

CCFFR Poster Abstracts : Arranged alphabetically by first author

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CRYPTIC STOCK STRUCTURE OF LAKE WHITEFISH, COREGONUS CLUPEIFORMIS, IN EASTERN LAKE ONTARIO

At least two distinct spawning stocks of lake whitefish, *Coregonus clupeaformis*, have been hypothesized for eastern lake Ontario, a stock that spawns in the Bay of Quinte, and one that spawns within the lake on the south shore of Prince Edward County. During the 20th century, the lake whitefish of this area exhibited numerous population fluctuations culminating in a large decline in adult numbers and an overall larval recruitment failure in the late 1990s. The current residual lake whitefish have lower body condition and growth as well as a delayed age at maturity. This study is to determine, via microsatellite analysis, the stock structure of the lake whitefish in this area as well as determine the relative contributions to both the adult mixed stock populations and to the larval recruitment. Archived historical scale samples will also be examined for any form of past genetic structure and temporal stability.

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DYKING AS A MEANS OF MAINTAINING FISH HABITAT IN COASTAL WETLANDS IN THE FACE OF CLIMATE CHANGE (P)

We examined fish assemblages and physical habitat characteristics in six paired coastal wetlands across the southern Great Lakes basin. Each pair consisted of a dyked (or natural barrier) coastal wetland and an adjacent open coastal wetland. Each wetland was sampled in the spring and fall of 2003 and 2004 using a grid-based sampling design and multiple gear types. Habitat and fish data from the dyked and open wetlands were analyzed to determine if dykes could be used to maintain water levels in coastal wetlands, maintain fish habitat although the accessibility to the wetland is compromised. We used diversity indices to compare fish assemblages between corresponding dyked and open wetlands. We also used canonical correspondence analysis to examine relationships between the fish species present and the physical and geographic characteristics of each site.

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DO WILD YOUNG-OF-THE-YEAR ATLANTIC SALMON PREFER TO SETTLE NEXT TO KIN OR NONKIN?

In laboratory conditions, juvenile salmonids preferentially settle next to and are less aggressive towards kin versus nonkin. However, there is little evidence for such kin-biased behaviour in the wild. We tested for an association between the local-scale distribution patterns of young-of-the-year Atlantic salmon and their degree of relatedness in Catamaran Brook, New Brunswick. In August 2004, the foraging locations of 91 salmon in an 8x40-m reach were identified and captured by snorkelling, after which adipose fins were removed for microsatellite amplification at six loci. The resulting alleles were scored and a measure of relatedness between individuals was calculated. The preliminary results suggest that patterns of kin-biased behaviour are not evident at one spatial scale. However, we are currently undertaking analyses of data collected at two other spatial scales within the brook.

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RESTORATION OF NORTHERN PIKE PASSAGE WITH NATURAL BYPASS CHANNELS ON THE NIAGARA PENINSULA

Radio transmitters were surgically implanted in twenty northern pike (472 - 752 mm TL) that were collected upstream from the Port Davidson Weir in March 2003. Tagged pike were released downstream from the Port Davidson Weir (Welland River) and both upstream and downstream from the Canborough Weir (Oswego Creek) to test bi-directional passage through new natural fish bypass channels. Fish locations (n=888) revealed critical spawning habitat and the distribution of discharge-dependent barriers to fish movement. Movement patterns through the bypass channels indicated that upstream and downstream movement was possible over a specific range of flows, and fish did not become stranded by low water levels, or displaced by high discharge. Passage rate was 80 % for upstream migrating fish ($Q = 0.7 - 15.2 \text{ m}^3/\text{s}$, $n = 14$), and 50 % for downstream migrating fish ($Q = 0.8 - 6.4 \text{ m}^3/\text{s}$, $n = 7$) at the Port Davidson Weir. At the Canborough Weir, the initial upstream passage rate was 100 %, and the downstream passage rate was 89 %. Ten upstream movements occurred ($Q = 0.4 - 7.6 \text{ m}^3/\text{s}$), and eleven downstream movements were recorded ($Q = 0.2 - 3.7 \text{ m}^3/\text{s}$). Most upstream and downstream passage occurred while discharge in Oswego Creek was $1.2 \text{ m}^3/\text{s}$ and maximum subsurface water velocity during upstream passage was 1.1 m/s. Remediation of fish passage at these sites involved careful design, construction and monitoring of fish bypass channel effectiveness, resulting in restoration of river connectivity for the first time in decades.

