. backcross). Successful

implementation of identification techniques will ensure accurate population estimates and provide fisheries management with reliable information regarding potentially introgressed bull trout populations.

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SCIENCE REQUIRED TO SUPPORT IMPLEMENTATION OF CANADA'S NEW SPECIES AT RISK ACT
Canada's new Species at Risk Act (SARA) entered fully into force in June 2004. SARA implementation requires scientific input in several key areas: assessing species risk status, establishing recovery objectives, identifying critical habitat, assessing allowable mortality, and identifying populations below the species level which merit protection. SARA provides for assessment of risk status by the Committee on Status of Endangered Wildlife in Canada (COSEWIC), an advisory body operating at arm's-length from government, while science advice on other issues will be provided by government agencies, in partnership with non-government scientists. The scientific issues to be addressed are similar to those in fishery assessment and management, but a much wider range of species and of threats must be considered than has been common in current Canadian fishery and aquatic science. Assessment of allowable mortality (required to support issuance of permits) can probably be done by adapting existing population dynamics and stock assessment approaches, but other SARA science questions are quite fundamental and require some conceptual thought: what constitutes "recovery" and when can we call a species or population "recovered"? what habitat is essential for survival and recovery? on what basis do we call a widely-distributed marine fish "endangered"? SARA requires a level of specificity in addressing some science issues which is not found in previous conservation legislation, and this may lead to changes in how scientists review and formulate advice relative to species at risk.

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CARBOCENTRIC LIMNOLOGY: BACKWARD AND FORWARD LOOKS. **Rigler Lecture**.
Abstract to be provided

Prairie[1], Y.T. and M.L. Pace[2].
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A GLOBAL ESTIMATE OF LAKE RESPIRATION
We developed empirical models of planktonic and benthic respiration from the literature and used these to project a global estimate of the carbon respired annually in the world's lakes. Respiration in both the water column and sediments is primarily dependent on lake nutrient concentrations and can be effectively modelled using total phosphorus. Respiration also depends on temperature and is related to other factors including dissolved organic carbon and food web structure. Using the models and global lake size distributions, we estimate that 62 Tmoles C per year are respired annually in the world's lakes exceeding the estimated annual gross primary production (54 Tmoles C) of these ecosystems, which implies a substantial oxidation of land derived organic carbon in lakes.

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PALEOLIMNOLOGICAL EVIDENCE OF RECENT CULTURAL EUTROPHICATION AND CLIMATE CHANGE VARIABILITY DURING THE LAST 300 YEARS IN LAKE MALAWI, EAST AFRICA
Lake Malawi is the second largest lake in Africa supporting diverse populations of endemic cichlids and supplying water resources to its riparian nations Malawi, Mozambique and Tanzania. However, rapid deforestation, population growth and intensive agriculture, especially in the southern catchments, have led to greater soil erosion over the last half century. Additionally, climate variability is an important regulator of limnological conditions by altering water levels, wind speeds and water temperature. In order to assess the effects of land use change and climate variability in Lake Malawi in the absence of long-term monitoring data, paleolimnological techniques were used. Four multi-cores were collected in 1997 and 1998 along a longitudinal transect, dated with ^{210}Pb analyses and analyzed for biogenic silica and diatom community composition. These four sites span gradients of land use and latitude, enabling reconstruction of limnological conditions during the past 300 years. Results indicate that patterns of diatom assemblage change are not uniform lake wide. Southern cores contain the first conclusive evidence of nutrient enrichment commencing in 1970, with increased sedimentation rates, diatom influx, silica burial rates and

shifts towards eutrophication-indicator diatom taxa, similar to observations made in Lake Victoria. The succession of diatoms in southern Lake Malawi begins with high percent abundance of *Aulacoseira nyassensis* and *Fragilaria africana,* followed by a shift towards diatom species with reduced silica requirements. The stratigraphies from the north end of the lake indicate no recent change in trophic status in the northern portion of Lake Malawi. However, both the north and central cores are highly sensitive to climatic variations. The Little Ice Age is denoted by an increased percent abundance of *Aulacoseira nyassensis,* while lake level rises in ca. 1850, 1937, 1961 and 1980 AD are reflected by increased percent abundance of *Stephanodiscus nyassae, S. minutulus* and *S. muelleri.* Meanwhile lowstands, resulting in reduced external nutrient inputs, correspond with relatively high percent abundance of *Cyclostephanos malawiensis*. These paleolimnological interpretations alert lake management to the threat of lake-wide eutrophication of Lake Malawi, should current land use practices persist.

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PALEOECOLOGICAL RESEARCH AT DESC – A SUMMARY

Rewarding partnerships have been developed between the Dorset Environmental Sciences Centre and university researchers using paleoecological approaches to determine long-term responses of lake ecosystems to human stressors such as acidic deposition and recreational shoreline development (cottages, resorts). The "calibration set" approach in paleolimnology, coupled with DESC's limnological databases for south-central Ontario lakes, has yielded numerous datasets describing the distribution of many aquatic taxa (diatom, chrysophyte, chironomid) to important limnological gradients such as trophic status and pH. Paleoecological inference models have been developed to 4reconstruct past changes in lakewater pH, TP, and hypolimnetic oxygen (as volume-weighted hypolimnetic DO). The examination of long-term changes in algal and chironomid assemblages from dated sediment cores and using the 'top-bottom' approach has yielded insights including: 1) lakes that experienced large pH declines due to acid deposition also experienced large TP declines; 2) small headwater lakes have suffered the greatest pH declines; 3) acidified watersheds with wetlands have experienced more variable aquatic community structure in response to droughts, compared to watersheds with no wetlands; 4) apparently inconsequential hydrological control structures (dams) have had a substantial impact on increasing hypolimnetic oxygen levels; 5) algae that produce taste-and-odour problems have increased in many shield lakes in recent decades; 6) in contrast to paleolimnological approaches, the Lakeshore Capacity Model is not able to estimate long-term declines in TP, or increases in hypolimnetic oxygen, in watersheds with anthropogenic TP inputs.

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EVALUATING LONG-TERM TRENDS IN CRAYFISH POPULATIONS FROM ACID SENSITIVE, SOFTWATER LAKES IN SOUTH CENTRAL ONTARIO (1988-2004)

The Dorset Environmental Science Centre has monitored crayfish populations in small lakes on the Precambrian Shield since 1988. Baited minnow traps have been used to sample crayfish and estimate relative abundances. To evaluate changes in crayfish catch per unit effort, we used the Mann-Kendall trend test which is a rank-order based method that is easy to calculate and insensitive to missing values. Each of the three common crayfish species, *Cambarus bartoni*, *Orconectes propinquus*, and *O. virilis,* were found in 8 lakes. However, some lakes contained several species of crayfish, and some lakes did not support any crayfish populations. We suspect that these latter lakes have not been re-colonized by crayfish following improvements in water quality, especially pH. The Mann-Kendall trend test indicated significant declines in the relative abundances of *C. bartoni* in 5 lakes, whereas *O. propinquus* and *O. virilis* catches have each declined in two lakes. The reasons for these declines are not obvious. For example, the decline in relative abundance of *C. bartoni* is unexpected, and somewhat surprising since *C. bartoni* is more acid tolerant than the two orconectid species. Perhaps observed declines in calcium and increases in lake-water aluminum concentrations are affecting some crayfish populations. Undoubtedly the concomitant introduction of largemouth and smallmouth bass (*Micropterus* spp.) has affected crayfish catches in at least one lake. Long-term monitoring of crayfish relative abundances and the evaluation of changes using the Mann-Kendall

test have underscored that the biota in many small lakes in south-central Ontario are not recovering from the effects of acidification as quickly as expected.

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EFFECTS OF HABITAT FRAGMENTATION ON TRENT RIVER REDHORSE SUCKER POPULATIONS;
The lower section of the Trent-Severn Waterway (Trent River) has been highly fragmented by hydro-electric and navigation dams. Between 1999 and 2003, we investigated the effects of river fragmentation on the demographic characteristics of four redhorse species: greater redhorse, river redhorse, shorthead redhorse and silver redhorse. Redhorse abundance during both the spawning period (May-June) and in the fall was positively correlated to river fragment length. The numerical dominance of shorthead redhorse in the largest river fragments was reduced in the medium and small-sized fragment. Male and female redhorse in spawning condition were either absent or rare in the smallest river fragments (<1.5 km in length). Skewed length-frequency distributions in the smallest fragments further indicate a lack of reproduction. Between 2000 and 2003, more than 6000 redhorse were marked with individually coded floy-tags. Two hundred and eighty tagged redhorse were recaptured, of which six were recaptured in river fragments outside the point of initial capture. Recapture data indicate that a small percentage of individuals are moving upstream and downstream between fragments, presumably over dams or through the navigational locks. Together, these observations suggest that redhorse populations along the Trent River exhibit source-sink population dynamics.

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DISTRIBUTION AND ECOLOGY OF THE CHANNEL DARTER IN THE BAY OF QUINTE DRAINAGE (LAKE ONTARIO)
The development of conservation and recovery strategies for Canadian channel darter (*Percina copelandi*) populations is limited by a lack of knowledge regarding ecology, population size and other factors that affect its distribution and abundance. During 2001 and 2003, five rivers in the Bay of Quinte drainage were sampled in order to test whether channel darter distribution reflected riffle micro-habitat characteristics (water velocity, depth, substrate) or landscape-scale factors such as surficial geology and waterfalls. One hundred and sixteen individuals were captured from 15 of the 47 sites sampled. Otolith-based age estimates ranged between 1 and 5 years with most channel darters either 2 or 3 years old. Male and females in spawning condition were collected between June 1st and 27th as water temperatures increased from 14.5 to 25^{o}C. At most sites yielding channel darters, riffles flowed into deep sand-bottomed run or pool habitats. The distribution of channel darters did not reflect either local surficial geology or riffle micro-habitat characteristics. However, the upstream limits of their occurrence corresponded with impassable waterfalls. Alternatively, the distribution of three other riffle dwelling species (*Etheostoma flabellare*, *P. caprodes* and *Rhinichthys cataractae*) reflected among site differences in riffle habitat and local surficial geology.