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GENETIC ANALYSIS OF IMMUNOLOGICAL DIFFERENCES IN TRIPLOID VERSUS DIPLOID CHINOOK SALMON

The increasing numbers of fish farms have led to growing concerns with the potential impacts of the industry on wild stocks. Since different forces of selection are acting on fish in captivity, domesticated fish at fish farms are quite different than those in the wild, hence, escaping farmed fish is a serious potential problem. Triploidization, the incorporation of an extra set of chromosomes, has been proposed as a possible way of ensuring genetic containment, since triploid salmon are sterile. The extra set of chromosomes produces several observable changes in chinook salmon such as lack of sexual maturation in females, larger cell sizes, and lower aggression, and possible lower disease resistance. The major objective of this study is to investigate the gene expression effects of the third set of chromosomes on immunological function in Chinook salmon. Using degenerate RT-PCR, eight immunologically related genes (TNF, IL-1, IL-1 receptor, IL-8, IL-8 receptor, RAG-1, pentraxin, and IgM) have been isolated and sequenced. An immuno-challenge with Vibrogen-2 has been conducted on offspring generated from two sets of matings between a single female salmon and two male salmon. Both sham and vaccinated fish were sampled at time zero and at two weeks and four weeks post first vaccination. Real-time quantitative PCR and ELISAs are being used to determine the effects of triploidization on gene expression and immune function. Current findings will be presented.

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THE DORSET ENVIRONMENTAL SCIENCE CENTRE 1975-2005

Over the past thirty years, the Dorset Environmental Science Centre has contributed to the understanding of how environmental stressors impact inland lakes in Ontario. The analysis of millions of water quality and biological samples has led to the publication of hundreds of peer review papers. Numerous research projects

have provided support for post graduate studies, and employment for hundreds of summer students. We present a pictorial history of the Dorset Environmental Science Centre that shows, in chronological order, many of the topics researched at the Centre between 1975 and 2005.

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DO CIRCLE HOOKS REDUCE INJURY AND MORTALITY? A REVIEW FOR RECREATIONAL FISHERIES

Circle hooks have rapidly become popular among recreational anglers based largely on the assumption that their use aids in the conservation of fisheries resources by reducing gut hooking, and hence, mortality. We surveyed literature databases and also used questionnaires to solicit information from unpublished or in progress circle hook research. Among studies, results have been quite disparate. However, overall mortality rates were consistently lower for circle hooks than J style hooks. In addition, circle hooks were more frequently hooked in the jaw, and less frequently hooked in the gut than conventional hook types. There is no doubt that in some marine fisheries such as tuna, billfish, and striped bass, capture efficiency remains high and injury and mortality rates are drastically reduced. However, in other species (e.g., bluegill), injury can actually be more severe from circle hooks relative to some other hook types. In other species such as largemouth bass, circle hooks have minimal conservation benefit, but have reduced capture efficiency relative to conventional hook designs. Factors such as hook size, fishing style, fish feeding mode, and mouth morphology all appear to affect the effectiveness of circle hooks. The recent interest in circle hooks has been beneficial for stimulating interest and research on the role of hook designs in reducing hooking related injury and mortality. We encourage tackle manufacturers to continue to develop new hook designs that have the potential to provide conservation benefit to caught and released fish.

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IMPORTANCE OF CAPELIN (*MALLOTUS VILLOSUS*) BIOLOGY IN SUSTAINING TROPHIC INTERACTIONS IN THE NORTHWEST ATLANTIC.

Capelin (*Mallotus villosus*) is the focal forage fish species in the Northwest Atlantic, preying on invertebrates and being preyed on by most large vertebrate predators. Recently, the biology and behaviour of capelin has changed dramatically. The basis for these changes is not well understood and has led to considerable uncertainty in capelin stock status. Through a collaborative, interdisciplinary initiative we investigate the bio-physical mechanisms underlying these changes. Owing to globally and regionally significant populations of marine fish, birds and mammals, we focus on the area encompassing Funk Island on the northeast coast of Newfoundland. Combining ROV observations with sediment grab and seabed mapping systems, we investigate the relative contribution of beach versus off-beach (demersal) spawning to overall reproductive success. A number of persistent demersal spawning sites (18-30 m) have been found that have similar developmental/survival rates to nearby beach sites. Integrating biological sampling with hydroacoustics both during a meso-scale survey (~1600 km) and at stationary mooring sites, we examine the vertical distributional/migratory patterns of capelin in relation to the thermohaline properties of the water column, combined with the density and distributional patterns of capelin predators and prey. This revealed

that capelin and their invertebrate prey consistently conduct diel vertical migrations. Finally, by integrating seabird diets (Funk Island) with capelin and other prey abundance data obtained during the survey, we plan to model how the use of food resources by these predators changes with capelin availability during the breeding season, and explore its implications for predator energetics and dynamics. We anticipate that this research will further increase our understanding of the recent changes in capelin biology and their implications for other trophic levels.

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NON-INVASIVE SEX DETERMINATION OF LARVAL SEA LAMPREYS USING ACOUSTIC MICROSCOPY

Ultrasound is a fast, non-invasive way to study the internal structures of living organisms, and has been used to determine sex and stage of maturity in commercially important fish species. Although conventional ultrasound (3.5–15 MHz) can show the sex of mature fishes, sex determination in immature fishes has been unreliable and difficult. In this study, a rapid, accurate, and non-invasive method to identify the sex of larval sea lampreys (*Petromyzon marinus*) using scanning acoustic microscopy (SAM) is described; until now, this process required dissection or invasive surgery. Unlike conventional ultrasound, SAM uses a focusing lens to concentrate high-frequency ultrasound (15–100 MHz) for obtaining high-resolution acoustic images. Cross-sectional acoustic images were generated in approximately 30 seconds per animal (110–130 mm in length), and showed such internal body structures as the gonad, intestine, kidneys, cardinal veins, notochord, and musculature. Females were identified by the presence of a relatively large (1–1.5 mm diameter) ovary, which was considerably less reflective to the acoustic signals than the surrounding kidney tissue. Males were recognized by the lack of the large non-reflective ovary and, in some cases, the appearance of a small (0.2–0.3 mm) testis with slightly stronger reflective properties than the kidney. Identification of sex was confirmed by optical microscopy following dissection, and in a blind test on additional specimens, the acoustic method was 100% reliable. This technique is versatile and may be useful in other fish species to determine sex, diagnose disease, and monitor the development of other internal organs.

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AN EXAMINATION OF THE EFFECTIVENESS OF ARTIFICIAL SUBSTRATES TO ASSESS NATURAL VARIABILITY AND ANTHROPOGENIC INFLUENCES ON THE BENTHIC COMMUNITY.

Benthic organisms have long been used as indicators of the condition of aquatic systems. As many traditional sampling techniques rely on penetrating or moving sediment, they are inappropriate for sampling benthic communities located in rocky substrates. This study examined the effectiveness of artificial substrate (rock baskets) at quantifying natural variability in benthic communities and detecting anthropogenic changes in the environment. By comparing artificial substrate data to kick and sweep data, we assessed the ability of artificial substrate communities to represent those found in natural substrate. General linear models (GLM) were used to evaluate data collected from three substrate sites in each of twelve lakes. Principal component analyses (PCA) and canonical correspondence analyses (CCA) were used to examine the impact of spatial heterogeneity. PCAs and CCAs were also used to determine the

ability of artificial substrates to detect changes resulting from anthropogenic activity. The results indicate that communities sampled using artificial substrate reflected lake size and environmental heterogeneity, and resembled the benthic community found within the natural substrate. The artificial substrates were sensitive to anthropogenic influences despite differences in community composition associated with environmental factors. Because the artificial sampler resembles natural rocky substrates, we believe that artificial substrates are a useful tool for monitoring benthic communities in difficult to sample locations.

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VARIANCE PARTITIONING OF BENTHIC MACROINVERTEBRATE COMMUNITIES IN PRECAMBRIAN SHIELD HEADWATER STREAMS.

As community ecologists, we are interested in the interactions between species and their environment. Several biotic and abiotic factors influence the distribution and abundance of species in relation to their environment. Determining what these factors are is a tumultuous task because of the natural variation inherent in biological communities. Even in pristine conditions, we expect to see variation in community structure across space and time.

The Dorset Environmental Science Centre is known for extensive monitoring of inland lakes and streams. Resulting from these efforts, the benthic macroinvertebrate communities from 56 unimpacted headwater streams on the Precambrian shield in south central Ontario were studied to determine the relative influence of spatial, temporal and environmental factors using variance partitioning. Variance partitioning determines what portion of the variance can be predicted by spatial, environmental, and temporal variables. In total 78 variables were reduced to those that showed marginal significance in a redundancy analysis using 999 Monte Carlo permutations. Variance resulting from these marginally significant variables was then partitioned into four components: non-spatial environmental variation, spatially structured environmental variation, spatial variation not shared by environmental factors, and unknown variation. Resulting from this work, a model of abiotic factors can be created to predict community assemblages in Precambrian shield headwater streams.