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PREY ELECTIVITY OF LAKE WHITEFISH IN THE CANADIAN WATERS OF LAKE HURON
Recent declines in growth, condition and recruitment of lake whitefish (*Coregonus clupeaformis*) stocks in the Great Lakes have been broadly attributed to the invasion of two species of dreissennid mussels; the zebra mussel (*Driessenna polymorpha* and *D. bugensis*). Other studies also suggest that another invasive species, the spiny water flea (*Bythotrephes longimanus*), may also have negative effects on whitefish growth rate and condition. These conclusions have been drawn largely from qualitative observations of the presence of these non-indigenous species (NIS) in the stomachs of lake whitefish, and from long-term benthic monitoring data. Great Lakes invertebrate communities appear to have changed dramatically since the appearance of these invaders, resulting in the loss of some once-abundant whitefish prey species. However, the quantitative relationship between Great Lakes lake whitefish diets and the benthic and pelagic invertebrate communities on which they feed has not been adequately described. For example, the degree to which lake whitefish might ‘select’ a given prey item over another relative to

its abundance is unknown. Alternatively, lake whitefish may feed entirely at random, in which case their diets should closely reflect the invertebrate community composition in which they feed. The degree of selectivity exhibited by lake whitefish is important in determining whether the present state of lake whitefish stocks are in fact due to changes in the benthic and planktonic communities following the invasion of NIS. Here, we examine (1) changes in the benthic invertebrate and zooplankton biomass before and after the invasion of NIS, (2) describe whitefish prey electivity using benthic and zooplankton community data and whitefish stomach content data collected in 2002 and 2003 from South Bay and Cape Rich, Lake Huron, and (3), briefly discuss the impact that observed changes in whitefish prey may have on diet assimilation rates and foraging activity in whitefish.

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CHANGES IN THE FISH COMMUNITIES OF THE KAWARTHA LAKES
IN RESPONSE TO ANTHROPOGENIC STRESSORS
This research investigated the role of changes in water clarity, nutrient levels and temperature in structuring the fish communities of large, shallow warm-water lakes. Concern has been expressed about a perceived decline in fishing yields in some of the Kawartha Lakes (central Ontario), but it is not known whether such declines are system-wide, and whether or not they are symptomatic of historical changes in the fish assemblages in these lakes. The objectives of this research were to characterize the patterns in the fish community structure in these lakes, document the changes in the fish assemblages throughout the past 25 years, and to assess whether such changes are related to changes in nutrient concentrations and/or the productivity of lower trophic levels. Extensive data on the historical fish communities were collected using standardized trapnetting surveys; gillnetting and funnel trapping were used to assess the current fish communities. Total phosphorus, chlorophyll *a* and zooplankton were collected to identify productivity differences between the lakes. Secchi depth was collected as a measure of water clarity. There was no significant change in the overall abundance of piscivores and no consistent changes in the species composition of the piscivore guild based on CUE over the period from 1980 to 2003. There has been a regional scale decline in the relative abundance of walleye and an increase in the relative abundance of *Micropterus* species. An increase in water clarity due to reduced nutrient loading and the introduction of zebra mussels and warmer summer temperatures were factors that corresponded with a decline in walleye relative abundance and an increase in the relative abundance of *Micropterus* species in these lakes.

Robinson*, C. (Ontario Federation of Anglers and Hunters' Fisheries Research Unit, Peterborough, Ontario), D. Brown (Ontario Federation of Anglers and Hunters, Peterborough, Ontario), and M. Rawson (O.M.N.R. Kawartha Lakes Fisheries Assessment Unit, Lindsay, Ontario). (E-mail: chris_robinson@ofah.org)
LONG-TERM GROWTH OF WALLEYE IN THE KAWARTHA LAKES – EXAMINING THE EFFECTS OF TEMPERATURE
Walleye (*Sander vitreus*) populations in the Kawarthas region of Ontario have experienced a series of changes in the past 30 years, including reductions in phosphorous loading, fish community, and global climate change. We developed long-term growth chronologies for the walleye populations of five lakes in the Kawarthas from archival scale samples collected by the Ontario Ministry of Natural Resources. Two populations, Balsam (n=1280) and Scugog (n=1174) Lakes, had mean annual deviation from expected growth linearly regressed against mean daily June-July-August air temperatures and growing degree days (GDD) above 5°C. The Balsam Lake population's growth chronology did not have significant relationships with mean summer temperature or GDD; however, *post hoc* significant relationships between ages 1 ($p<0.001$; $r^2=0.307$) and 2 ($p=0.005$; $r^2=0.233$) growth and September temperatures were observed. The Lake Scugog population was observed to have significant relationships between ages 1 ($p=0.009$; $r^2=0.236$) and 2 ($p=0.034$; $r^2=0.182$) annual growth and GDD. A significant relationship was also observed between age 1 growth and mean summer temperature ($p=0.008$; $r^2=0.243$). No significant relationships between annual growth of the two populations were observed at any age. We speculate the differences in responses to temperature in these populations may result from different lake characteristics, with Balsam Lake being deeper than Lake Scugog (mean depth 5.0m vs. 1.8m), or differences in fish community changes. This suggests even geographically proximate fisheries will exhibit different responses to future climate change. Further analyses and forthcoming data from Rice, Buckhorn, and Pigeon Lake populations will help expand upon this issue.

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WITHIN AND ACROSS LAKE pCO_2 HETEROGENEITY.
The spatial and temporal variability in surface water pCO_2 concentrations was studied in 10 lakes of varying trophic status in the Eastern Township region of Southern Quebec. The aim of the project is to i) determine what parameters influence and can explain the observed heterogeneity; and ii) determine how pCO_2 variability within lakes can be used to assess current estimates of lake metabolism. On any given day spatial variability within a lake was found to be large and independent of trophic state. It was also observed that at any one point in time a lake can be both under-and oversaturated in pCO_2. This variability is further overridden by seasonal variability, with variability decreasing in mid-summer and increasing again towards the end of the season. This may be a reflection of a shift from primarily internal biotic to external abiotic controls. GIS techniques are used to map the spatial heterogeneity of surface water pCO_2, O_2, pH, temperature and bathymetry. Combined with surface elevation contour maps we hope to identify hot spots related to slope and groundwater input. Additionally, statistical analysis are being performed to determine the most influential parameters and to use these to best predict the degree and magnitude of pCO_2 spatial and temporal heterogeneity.

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COMPARISION OF GROWTH RATES OF LIMNETIC AND DRIFT-FEEDING JUVENILE COHO SALMON IN OFF-CHANNEL HABITATS
Limnetic feeding in the water column of still water (pond or lake habitat) vs. drift-feeding in faster water (stream habitat) represents a fundamental dichotomy in foraging strategies. Although juvenile coho will rear in both flowing streams and constructed off-channel pool habitat, it is unclear which strategy maximizes growth. We compared growth rates of juvenile coho drift-feeding in enclosures placed near the inlets and outlets of off-channel ponds to coho feeding in the water column of enclosures in still water at the center of ponds. Growth rates of drift-feeding coho in inlet enclosures were 50-100% higher than coho in either outlet enclosures (drift-feeding) or still-water enclosures (water-column feeding). Results indicate that drift-feeding generates higher growth rates than limnetic feeding because 1) drift-feeding fish can exploit flow heterogeneity (velocity refuges) in fast water that enables them to scan a larger volume of water than fish swimming at similar velocities in the open water of a pond, 2) upstream riffles act as significant sources of invertebrate prey for drift-feeding fish, and 3) depletion of invertebrate prey occurs quickly in ponds because of intense fish predation relative to turbulent riffle habitat. Design implications for off channel habitats are that the presences of riffles and moderately fast habitat suitable for drift-feeding will provide for higher growth rates of juvenile coho than still water, although ponds may be more effective as overwintering habitat.

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ACOUSTIC SEABED CLASSIFICATION OF CAPELIN SPAWNING HABITATS IN NEWFOUNDLAND
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Historically capelin (*Mallotus villosus*) spawning in Newfoundland has been reported to occur on and near beaches along the coast. The only known demersal spawning occurred offshore on the Southeast Shoal of the Grand Bank of Newfoundland. Recently capelin have been observed spawning demersally several kilometers from shore in coastal northeast Newfoundland. These spawning sites are dominated by gravelly substrate, which in part may represent submerged beaches formed ca. 7000-9000 years ago when local sea level was lower. As part of a multi-disciplinary study into the predator-prey dynamics of demersal capelin spawning in coastal Newfoundland, our goal is to use acoustic techniques to classify and map demersal capelin spawning habitats. In addition, we also intend to reconstruct submerged shorelines as a potential guide to spawning habitat. Normal incidence acoustic data (38 kHz) were collected at one of the demersal spawning sites in 2003. We used objective classification techniques to characterize the seabeds both at and around these sites. We discuss the utility of these data to map seabed landscapes and make predictions regarding potential demersal capelin spawning habitats.