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DISSOLVED ORGANIC CARBON LABILITY: DYNAMIC AT THE DRAINAGE BASIN LEVEL.

In freshwater ecosystems, bacterial metabolism is largely fuelled by dissolved organic matter derived from both allochthonous and autochthonous sources. Allochthonous dissolved organic carbon (DOC) of terrestrial origin has traditionally been considered to be more recalcitrant to bacterial metabolism than organic matter derived from lake processes such as algal or macrophyte production, mainly due to its intrinsic composition and diagenetic state. Several new lines of evidence, however, have challenged this notion and suggest that allochthonous carbon inputs to lakes may still represent a relatively large pool of labile DOC and thus have a major impact on lake metabolism. We assessed the relative lability of allochthonous versus lake DOC by following the changes in DOC lability along a flow path within a drainage basin in Southern Québec. We define the labile pool as the amount of DOC degraded in regrowth bioassays incubated without nutrient or DOC additions. We compared the resulting rates of carbon consumption and the proportion of DOC consumed from the DOC pool transported by rivers, composed mainly in allochthonous carbon, to the consumption and lability of the DOC in the receiving lakes and in the lake outflows. Our results show that the DOC pool in inflowing rivers generally contains more labile carbon than the DOC present in the receiving lakes and in the lake outflows. There are often large changes in both total DOC and labile

DOC during transit between lakes, due to local features such as wetlands and beaver ponds. Our results show that river carbon inputs are a significant source of labile organic matter that can be metabolized in lakes, and that lakes in turn are a source of labile organic matter for downstream water bodies. There is a relatively weak coupling between the total amount of DOC and the amount of labile DOC, so that similar DOC loading may have very different impacts in terms of lake metabolism.

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WARNER LAKE ECOLOGICAL OBSERVATORY: INSIGHTS INTO FISH BEHAVIOUR USING A WHOLE-LAKE THREE-DIMENSIONAL ACOUSTIC TELEMTRY ARRAY

The Warner Lake Ecological Observatory is located on the property of the Queen's University Biological Station and represents the first whole-lake experimental system capable of monitoring the behaviour of fish in three dimensions. The acoustic telemetry system uses code discrimination multiple access protocols to enable the simultaneous real-time monitoring of numerous tagged animals. During preliminary experiments, 22 largemouth bass (*Micropterus salmoides*) were implanted with acoustic transmitters in November, 2003. These transmitters provided the positional information required to generate X-Y-Z positions and temperature of each animal every 15 seconds. Transmitter signals were collected by a series of 13 moored hydrophones that relayed information to two receiving stations. This initial phase of the project produced a comprehensive dataset of fish behaviour from November, 2003 through April, 2004. Individual movements across various time scales (e.g., gross daily movement to instantaneous movements) were recorded with sub-meter accuracy. During the winter, fish resided in the deep basin of Warner Lake and avoided the shallow basin. Contrary to existing paradigms that largemouth bass are quiescent during the winter, fish moved extensively under the ice, exhibiting subtle but regular patterns of vertical distribution. In late March ice cover left the shallow basin before the deep basin, and the majority of individuals moved into the ice-free basin. This preliminary deployment using largemouth bass as a model has revealed the power of the ecological observatory to provide data that are unattainable using other techniques and will enable a better understanding of the community ecology in temperate lakes.

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THE INFLUENCE OF DISSOLVED ORGANIC MATTER SIZE AND CONCENTRATION ON THE BIOAVAILABILITY OF MERCURY, MEASURED AS UPTAKE BY SIMULIUM SPP (DIPTERA, SIMULIIDAE) LARVAE

Accumulation of Hg by filter-feeding larvae of Simulium spp (Diptera, Simuliidae) was investigated through larval exposure to ¹⁹⁹Hg in laboratory microcosms containing dissolved organic matter (DOM) in different size fractions (1 µm, 0.45 µm, 100 KD, and 10 KD) and different concentrations. The amount of ¹⁹⁹Hg accumulated varied depending on the concentration and size fraction of DOM present in the microcosm. In the spiked microcosms with very low concentrations (<1 mg/L) of dissolved organic carbon (DOC, a surrogate for DOM), the concentration of ¹⁹⁹Hg in the black flies rose significantly over the first 4