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FIREPROOF KILLER WHALES: ICONS OF THE NORTHEASTERN PACIFIC OCEAN ARE AT RISK FROM CHEMICAL EXPOSURE,-**Stevenson Lecture**
The long-lived and high trophic level nature of many marine mammals renders them vulnerable to accumulating often very high concentrations of persistent chemicals, including pesticides, industrial by-products and flame retardants. In the case of killer whales (*Orcinus orca*), some of the older individuals currently frequenting the coastal waters of British Columbia (BC) were born during the First World War, well before the advent of widespread chemical manufacture and use. Offspring of killer whales born today are exposed to thousands of chemicals that have been inadvertently or deliberately introduced into the environment over the past 60 years. The use of polychlorinated biphenyls (PCBs) as heat- and fire-resistant fluids for transformers and industrial machinery between 1929 and 1977 in North America resulted in widespread contamination of biota. Using biopsy samples, we have since found that the killer whales of British Columbia are among the most PCB-contaminated marine mammals in the world. The more recent use of polybrominated diphenyl ethers (PBDEs) as flame retardants in consumer textiles, electronics and plastics represents a current concern for toxicologists and regulators. We have found moderate levels of PBDEs, as well as other classes of new generation fire retardants, in BC's killer whales. However, our temporal studies of the non-migratory harbour seal (*Phoca vitulina*) profile the rapid emergence of PBDEs as a major chemical concern in BC's coastal food web. The physical and chemical properties of these fire retardants that confer benefits upon commercial applications represent the very same properties that have caused widespread environmental problems: the chemicals are resistant to breaking down in their intended use, as well as in the environment and in biota. In addition, many flame retardants resemble natural hormones and can lead to a disruption of endocrine processes in exposed individuals. We have found that several biological endpoints in free-ranging harbour seals inhabiting the transboundary waters of BC and Washington have been adversely affected by exposure to environmental contaminants. These effects include a contaminant-related alteration of i) circulatory vitamin A and thyroid hormone levels, ii) expression of thyroid hormone and Aryl hydrocarbon receptors, and iii) immune function. The degree to which killer whales and other high trophic level marine mammals are exposed to persistent flame retardants, coupled with their vulnerability to adverse health effects, highlights the need for a 'weight of evidence' approach in research, conservation planning and regulatory processes. Given the global nature of contaminant dispersion, such approaches can only be effective when carried out on both national and international scales.

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PHENOTYPIC AND BEHAVIOURAL CORRELATES OF INDIVIDUAL VARIATION IN ATLANTIC COD REPRODUCTIVE SUCCESS
Census estimates of mature individuals (Nc) may not be indicative of the actual numbers of individuals that contribute genes during spawning, as reflected by the effective population size (Ne). For broadcast spawning marine fishes, it has been estimated that Ne may be 2 to 5 orders of magnitude lower than Nc because of unusually high variance in individual reproductive success. Allowing cod from two Northwest Atlantic populations to breed undisturbed in a very large (684 m^3) mesocosm tank, we quantified individual variation in male reproductive success and evaluated the degree to which this variation could be explained by phenotypic metrics of morphology, condition, and spawning behaviour. We found that the number of offspring sired was highly variable among males, with most eggs being fertilized by a very small percentage of available males. Fertilization success was positively associated with male body size and aggression. These results, in addition to our estimates of the ratio of Ne/Nc for Atlantic cod, have important implications for the conservation of marine fishes, particularly those with mating systems similar to Atlantic cod.

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COHERENCE REVISITED: REGIONAL CLIMATIC DRIVERS OF (STILL) SYNCHRONOUS ZOOPLANKTON DYNAMICS IN DORSET LAKES

Significant patterns of temporal coherence were documented in the zooplankton of 8 Dorset lakes from 1980-1992, implying that a portion of the interannual variation in abundance was produced by factors operating on a scale larger than the individual lake catchment. We revisit that analysis here with an additional decade of zooplankton abundance data and use a seasonal decomposition of annual abundance to investigate the climatic drivers of inter-lake synchrony. Significant intraclass correlation coefficients were documented in the extended dataset for many of the same taxa as in the earlier analysis demonstrating both the robustness and generality of these patterns. We sought the ultimate climatic drivers of the patterns in the relationship between global teleconnection indices, as well as local meteorological variables, and seasonal abundances of coherent zooplankton taxa. ENSO events appeared to be an important climatic influence on interannual synchrony and both spring and fall appeared to be the most important seasons for expressing these synchronous dynamics in north-temperate lakes. This study emphasizes the need to consider global climate signals when attempting to understand local changes in zooplankton community structure and dynamics as well as the importance of intra-annual differences in response to climatic variables.

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THIRTY YEARS OF AQUATIC SCIENCE AT THE DORSET ENVIRONMENTAL SCIENCE CENTRE: AN INTRODUCTION
The Ontario Ministry of the Environment's Dorset Environmental Science Centre (DESC) is approaching its 30th year of operation. Through partnerships with universities and other agencies, DESC continues to be a leader in environmental aquatic science, maintaining powerful datasets of water quality, hydrology, meteorology, and biological communities in streams and lakes across Ontario. Over the past three decades the centre has conducted millions of laboratory analyses, produced several hundred peer-reviewed manuscript and technical reports, and been involved in the training of hundreds of summer and graduate students.

The following special session will highlight past and current research at the centre, with particular emphasis on studies that use long-term data to assess the impacts of environmental stressors on aquatic ecosystems of the Canadian Shield. The session is cross-disciplinary, and will include experimental, modeling, biomonitoring, and paleoecological studies that have been conducted at or in partnership with DESC.

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~6,000YR OF PACIFIC SALMON PRODUCTION IN BRITISH COLUMBIA – A PALEOLIMNOLOGICAL RECONSTRUCTION OF SOCKEYE SALMON (*ONCORHYNCHUS NERKA*) POPULATION DYNAMICS IN TAHLTAN LAKE, BC
Declines in natural runs of Pacific salmon (*Oncorhynchus* spp.) have been precipitous and unprecedented within the period of recorded history. Instrumental records of salmon escapement to nursery systems, however, are often short, incomplete, and transcend the period of significant human impacts. Understanding current population trends in the context of natural variability requires a longer-term perspective. We present a ~6,000 yr record of sockeye salmon (*O. nerka*) population dynamics, the longest record and only Canadian one to date, inferred from analysis of nutrient indicators (e.g. stable nitrogen isotopes ($\delta^{15}N$), diatoms), archived in a dated sediment core from Tahltan Lake, BC. Our data suggest salmon runs over the length of the instrumental record (45 yr, avg. ~23,000 fish/yr) represent a fraction of previous returns to this system, however, not the lowest returns in the past ~6,000 yr. Periods of both sustained low and high production, as well as rapid fluctuations in stock abundance characterize the record. Over the past ca. ~4,000 yr BP, cyclical, millennial-scale salmon production regimes are evident, and links to climatic forcing mechanisms are discussed.

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MODELLING WALLEYE HABITAT USING ENVIRONMENTAL CONDITIONS IN LAKE ERIE.
There has been a decline in the abundance of walleye (*Sander vitreus*), an important sport and commercial fish, likely as a result of extensive changes in environmental conditions and community structure over the past decade in Lake Erie. Environmental monitoring surveys were conducted in the nearshore of the northeastern basin of Lake

Erie over a nine month period in 2001 to acquire a detailed assessment of environmental conditions by collecting near-continuous and discrete measurements of selected water quality and physical parameters. Additionally, nearshore fish community data were gathered across the same region. Using these data, assessments of walleye habitat based on optical and thermal habitats were possible on both a spatial and temporal scale, for different life stages of walleye in the lower Grand River and the lake adjacent to the Grand River. The greatest amount of optimal habitat available to walleye tended to be found along the shoreline of Lake Erie adjacent to the Grand River depending on the dynamic nature of the Grand River plume. Generally, there were low amounts of optimal habitat available to walleye further offshore or in the Grand River as high light levels in the lake and high water temperatures in the river limited the amounts of habitat available to adult walleye. Improvements in both abiotic and biotic features of the habitat in the tributaries and along the shoreline may increase the amount of optimal habitat, and potentially the abundance of walleye, in Lake Erie.

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EARLY LIFE-HISTORY CHARACTERISTICS AND GROWTH OF THE SYMPATRIC RAINBOW SMELT IN LAKE UTOPIA, NEW BRUNSWICK
Lake Utopia appears to have three sympatric morphotypes of rainbow smelt. The giant form spawns first, is larger and has the fewest gill rakers. A second smelt run occurs in May and is designated as threatened. Current research suggests this late run consists of two morphs referred to as normals and dwarfs. The normal form spawns first, is larger and has increased numbers of gill rakers. The dwarf form overlaps in spawning with the normal form, is the smallest and has the highest gill raker count. The objective of this study is to compare the early life-history characteristics and growth of the three different smelt forms. Spawning date, egg size, incubation time, incubation temperature and emergence size are compared between form and four spawning brooks. Growth rates of larval smelt were compared using otoliths to determine if a divergence in growth occurs. The preliminary results of this work will be presented and discussed.

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A 700-YEAR RECORD OF HYDROLOGICAL AND ECOLOGICAL CHANGES OF A SHALLOW DELTA POND NEAR THE SHORE OF LAKE ATHABASCA, NORTHERN ALBERTA
PAD9 is a small, closed-drainage open-water wetland located in the Peace Sector of the Peace-Athabasca Delta (PAD) near the northwest shore of Lake Athabasca. Previous paleolimnological analyses combining physical, biological and geochemical information preserved in lake sediments indicate substantial hydroecological changes at PAD9 over the past ~500 years. Notably, the lake exhibited open-drainage conditions and was part of a shallow embayment of Lake Athabasca from the ~1600s to the early 1900s, suggesting wetter conditions in this sector of the PAD and higher Lake Athabasca lake levels at that time. Since ~1925, PAD9 has existed as an isolated closed-drainage lake indicating drier conditions in the delta and lowering of lake levels in Lake Athabasca. To critically assess the relative roles of climate and natural geomorphic processes on the local hydroecological history, we extend the diatom record from PAD9 to ~550 AD and compare inferred paleolimnological changes with independent proxy records of climate and flood frequency in the PAD.

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EXPLORING THE ROLE OF DENSITY-DEPENDENT AND DENSITY–INDEPENDENT FACTORS IN THE RECRUITMENT FLUCTUATION OF RAINBOW SMELT IN LAKE SAINT-JEAN
Rainbow smelt *(Osmerus mordax*) is the most important prey of landlocked Atlantic salmon (*Salmo salar*) in Lake Saint-Jean (QC), representing more than 70% of the biomass ingested by this salmonid. Consequently, inter-annual variations in the year-class strength of rainbow smelt is a key factor affecting the production of landlocked Atlantic

salmon. Fluctuations in the year-class strength of fish populations are generally recognized to be determined during early life stages. However, little is known about how density-dependent and density-independent processes affect population recruitment. To address this problem for rainbow smelt, we examined the influence of abiotic and biotic factors on the recruitment of this species in Lake Saint-Jean during 21 years. We reconstructed the abundance of YOY rainbow smelt from 1984 to 1994 using observed data from 1995 to 2004. Our investigation showed significant correlations between smelt recruitment and density-dependent variables such as reproduction (abundance of spawners) and cannibalism (abundance of 1+ smelt) and density-independent variables such as predation (abundance of landlocked Atlantic salmon smolts) and hydrology (discharge of Peribonka River). Understanding factors affecting survival of young smelt may provide a promising tool to predict year-class strength fluctuations of this important forage fish in Lake Saint-Jean.

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DEVELOPING THE USE OF DIATOM ALGAE FOR HYDRO-ECOLOGICAL STUDIES AT THE SLAVE RIVER DELTA, N.W.T.
The Slave River Delta (SD), NWT is a key ecological resource in Canada's North. There is tremendous concern over recent changing delta water levels and impacts on aquatic and terrestrial ecosystems, wildlife habitat and traditional First Nations occupations such as fishing, hunting and trapping. The SD is a hydrologically complex wetland system, comprised of meandering streams and channels, along with many small water bodies. Scattered throughout this landscape are numerous small, shallow (<4m) ponds, which are characterized by extensive macrophyte growth throughout all, or most of the system. The shallowness of wetlands and delta ponds along with the large area of submergent and emergent macrophytes, provide abundant habitat for the development of epiphytic algae. Epiphytic algae are significant contributors to the primary production of SD ponds and provide a rich food source for a variety of aquatic life. Diatom algae are the dominant component of epiphytic assemblages in the SD and this has important implications for the purpose of paleolimnological reconstructions.

We present results from an ongoing study on the ecology of diatoms in SD water bodies. Comprehensive sampling of various substrates in six SD ponds was conducted to determine if there are species-specific relationships between epiphytic diatoms and macrophyte taxa or whether limnological characteristics of a water body has a stronger influence on epiphytic diatom community composition. Seasonal phytoplankton samples were collected from the same six ponds, Great Slave Lake, and distributaries of the Slave River, to assess the potential use of centric diatoms as paleo-indicators of past river connectivity, flood frequency and the timing of flooding in SD ponds. Inter-annual studies were also conducted on a small SD pond to determine the effects flooding on epiphytic and planktonic diatom community composition. The study presented here contributes to a much larger program of research relating past and present hydrology, limnology, and ecology of the Mackenzie Basin Deltas.

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EVALUATING SHORT TIMES SERIES WITH A MODIFIED MANN-KENDALL TREND TEST
Despite almost 30 years of data collection at the Dorset Environmental Science Centre, evaluating trends over time remains a challenge because of the relatively short length and non-linear nature of many of the time series. In the water-quality literature, the Mann-Kendall trend test is often used to assess monotonic trends in short data series. Although this test is simple to calculate and based on rank-order nonparametric statistics, it is rarely used with biological data. Undoubtedly many biologists are not familiar with this test, but its lack of popularity may also reflect the somewhat restrictive, monotonic trend hypothesis that is evaluated. The Mann-Kendall trend test can be generalized using the Mantel test. This generalization provides opportunities to evaluate competing hypotheses of non-monotonic trends, step functions, and so on. In addition, the Mantel-test approach extends to tests of partial correlations and multivariate trend. The ability to test monotonic, non-monotonic, partial and multivariate trend hypotheses should provide biologists with a valuable assessment tool. We demonstrate calculations for the traditional Mann-Kendall trend test and Mantel test variant using relatively short, time-series data for benthic macroinvertebrates and water quality collected from Dorset-area lakes.

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INTO THE BLUE; USING CS-137 TO TRACK THE OCEAN MIGRATION OF ATLANTIC SALMON
Wild anadromous Atlantic salmon, *Salmo salar*, are swimming against extinction. Unspecified marine mortality has been suggested for the past two-decade decline, thus ocean migration knowledge is critical in offering an explanation. Past radioactive cesium and tagging evidence suggests some or all Atlantic salmon undertake trans-Atlantic migrations utilizing the North Atlantic Gyre. This research tests a hypothesized trans-Atlantic migration using bioaccumulated Cs-137 in returning salmon. An east-west radionuclides gradient exists in the North Atlantic due to European anthropogenic inputs. Wild salmon were collected from Atlantic Canada and Western Ireland during 2002 and 2003 spawning runs. Juveniles were collected to provide a pre-marine migratory Cs-137 baseline. Aquaculture fish were collected from farms in Canada and Ireland for non-migratory controls. All samples (n = 220) were counted using gamma ray spectrometry. Results from 2002 reveal low Cs-137 concentrations overall, but an increasing trend from aquaculture to aquaculture escapees and wild fish. Irish 2003 wild and aquaculture were on par with North American wild concentrations. Complete results in correlation with temporal and spatial Cs-137 concentrations, surface currents and sea surface temperatures in the North Atlantic with reference to the hypothesized migration model and implications on current management policies will be discussed.

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ABUNDANCE, DISTRIBUTION, AND CATCH RATES OF TWO COMMERCIALLY VALUABLE FISH SPECIES AS AFFECTED BY THE LIMNOLOGY AND METEOROLOGY OF LAKE WINNIPEG, CANADA
The abundance and distribution of sauger (*Stizostedion canadense*, and walleye (*S. vitreum*) were established in the south basin of Lake Winnipeg through commercial catch records. Limnological conditions were restricted to the examination of turbidity in the form of turbid water perimeter length and mixing complexity via data obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS)-Terra satellite. Mixing complexity was quantified through both fractal dimension utilizing the box counting technique and turbid water perimeter length. Dry bulb temperature, cloud ceiling, cloud cover, wind direction, and wind speed were examined for any potential relationship with catch rate.

Preliminary analyses indicate that no significant relationship exists between the meteorological conditions examined and catch rates. The fractal dimension of the turbidity fronts provided little insight into any concurrent relationship with catch rates. However, the length of the turbidity boundary perimeter length suggests an inverse parabolic relationship with the catch rate of *S. vitreum*. Such a relationship could be explained by an 'ideal' boundary length. It is possible that shorter boundary lengths discourage frequent foraging over large areas due to the increased risk of attack from visual predators. Similarly, large boundary lengths may facilitate the movement of visual prey species further away from the turbidity front to areas of greater water clarity. An ideal boundary length could suggest low risk of visual attack coupled with typical visual prey densities. This situation may lead to an increase in *S. vitreum* mobility and consequently increased encounters with fishing gear, leading to increased catch rates.

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GEOGRAPHIC PERSISTENCE OF LARVAL HERRING: THE EVIDENCE FOR LARVAL RETENTION
Recent studies have demonstrated geographic persistence of larvae and apparent natal homing to coral reefs as well as within estuaries. Those studies are relevant to the Iles and Sinclair (1982) stock hypothesis, which suggested larval retention as a mechanism in the formation of stocks and their subunits. New analyses of larval herring distribution and sizes from 23 fall and 10 spring surveys of herring spawning areas off western Nova Scotia and in the Bay of Fundy, reveal significant overlap in the spatial distribution of 4 size classes, estimated to be <2 week old, 2-8 week old, 8-16 week old and >24 week old larvae. Spatial overlap of larval age classes is a practical definition of larval retention since residual flow through this region at 5-10 km per day would disperse passive particles. Geographic persistence was also evident within years (1985, 1986), at a scale of weeks and 10s km, from consistency in the relative station abundances. The relationship of the larval distribution area to the region of tidally driven vertical mixing (0 delta sigma-t), and to the corresponding year class strength will be discussed.

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DROUGHT VARIABILITY IN THE NORTH AMERICAN GREAT PLAINS DURING THE LAST 700 YEARS
Drought is endemic to the North American Great Plains, causing severe economic consequences. However, accurate instrumental climatological data only exist from circa 1895 A.D.. The tree-ring derived drought record exists from circa 1650 A.D. but has been spatially extrapolated to the Prairies. Limited paleolimnological, archeological and eolian activity records extend back for two millennia, but either at a relatively coarse resolution or with large dating uncertainty. This lack of monitoring data inhibits our understanding of drought in this region. To address this problem, we analyze the diatoms and pollen preserved in the sediments of Mina Lake, Minnesota, a prairie lake that is varved, i.e. one with well-preserved annual sediment layers which allows high-resolution dating. What is unique and new about this study is its high-resolution, which thereby allows extension of the tree-ring record. As well, by analyzing tandem diatom and pollen, events in the aquatic and terrestrial ecosystems can be directly compared.

The diatom analysis shows two main phases: one post-European settlement, and one pre-settlement. The diatoms of the European settlement period are characteristic of relatively eutrophic waters and are summarized as a trading off between *Fragilaria crotonensis* and the small *Stephanodiscus* species: *S. minutulus* and *S. parvus*. Comparing the diatom stratigraphy to the instrumental Palmer Drought Severity Index (PDSI) shows that *F. crotonensis* tends to dominate during drought periods and the small *Stephanodiscus* tend to dominate during moist periods. The diatoms show a probable salinity signal in the pre-European period prior to 1880 A.D.. The diatom stratigraphy is summarized here as a trading off between *F. crotonensis* and the small *Cyclotella* species: *C. pseudostelligera* and *C. michiganiana*. Comparison of the diatom stratigraphy to a tree-ring inferred PDSI shows that the very fresh *C. pseudostelligera* complex tends to peak in abundance during rainy periods and reaches local lows during dry periods. Comparison of the pollen stratigraphy to the instrumental and tree-ring derived PDSI shows that there is an increase in pollen deposition in response to a moderate to severe drought followed by returning precipitation.

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OCEANIC PHYTOPLANKTON DYNAMIC OF THE GALAPAGOS ARCHIPELAGO AND VALIDATION OF SATELLITE INFORMATION.
The Galápagos Archipelago is characterized by a complex hydrology because of the convergence of several currents at the equator that are responsible of an extreme spatial and temporal variability in oceanographic processes. Phytoplankton biomass is related to episodic events such as El Niño and also to seasonal changes in water temperature, salinity and nutrients, which are themselves related to physical processes such as wind force, upwellings, fronts, eddies formation and tidal mixing. The availability of ocean colour satellite data greatly facilitates the study of phytoplankton pigment distribution in space and time, although such data needs *in situ* calibration. However, there is little *in situ* data available on phytoplankton pigments and primary production around Galápagos Archipelago, and even less over the water column. The main objectives of this research are 1- to study phytoplankton dynamic in productive (upwelling) and less productive areas of the Galápagos Archipelago using *in situ* and satellite measurements, and 2- to validate satellite information provided by the NASA for this region. The most important factors controlling chlorophyll distribution and the concordance between satellite and *in situ* data will be discussed.

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BYTHOTREPHES-INDUCED CHANGES IN ZOOPLANKTON COMMUNITY STRUCTURE AND GRAZING IN BOREAL LAKES
The invasion of non-native species into freshwater habitats is an important stressor in the 21st century. *Bythotrephes longimanus* is an invasive invertebrate predator from Eurasia that has now been present in North America for >20 years. However, little is understood about the impacts of *Bythotrephes* over a spatially variable landscape, especially in lakes which experience varying degrees of invader density. In addition, few studies have examined if the effects of an invasive species on community structure can lead to alterations of the functions and services

provided by ecosystems. It seems likely that important processes, such as grazing, that transfer energy and nutrients to other trophic levels, will be altered by an invasion. Very few studies of aquatic invasions have examined ecosystem processes. A survey of boreal shield lakes invaded by *Bythotrephes* and uninvaded lakes was conducted from May to September, 2003, in the Muskoka region of Ontario. Lakes were sampled biweekly for zooplankton, *Bythotrephes*, chlorophyll *a*, temperature, and dissolved oxygen. As well, an experiment was performed to test if the ability of the zooplankton community to graze algae was disrupted by the presence of *Bythotrephes*. Carboys were incubated in lakes with and without *Bythotrephes* for three days during June, July, and August. Carboys received a treatment of zooplankton at concentrations from 0-3x ambient lake density. Chlorophyll *a* was measured prior to incubation and at the conclusion of the experiment to detect changes in zooplankton grazing impact. The zooplankton of invaded lakes differed from uninvaded lakes in measures such as total community biomass, abundance, and composition. These changes to the overall structure of zooplankton communities translated into differences in the grazing pressure exerted on phytoplankton in the lake. Results from this study indicate that the impacts of *Bythotrephes* run deeper than merely changing the identity of species present in invaded lakes, but may have substantial impacts on the ability of zooplankton to graze algae and pass this energy on to higher trophic levels.

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DETERMINING YOUNG-OF-THE-YEAR ARCTIC CHAR (SALVELINUS ALPINUS) THERMAL HABITAT USE WITH δ^{18}O OTOLITH ISOTOPES
Recent interest in the possible effects of climate warming on fish populations and the availability of fish habitat and fish habitat use has focused research interest on the use of stable isotopes to reconstruct fish thermal habitat use histories. This study compared field monitored and otolith oxygen isotope inferred water temperatures to study thermal habitat use by young-of-the-year Arctic char (*Salvelinus alpinus*). Young-of-the-year Arctic char otoliths were obtained from the Ikarut River, Labrador (58º03'N, 63º13'W) for the years 1983-1985. Extracted otoliths were acidified using standard phosphoric acid reaction techniques and eluted gases were isotopically measured and calibrated against international standards. Otolith predicted water temperatures were derived from standardized fractionation equations and results were validated against in-situ temperature records. Successful application of standardized temperature inference methods required inferential use of precipitation oxygen isotope monitoring data, the methods for which are discussed. Discrepancies between water measured and otolith inferred temperatures were found and interpreted to imply active selection of warmer thermal habitats. Implications for use of archival otoliths for inferring past water temperatures and determining thermal baselines for climate change studies are discussed.

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THE INVASION TRAJECTORY OF AN EXOTIC ZOOPLANKTON SPECIES, *BOSMINA* (*EUBOSMINA*) *COREGONI*,-INTO LAKE WINNIPEG
Ecosystems throughout the world are threatened by invasions of non-indigenous species (NIS) as a result of human activities. Ballast water is the primary invasion route of aquatic NIS entering the Laurentian Great Lakes, however, dispersal over land and via interconnecting river systems are more likely routes for non-indigenous species to invade lakes in central Canada. This study examines the putative invasion pathway of a European cladoceran species, *Bosmina* (*Eubosmina*) *coregoni*, into Lake Winnipeg, a species already known to occur in the Great Lakes. Well-preserved cladoceran remains in short and long sediment cores from Lake of the Woods, the Winnipeg River system, and Lake Winnipeg track the invasion of *B. coregoni.* Historical abundances and timing of dispersal have been determined from long cores from both Lake of the Woods and Lake Winnipeg. Analysis of 17 short cores and four long cores from Lake of the Woods confirmed that *B. coregoni* is a recent invader. Extant zooplankton samples from Lake of the Woods and Lake Winnipeg revealed the present distribution and abundances of *B. coregoni*, thereby providing an estimate of population expansion to date and the extent of this species' dispersal during its residence in these lakes.
(GS)

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ANALYSIS OF 27 YEARS OF AUTUMN ZOOPLANKTON BIOMASS SIZE DISTRIBUTIONS OFF WESTERN NOVA SCOTIA
Zooplankton collections made with a standard bongo net (0.3 and 0.5 mm mesh) were made across a standardised grid from 1972 to 1998, where the geographic persistence of larval herring in a well mixed region is observed. Plankton samples from eight stations were analysed for size frequency composition with an optical plankton counter, and converted to a nomalised biomass size distribution ("spectrum"). Multivariate analysis of ten taxonomic categories correlated with an identical analysis of the biomass of size categories. After accounting for within year, between day-night and among station variation, we found the slopes of the normalised size spectra – an index of secondary production - fluctuated around a theoretically derived value of -1. The slope will be compared with the year class estimates of the annual herring assessments.

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PATTERNS IN THE DISTRIBUTION AND DIVERSITY OF CLADOCERA (CRUSTACEA: BRANCHIOPODA: ANOMOPODA) IN LAKES ACROSS A NORTH-SOUTH TRANSECT IN THE WESTERN SUBARCTIC OF NORTH AMERICA
The Cladocera are an integral component of both pelagic and benthic environments, yet for most of the subarctic and arctic regions of North America, very little is known about their occurrence and distribution. We examined the subfossil remains of cladocera preserved in the surfacial sediments of 51 lakes from Alaska, USA, that were distributed along a north-south gradient. Of the 51 lakes, only 29 possessed a sufficient number of remains for quantification. A total of 23 species were identified, which represented 12 genera, the majority representing benthic chydorid taxa. We compared the relative abundance of cladoceran taxa to measured physical and chemical characteristics to determine if these environmental factors had a role in determining the distribution and abundance of cladocera in the study lakes. Redundancy analysis indicated that lake depth, total phosphorus (TP), and conductivity were significant factors in structuring cladoceran communities within these lakes.

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HARMONIZED CONTROL OF EXOTIC AQUATIC SPECIES IN THE GREAT LAKES: THE ROLE FOR ONTARIO
Exotic aquatic species (EAS) have arrived in the Great Lakes from shipping ballast, aquaculture, bait fish, and the pet and food fish trade. For some species, the damage caused may be enormous, both ecologically and economically. Increased global trade, global warming, and potentially increased use of Hudson Bay for shipping, mean that more EAS are likely to enter the freshwaters bordering the Province.

Canada (and thus Ontario) is obligated to participate in the preventative management and control of EAS, and especially in the common waters that they share with the USA. The USA has developed much enforceable legislation at both the federal and state level to prevent EAS introductions. In contrast, Canada has developed only guidelines applied to shipping ballast. Ontario has no laws that prevent EAS from entering the province or spreading within provincial waters. By analogy with national security, a harmonized, bilateral, approach to EAS management is recommended for Canada and the USA in which provincial (state) provisions are nested in federal laws. While the USA has been vigorously creating and updating its laws pertaining to EAS control, Canada has shown little inclination to act in parallel.

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THE ISSUE OF GREENHOUSE GASES FROM HYDROELECTRIC RESERVOIRS: WHAT DO WE UNDERSTAND ?

Carbon dioxide (CO_2) and methane (CH_4) are the world's main greenhouse gases and are emitted from both natural aquatic ecosystems (lakes, rivers, estuaries, wetlands) and manmade reservoirs. The role of greenhouse gas emissions from freshwater reservoirs and their contribution in increasing atmospheric GHG concentrations is actually well discussed worldwide. To our knowledge, although they are at the heart of the debate concerning pros and cons of different sources of energy production, there are fairly few emission measurements available for fresh water reservoirs. Increasing the number of measurements will significantly reduce uncertainties surrounding representative mean gross flux from natural systems as well as from reservoirs.

This communication presents data of GHG flux measurements taken recently on reservoirs of various ages and sizes as well as on adjacent lakes and rivers from boreal, tropical and semi-arid regions. GHG emissions were measured with a floating chamber connected to an automated NDIR instrument giving real-time values. Our results indicate that the processes leading to GHG emissions in boreal, semi-arid and tropical reservoirs are similar. The main differences are related to the much greater presence of anoxic conditions in tropical reservoirs, which favour and sustain methanogenesis over longer time periods (>10 years). Additionally, in boreal and semi-arid regions, GHG emissions are similar between natural lakes and reservoirs older than 10 years within the same drainage basin.

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DISCRIMINATING RESIDENCY OF *HAEMULON FLAVOLINEATUM* (FRENCH GRUNT) USING OTOLITH MICROCHEMISTRY: DIFFICULTIES AT SMALL SPATIAL SCALES.

We investigated whether otolith chemistry of *Haemulon flavolineatum*, a moderately important commercial species which frequents mangroves and reefs during different life history stages, could be used as a means to differentiate individuals occupying different habitats. In 2003, adults were collected from 9 mangrove and 10 coral reef sites throughout Turneffe Atoll, Belize. Study sites were separated by relatively small spatial scales (0.8-20 km). Concentrations of trace elements were measured at the edge of sagittal otoliths by laser ablated inductively coupled plasma mass spectrometry. Results indicated that fish were classified to the habitat (mangrove vs. reef) from which they were collected with a relatively high degree of accuracy, but were poorly classified to the site from which they were collected. Overall, because of sufficient variability in elemental concentrations between habitats, otolith microchemical investigations of *H. flavolineatum* at Turneffe Atoll can be used to successfully identify habitat of residence. However, nocturnal movement of individuals might mask site signatures making it impossible to accurately identify specific sites of origin within a given habitat.

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HOW DOES ENTRAINMENT INTO AN IRRIGATION CANAL AFFECT POPULATION ABUNDANCE?

Large diversion canals have the potential to divert large proportions of water from the stream or lake that feeds them. Without proper physical or behavioural barriers to divert fish from away from the headworks of these canals, there is the potential for large numbers of fish to be entrained, especially in a productive system. We examined the seasonal entrainment of rainbow trout, brown trout and mountain whitefish into the Carseland Canal, on the Bow River in Southern Alberta. By examining catch rates of these three species and estimating the rate at which they "evacuate" through the system, we were able to estimate total annual entrainment of the three species. Using a simple population model, the resulting effect of entrainment on population abundance was estimated. Using this model, it is then possible to estimate the net benefit to the river populations if screening of the headworks occurs. Although large numbers of fish are entrained annually, this is a small proportion of each population. While countless fish could be saved in the future if barriers to entrainment are put in place, there may not be enough benefit to this productive system to warrant such an action.

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MERCURY DEPURATION FROM PREDATOR AND PREY FISH TISSUES

The rate of mercury loss from fish tissues is a major unknown in studies of mercury and fish bioenergetics. We take a novel approach to addressing this question by examining the decline in mercury in fish that have become contaminated with an isotopically-enriched form of mercury in a whole-ecosystem experiment (METAALICUS: Mercury Experiment to Assess Atmospheric Loading in Canada and the United States). Stable isotopes of mercury have been added to a lake for the past four years and presently account for one-third of the mercury in the prey fishes present. Yellow perch (*Percus flavescens*) and northern pike (*Esox lucius*) were transported from this lake to a "clean" lake, and their levels of mercury isotope will be monitored until August 2005. The perch were moved to an enclosure open to the sediments and water flow. Perch are collected periodically and analysed for muscle and whole-body mercury isotope content. The pike were surgically implanted with acoustic transmitters to aid in recapture, so that muscle biopsies can be taken periodically from individual fish. The data will be applied to a bioenergetics mercury model to refine the clearance value. The accumulation of "labelled" mercury under natural conditions represents a strong departure from previous depuration studies and will allow for improvement of fish bioenergetics and contaminant models as well as further defining mercury dynamics in fish.

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UNDERSTANDING THE ROLE OF COMMUNITY IN DETERMINING LIFE HISTORY VARIATION IN *COREGONUS ARTEDII*(THE LAKE CISCO)
The lake herring (*Coregonus arteddii*), exhibits a large range of life history characteristics (body size, growth rates, size at maturity). The underlying mechanisms that allow for the demonstration of these phenotypes has remained largely unexplored. The goal of this chapter is to examine the mechanisms underlying observed variation in herring life history characteristics through an analysis of 72 lakes that include both the environmental and community components. Strong correlation of life history traits was observed, with maximum attainable size ranging 132 – 488 mm forklength, size at maturity ranging 85 – 280 mm, and maximum observed ages from 7 – 37. Community structure ranged from lakes with no potential predators or competitors, to those with strong potential top down effects from a suite of piscivorous predators and competition from other obligate pelagic planktivores. Results suggest that the structure of the overlying trophic levels appear to be the dominant determinant of herring life history with walleye (*Sander vitreus*) playing a dominant role. Effects of competition and environmental variation are masked by this. A mechanism is proposed that examines the basic biology of the predators, alongside an energetic analysis of the potential top-down effects on the lake herring population.

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LAKE STURGEON OF THE GREAT LAKES: A HISTORY OF EXPLOITATION, DECLINE, AND RECOVERY
Although lake sturgeon, *Acipenser fulvescens*, was once abundant in all of the Great Lakes, overfishing and construction of dams on spawning rivers throughout the 20th century decimated most populations. Bill Beamish carried out field studies of the feeding ecology, energetics and population status of lake sturgeon in northern Ontario. He also co-edited a recent monograph on North American sturgeons and paddlefish. Historically, management of lake sturgeon on the Great Lakes was non-existent because early commercial fishermen regarded the lake sturgeon as a "nuisance" species that tangled or destroyed gear deployed for lake trout or whitefish. By the late 1800s however, new markets for sturgeon meat and caviar were developed. Targeted lake sturgeon fisheries soon followed but by 1900 most Great Lakes populations had become commercially extinct as early harvest restrictions proved to be woefully inadequate. During the 20th century, most populations have remained either disappeared or persisted as remnant stocks. In recent years however, interest in lake sturgeon has rebounded throughout the Great Lakes, as native species restoration has become an important priority of most state and federal management agencies. As an important first step in the restoration of lake sturgeon in the Great Lakes, our research has focused on stock assessment and life history of lake sturgeon in the Manistee and Muskegon rivers on the eastern shore of Lake Michigan. From 1999-2001 on the Manistee River, and 2002-2004 on the Muskegon River, we estimated annual run sizes of lake sturgeon through mark-recapture sampling conducted at the mouth of each river in early spring. We also determined age, growth, and sex of all lake sturgeon captured. Our results show that both populations probably contain fewer than 250 adults and that the adult age-structures of both are characterized by a preponderance of young fish – many of which appear to be first-time spawners. Although causal mechanisms are uncertain, the resumption of commercial lake sturgeon harvest in Lake Michigan from 1950-1970

is one possible explanation that may also help explain why these populations remain at critically low levels today. Future studies are needed to measure current levels of recruitment in these remnant stocks and to understand mechanisms affecting juvenile survival.

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ATLANTIC SALMON DENSITY INCREASES WITH HABITAT COMPLEXITY; THE JOINT EFFECTS OF A REDUCTION IN TERRITORY SIZE AND PERCEIVED PREDATION RISK?
Previous experiments have shown that an increase in habitat complexity results in higher densities of young-of-the-year (YOY Atlantic salmon. In this study we test three hypotheses to explain this effect: the velocity refuge effect, the predator refuge effect, and the territory size effect; a reduction in territory size due to increased visual isolation. To test these hypotheses, we manipulated habitat complexity in three different treatments (boulder added, boulder removed and control) at eight sites in Catamaran Brook and the little Southwest Miramichi River in New Brunswick. We first verified that the density of salmon increased with habitat complexity and then compared microhabitat selection, anti-predator behaviour and territory size of focal fish among treatments. We found no support for the velocity refuge hypothesis; the snout velocity used by salmon did not differ between treatments, and fish did not prefer low-velocity microhabitats in the boulder treatment. Our results showed partial support for the predator refuge hypothesis; compared to the other treatments, salmon in the boulder sites were closer to cover and showed reduced anti-predator behaviour, but within boulder sites did not select microhabitats closer to cover. Our data were consistent with the territory-size hypothesis; visual isolation was highest and territory size was smallest in the boulder sites, and within the boulder sites salmon selected microhabitat to maximize their field of view. Our results suggest that YOY salmon are attracted to complex environments for anti-predator reasons and the decreased visibility of these sites causes a reduction in territory size, allowing a higher density.

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GROWTH AND LIFE-HISTORY TRAITS OF INTRODUCED PUMPKINSEED (*LEPOMIS GIBBOSUS*) POPULATIONS IN SOUTHERN ENGLAND
Introduced into the UK more than 100 years ago, the pumpkinseed has a limited distribution in southern England, but there is concern that it is spreading through small streams into the Thames and beyond. To assess its adaptations to the introduced environment, we examined the growth and life history traits of pumpkinseeds in the Ouse catchment (East Sussex) where it is most abundant, and compared these to native North American populations. English pumpkinseeds were sampled from 19 waterbodies during the spring and summer of 2003 and 2004. English populations exhibited slow growth and small adult body size relative to native North American populations. Age at maturity was significantly earlier and size at maturity was significantly smaller than that of native populations, and age at maturity was negatively related to the juvenile growth rate. Coded wire-tagged pumpkinseeds in lakes and ponds were later recovered in outlet streams, and individuals of all sizes and ages PIT-tagged in the stream were recaptured further downstream, suggesting that dispersal was occurring. While there was no evidence of reproduction in the streams, pumpkinseeds tended to occupy the same pool habitats as native brown trout, suggesting the possibility of competition between the two, and that pumpkinseeds may be a food source for the larger trout.

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FLOW MEDIATES THE COMPETITIVE INFLUENCE OF AN INVASIVE MINNOW ON A THREATENED NATIVE STREAM FISH
Approximately 15 years ago the yellowfin shiner (*Notropis lutipinnis*) was introduced into the headwaters of the Little Tennessee River in western North Carolina, USA where it exhibits microhabitat preferences that overlap significantly with those of a threatened native minnow, the rosyside dace (*Clinostomus funduloides*). Both shiner and dace employ aggression to maintain the most profitable positions forage in single- and mixed-species groups.

Recent laboratory experiments have established that the introduced shiner is two-three times as aggressive as the native dace in foraging groups, but a significantly less efficient forager at the higher stream velocities it shares with the native dace. We conducted a response-surface competition experiment to examine the effects of water velocity (10 or 20 cm/s) and group size (4 or 8 individuals) on intra- and interspecific aggression and foraging performance in these species (six treatments: 4 dace, 4 shiner, 8 dace, 8 shiner, 2 dace + 2 shiner, 4 dace + 4 shiner). When competing with dace, the more aggressive shiner occupied significantly higher ranked positions at low and high velocities and group sizes. However, shiner only monopolized prey captures at the low velocity. At high velocity clear competitive release occurred for the native dace as: 1) in small groups dace acquired the largest proportion of the available prey (i.e., competitive reversal); and, 2) in large groups dace received an equal proportion of the available prey. Such asymmetric condition-specific competition implies habitat diversity (high and low velocity patches) may provide a competitive refugia for the rosyside dace.

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THE EFFECTS OF SUSPENDED INORGANIC SSENDIMENT ON FEEDING AND STRESS IN JOHNNY DARTER (ETHEOSTOMA NIGRUM)
Suspended inorganic sediments (SIS) are a substantial threat to aquatic ecosystems and their inhabitants. SIS sources are often anthropogenic and terrestrial in origin. SIS damage fisheries and reduce the recreational value of streams. Most of the research on the effects of SIS has focused on fish from the salmonid family and their habitats due to their economic importance. This research has, for the most part, been laboratory based. In contrast, this study looked at the effects of SIS on feeding and stress in Johnny darter (*Etheostoma nigrum*). Research was conducted in mesocosms that replicated darter habitat and allowed for possible coping mechanisms, and thus more realistic results in terms of the effects of SIS on this fish species. Three concentrations of suspended sediment were used 3500mg/l, 350 mg/l and 35mg/l. Blood glucose levels were used as a measure of stress and gut contents were examined following the 24 hour exposure to SIS. Preliminary results indicate that highest sediment levels (3500mg/l) are the most stressful to these fish and inhibit feeding. Moderate levels (350mg/l) also appear to negatively impact feeding abilities and raise glucose levels.

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NEUTRAL BIODIVERSITY THEORY HIGHLIGHTS CONSISTENT DIFFERENCES IN COMMUNITY STRUCTURE BETWEEN PHYTOPLANKTON, ZOOPLANKTON AND FISH COMMUNITIES IN LAKES WORLDWIDE
The field of biogeography tells us that there are three processes that determine the structure of local communities: (1) speciation, (2) population dynamics (including extinction) and (3) metapopulation dynamics (including dispersal). Neutral biodiversity theory tells us how local communities are likely to be structured if these three processes are statistically identical among species within an infinitely large panmictic metacommunity with a constant environment. Specifically the theory assumes that, (1) all individuals in the metacommunity are equally likely to be the most recent common ancestor of a new species, (2) all individuals have the same probability of giving birth and dying and (3) all individuals in the metacommunity have the same probability of immigrating into the local community. We used this theory as a statistical null hypothesis for analysing species abundance data sets of fish, zooplankton and phytoplankton communities worldwide. Only three out of the twenty fish and zooplankton communities significantly ($\alpha = 0.05$) differed from best fit neutral predictions. However, we found that the abundances of the dominant phytoplankton species in each community were significantly higher than would be expected by the best fit neutral model in all eight phytoplankton communities analysed. This finding probably represents the most consistent failure of the neutral model to explain species abundance distributions to date.

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FISHERIES RESEARCH TO CONSERVE NATIVE SPECIES AND SPECIES AT RISK IN THE UPPER MISSOURI RIVER BASIN

Conservation of native fish species is a growing concern as habitat continues to be altered and more species are becoming at risk. We present an overview of research conducted at several spatial scales directed towards the conservation of native, lotic species within the upper Missouri River Basin, an area that includes portions of six states and two Canadian provinces. This presentation will discuss: 1) gap analysis of fish species across the Upper Missouri River Basin, which uses biological data, remote sensing, and geographic information systems technology to model species distributions and habitat at broad spatial scales, and where conservation programs can best protect threatened species and biodiversity, 2) practical demonstration of how gap models where used to aid in the conservation of the Topeka shiner (*Notropis topeka*), an endangered cyprinid indigenous to the Great Plains, 3) assessment of local-scale habitat associations of Topeka shiners, and 4) impacts and mitigation of road construction (culverts) in low gradient streams at stream crossings occupied by Topeka shiners. Our experiences in the upper Missouri River Basin can be applied to management issues within Canada relating to conservation of species of concern.

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PREDICTING THE FUTURE CALCIUM STATUS OF ACID-SENSITIVE PRECAMBRIAN SHIELD LAKES IN ONTARIO
Calcium (Ca) is an important nutrient for aquatic biota, but in recent years several studies have documented declining Ca concentrations in acid sensitive (Ca typically < 150μeq L^{-1}) lakes. The declining Ca concentrations have, to varying degrees, offset much of the benefits expected from declining sulphur emissions, and there is increasing concern that Ca may decline to levels that negatively impact lake biota. Calcium concentrations in lakes are largely determined by inputs from the terrestrial catchment and understanding the processes controlling catchment export is the key to predicting the future Ca-status of lakes. Acid-sensitive lakes generally have minimal groundwater inputs and Ca input to lakes is primarily determined by the size of the exchangeable Ca pool in soil. Current studies indicate that the soils of acid-sensitive lake catchments are still acidifying (losing Ca) and therefore Ca levels in lakes will continue to fall until soils cease to acidify. At steady state, the Ca concentration in lakes can be predicted from the difference between Ca inputs (weathering and deposition) and losses (harvesting). At sites that are intensively harvested, Ca concentrations in lakes may be up to 70% lower than current values. However lakes are rarely at steady state because several factors, including the level of acid deposition, climate and disturbance due to harvesting vary over time, altering Ca export from catchments and therefore lake Ca concentrations in the short term (years/decades). Current research efforts are directed toward predicting Ca inputs to lakes at steady state and the development of dynamic models that take into account 'short-term' changes in Ca export due to changes in acid leaching, climate variations or harvesting disturbance.

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THE ROLE OF RIVER FLOODING ON LIMNOLOGICAL CONDITIONS IN WATERBODIES OF THE PEACE-ATHABASCA DELTA.
The Peace Athabasca Delta lies mostly within Wood Buffalo National Park and is the world's largest boreal freshwater delta. It has been accepted previously that flooding induced by river ice-jam events play an important role in regulating aquatic communities through recharge of water volume and supplying nutrients to maintain the high productivity of deltaic lakes. While such assumptions are not unreasonable, little research has been done to test this theory. In this study, ten lakes positioned along a gradient of susceptibility to river flooding and Evaporation/Inflow ratio were examined during growing seasons of 2003 and 2004 to assess how hydrologic setting influences the limnology of such waterbodies. The role of hydraulic connectivity was examined with respect to nutrient and light regimes, productivity of macrophyte and plankton communities. In 2003; PAD 31 experienced heavy spring flooding during ice breakup and was found to be more productive in macrophyte biomass than PAD 1, a morphologically similar non-flood water body. Total productivity was also more highly dominated by a single species (*Potamogeton zosteriformis*) in PAD 31 than in PAD 1. In 2004, PAD 31 did not flood during early spring, but it flooded twice during the growing season (22 June and 20 July 2004), which altered limnological conditions compared to 2003 and resulted in reduced macrophyte biomass. The timing of flood events has a major impact macrophyte productivity.

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PERCEPTUAL WORLDS OF INDIVIDUAL YOUNG OF THE YEAR BROOK CHARR: BEHAVIOURAL RESPONSES TO NOVEL SITUATIONS

Recently-emerged brook charr (*Salvelinus fontinalis*) foraging in still-water pools along the sides of streams tend to be either sedentary, feeding from the lower portion of the water column (a sit-and-wait tactic), or very active, feeding from the upper portion of the water column (an active search tactic). We tested whether charr using different search tactics in the field differ in their willingness to explore and take risks in novel environmental situations. After quantifying the behaviour of fish in the field, focal individuals were captured and their behaviour quantified in novel laboratory situations. In an aquarium, individuals that used an active search tactic in the field spent a higher proportion of time moving and less time near the aquarium bottom, and took less time to find their way out of an erect glass jar, than did individuals that used a sit-and-wait tactic in the field. Differences in activity were maintained up to eight days. Individuals did not respond differently to a pebble dropped in the aquarium (simulated risk from above). How individuals behave in some novel environmental situations can be predicted by past behaviour in the field suggesting that individuals may differ in how they perceive new environmental situations.

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CHANGES IN PHYTOPLANKTON COMMUNITY COMPOSITION IN DORSET AREA LAKES OVER TWO DECADES

Phytoplankton are sensitive indicators of environmental stresses making them valuable in monitoring programs. The Ministry of the Environment has been monitoring phytoplankton in lakes on the Precambrian Shield since the 1970s. Patterns of distribution of phytoplankton classes and genera in counts of seasonally recombined samples were determined for 7 lakes in the Muskoka and Haliburton area from 1981 to 2001. Principal components analysis (PCA) and correspondence analysis (CA) were used to examine patterns in phytoplankton community composition through time. Relationships with water chemistry variables were then determined using redundancy analysis (RDA) and canonical correspondence analysis (CCA). There was an increase in the relative abundance of chrysophytes ($p< 0.007$) in 4 of the lakes, with a concomitant decrease in the relative abundance of diatoms (particularly *Cyclotella* sp. aff. *C. comta* (Ehr.) Kütz.) in 3 of the lakes ($p<0.001$). The separation of samples from these lakes in PCA represents a shift from a diatom to a chrysophyte dominated community, and was highly correlated with a gradient in calcium concentration ($r = -0.76$). Phytoplankton genera were also correlated with a gradient in calcium ($r = -0.42$). Taxa characterizing this gradient included the diatoms *Cyclotella* spp., *Synedra* spp. and *Eunotia* spp., the chlorophytes *Closterium* spp., *Spondylosium* spp., *Sphaerocystis* spp. and *Tetrastrum* spp., and the cyanobacteria *Aphanothece* spp. at the high end and the chrysophytes *Synura* spp., *Chrysosphaerella* spp. and *Uroglena* spp., and the dinoflagellates *Gymnodinium* spp., *Peridinium* spp. at the low end. The observations at the class level are particularly interesting and indicate a major change in the composition of the phytoplankton community in 4 of the lakes. A paleolimnological study on a sediment core from one of these lakes (Paterson et al., 2004) showed a marked increase in the abundance of colonial chrysophytes over the same time period. Multiple stressors, including acidic precipitation, climatic warming, stratospheric ozone depletion and invasions by exotic species, impact boreal lakes and need to be considered in explaining the changes observed.

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SCENARIOS OF GLOBAL LOSS OF FRESHWATER BIODIVERSITY FROM CLIMATE CHANGE AND WATER WITHDRAWAL

The rate of water flow in rivers (discharge) is one index of aquatic habitat heterogeneity. Analogous to a species-area curve, fish, mussel and invertebrate species richness increases with greater river discharge. Reduced discharge in rivers will result from climate warming and/or reduced precipitation and human use of water, but the possible consequences of these changes on richness are poorly quantified. We used the scenarios developed by the Millennium Ecosystem Assessment (MA) and the Intergovernmental Panel for Climate Change (IPCC) to build

scenarios of losses in river discharge and therefore losses of richness (primarily fish) that will result from climate change and increased water withdrawal for agriculture and other human uses over the next 100 years. Geographic regions that the scenarios indicate would experience reduced discharge are concentrated in rivers that are rich in total and endemic species, including rivers in Central and South America, West Africa and India. While results differ somewhat across scenarios, typical losses are 1-55% of riverine fish biodiversity by 2100 due to climate change and an additional 1-5% loss of richness due to water use. However, some rivers (e.g., Euphrates R., Indus R.) are predicted to have more substantial fish loss from water use alone. Our approach estimates losses of freshwater fish conservatively (given the scenario assumptions) because losses are driven exclusively by climate change and water withdrawal. If any scenario became reality, much greater declines in freshwater biodiversity would result because interactive, cumulative, and long-term effects of additional environmental drivers (in addition to discharge) would occur. Extinctions of other taxa (mussels and invertebrates) will be discussed.

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DECADE-SCALE CHANGES IN THE COMPOSITION OF CRUSTACEAN ZOOPLANKTON COMMUNITIES IN ALL EIGHT OF THE DORSET ENVIRONMENTAL CENTRE (DESC) CORE STUDY LAKES
In the late 1970s the DESC began a long-term sampling program of eight small Canadian Shield lakes: Blue Chalk, Chub, Crosson, Dickie, Harp, Heney, Plastic and Red Chalk. The lakes were selected to differ in sensitivity to acid inputs, and in contributions of shoreline development to phosphorus inputs. Crustacean zooplankton assemblages of the lakes have been sampled in a consistent manner on at least a monthly basis from May to October since 1978, and counting protocols have remained constant since 1980. Over 400,000 animals from the 8 lakes have been identified, counted and measured. The 1980 to 2002 data set reveals that zooplankton composition has changed in all eight of the study lakes. With its glacial relict species, Harp Lake differed in composition from the other 7 lakes at all times, and since the mid-1990s, the introduction of the spiny water flea, Bythotrephes, has transformed this community. As Bythotrephes only colonized Harp Lake, it was removed from the current analysis. The average composition of the zooplankton communities of the other 7 lakes was clearly distinguishable on a pH gradient, and these differences were generally preserved over time. To examine inter-annual variability and temporal trends in compositional variation in the lakes we examined the first two axes of a correpondence analysis (CA) of log-transformed annual abundances of the 30 most common taxa in the 22 year records. There were significant (five-fold) differences in the magnitude of inter-annual variability among the lakes, Dickie Lake having the most variable community. Further, clear evidence of temporal changes was evident in all seven lakes, including both non-acidic, undeveloped lakes (Blue Chalk and Red Chalk), that serve as the principal reference communities. In particular, seven of 14 derived variables (the 1st two CA axes from each of the seven lakes) changed significantly over time (Kendall's tau with year). The changes in zooplankton composition were correlated both with changes in nutrient status and acidity in the lakes. These time series indicate that the zooplankton composition of both developed and undeveloped south-central Ontario Shield lakes is changing on a scale of decades.

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EFFECTS OF INCREASING USE OF NO-TILL CROPPING SYSTEMS ON STREAM QUALITY IN SOUTHERN ONTARIO, CANADA
Agriculture is a serious threat to aquatic species at risk in southern Ontario and is potentially a cause for currently unlisted species to become at risk. Release of sediments to streams from tilled lands has been a significant stressor to streams in agroecosystems for decades and has been shown to impact aquatic species in a variety of ways. To limit soil erosion from tilled fields a conservation tillage techniques, including the use of no till systems, have been developed and widely adopted throughout the region. However, there has been no testing of the effects of no-till systems on stream quality at a watershed scale. We measured habitat and water quality and sampled the benthic macroinvertebrate (BMI) and fish communities in 32 small (100-1400 ha) subwatersheds that exhibited a gradient of the proportion of land under no-till cropping systems to determine relationships between the use of no-till and stream quality. Our results demonstrated trends of improvement in indices of all four stream quality measures with increasing amounts of crop land under no-till systems. With increasing use of no till systems habitat scores improved, the quantities of sediment and sediment associated stressors in the water declined, the BMI community exhibited reduced dominance by Oligocheaeta and Sphaeriidae as well as improved family biotic index scores, and

fish community richness increased. Based on these results we concluded that increased use of no till cropping systems by farmers does contribute to improved quality of streams in agroecosytems.

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SEASONAL VARIATION OF *BYTHOTREPHES* BODY LENGTH IN SHIELD LAKES: POSSIBLE PLANKTIVORE INDUCED LIFE HISTORY SHIFTS
In European and North American populations, *Bythotrephes* body size has been shown to vary both seasonally and from lake to lake. One proposed mechanism of this variation in body size is predation by planktivores — either directly through size selection or indirectly by inducing life history shifts in body size. The two key pelagic planktivores of *Bythotrephes* in Canadian shield lakes are cisco, *Coregonus artedii*, and rainbow smelt, *Osmerus mordax*. Cisco are a large bodied fish that have been shown to prey on all sizes of *Bythotrephes*, while smelt are a much smaller fish and hence are potentially gape-limited. Because larger *Bythotrephes* body size could inhibit predation by the gape-limited smelt, we would expect *Bythotrephes* to be larger in lakes that contain only smelt as the key planktivore. To test this hypothesis, we compared the seasonal instar body size of *Bythotrephes* in three lakes that contained only smelt (Peninsula, Mary and Fairy) to three lakes that have both types of planktivores, smelt and cisco (Vernon, Bernard and Lake of Bays). Although a two-way repeated measures ANOVA of 3rd instar *Bythotrephes* body length in lakes with the two fish types was not quite significant, there were very distinct synchronous shifts in body size in the lakes with different fish types: 3rd instar *Bythotrephes* were significantly larger in lakes containing only smelt in the early summer, and in two of these lakes again in late summer. These seasonal life history shifts towards larger individuals in lakes with only smelt could have negative implications on birth rates, since larger neonate size is often a trade-off to larger clutch sizes.

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SPATIAL AND TEMPORAL VARIABILITIES OF FISH COMMUNITY IN LAKE ERIE SYSTEMS
Spatiotemporal variability in fish community composition in Lake Erie was described using index gillnets between 1989-2003. Canned and bottom gillnets (32- to 152-mm stretch monofilament twine) were fished at 204 to 322 locations annually, utilising a depth stratified random design encompassing the entire Canadian waters of Lake Erie. Expected habitat differences (depth, temperature, dissolved oxygen, and transparency) were documented among the three basins. Fifty-one species, representing 18 families and 11 orders, were captured during the program. Eleven non-indigenous species accounted for 55% of abundance while the 40 native species accounted for 63% of biomass. Canonical correspondence analysis and clustering dendrograms relating environmental variables to community diversity indices, indicated dissolved oxygen was the principle determinant of spatial differences in community composition. Surface temperature and transparency also exhibited significant spatial and temporal differences among basins. Abundance and biomass from both pelagic and demersal catches decreased from west to east. Diversity of the demersal catch was higher than the pelagic catch which was dominated by alewife and gizzard shad. Overall demersal diversity decreased from west to east, while pelagic catch diversity showed no spatial trend. The coupling of spatial and temporal variation in environmental variables with attributes of fish community organisation illustrated the existence of three distinct demersal assemblages partitioned on the basis of high biological productivity in the west basin, hypoxic constraints in the central basin, and thermal stratification in the east basin. The influence of water transparency on foraging dynamics, and dissolved oxygen on physiologic tolerances of fishes will be explored with this powerful fish community database.

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SEASONAL MOVEMENT PATTERNS OF RESIDENT BROWN TROUT IN A LAKE ONTARIO TRIBUTARY

The seasonal movement patterns of adult Credit River brown trout (*Salmo trutta*) were studied from 15 May 2002 to 28 July 2003, in three heterogeneous river sections over a confined 39.8 km portion of the river. Section 3 was 6.15 km, had 1.03% channel slope and 75.8% mature mixed riparian cover; Section 2 was 8.85 km, had 0.25% channel slope and 76.2% mature deciduous riparian cover; and Section 1 was 24.80 km, had 0.26% channel slope

and 24.2% mature deciduous riparian cover. Brown trout exhibited seasonal range and activity patterns that varied by individual and section of origin. Upstream Section 3 brown trout moved the least and occupied the highest quality habitat available in the study area. Section 1 (downstream) and 2 (midsection) brown trout moved the most, triggered by water temperatures. Movements were most extensive during late spring – early summer and fall. Late spring – early summer upstream movements in search of cooler refugia were positively correlated to water temperatures exceeding the species physiological optimum of 17.4 ºC. Downstream fall movements occurred when water temperatures dropped below 7 ºC. Section 1 and 2 brown trout often maintained different, single occupation locations, or home sites, throughout summer and winter periods, with winter ranges being occupied for up to seven months. Several individuals returned to the same home sites in consecutive summers. Results indicate movement patterns are linked to habitat suitability and change in key environmental variables affecting growth and reproductive potential.