days, then fell sharply by day 8. In the microcosms with moderate DOC concentrations (<9 mg/L), which may have had ¹⁹⁹Hg not bound to DOM present in the water column, ¹⁹⁹Hg accumulation also rose and fell significantly over 8 days. In the microcosms with high concentrations of DOM (>15 mg/L), ¹⁹⁹Hg accumulation rose more slowly over 8 days. Black fly larvae in microcosms with large DOM size fractions (1 µm and 0.45 µm) increased significantly in ¹⁹⁹Hg concentration over time, while larvae in microcosms with the small size fractions (100 KD and 10 KD) did not increase significantly over time. Over the short term, DOM prevented uptake of Hg; however, in the long term uptake of Hg increased over time. When unbound Hg was present in the microcosms, the black fly larvae increased initially in Hg, and then decreased in Hg.

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IMPACTS OF ENVIRONMENTAL STRESSORS ON LAKES OF NEW BRUNSWICK, CANADA: A PALEOLIMNOLOGICAL ASSESSMENT

Lakes of New Brunswick (N.B.), Canada, are important as fish and piscivorous aquatic fowl habitat, as well as to local residents for recreation and tourism. However, these lakes are subject to multiple stressors including acid deposition, nutrient inputs and climate change. Certain lakes in southwestern New Brunswick and in Fundy National Park have been identified as particularly sensitive to acid deposition. Governmental monitoring of lakewater chemistry began in the late-1980s but, despite this 20-year record, the limnological conditions of these lakes prior to broad-scale human influence remain unknown. This study employs paleolimnological approaches to assess environmental changes within these lakes. Sediment samples were collected in July of 2003. In what is typically termed a “top-bottom” analysis, diatom algal assemblages present in recently deposited lake sediments are compared to assemblages found in sediments deposited pre-1850 to provide an estimate of the type and degree of environmental change experienced in each lake. Top-bottom analyses of 16 lakes from New Brunswick will be presented and the effects of each environmental stressor evaluated with particular emphasis on the effects of acid deposition. This study should provide important insights into the background conditions of New Brunswick lakes, and how they have been impacted by human activities.

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RISKY BUSINESS: EFFECTS OF SOCIAL STATUS AND FOOD AVAILABILITY ON PREDATOR AVOIDANCE BEHAVIOUR IN YOY RAINBOW TROUT.

Behavioural decisions made by prey under the risk of predation are based on a series of threat-sensitive trade-offs. Individuals capable of maximizing these trade-offs through the use of context specific predator avoidance behaviour should be at a selective advantage. A variety of factors, including food availability and social status, have been shown to exert a strong influence on these trade-offs. However, to date it remains unknown if these factors interact. Using pairs of Young-of-the-Year rainbow trout, *Oncorhynchus mykiss*, we examined the effects of food availability and individual social status, as well as their interaction, on individual responses to perceived predation threats. Each dominant-subordinate pair was assigned to one of three feeding regimes (1%, 5%, or 10% of their combined body weights), and either exposed to a conspecific alarm cue (predation threat) or a distilled water control (no threat). We quantified 1) the time spent moving, 2) number of feeding attempts, 3) latency to first feeding attempt, and 4) number of aggressive interactions. Our results suggest that an individual's response to a perceived predation threat is indeed dependent upon both social status and food availability. Subordinates increased antipredator behaviour in response to a predation threat under 1% and 5% feeding regimes, but not under 10%.

Dominates increased antipredator behaviour under 5% and 10% feeding regimes, but not under 1%. Thus our results support the hypothesis of context dependant predator avoidance strategies.

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A SUMMARY OF LONG-TERM WATER QUALITY TRENDS FOR EIGHT INTENSIVELY STUDIED LAKES IN CENTRAL ONTARIO

Nearly 30 years of environmental studies conducted at the Dorset Environmental Science Centre have resulted in long term records of chemical, physical and biological data for eight intensively studied, headwater lakes in Central Ontario. These calibrated watersheds, referred to as the Dorset 'A' lakes, were initially selected to span a gradient of shoreline development. While sampling frequency has varied since the mid 1980's, these lakes, and their inflows and outflows, have been monitored at least monthly during the ice free season. Here we present a summary of major water quality trends for these lakes since the mid 1970's. For some parameters, water quality has not been static over the study period. For example we show coherent declines across lakes in concentrations of total phosphorus and calcium. Furthermore, many lakes show declines in sulphate and increases in alkalinity consistent with recent decreases in atmospheric sulphate deposition. Other parameters, such as dissolved organic carbon (DOC), show significant variability, but no consistent trends through time. The environmental monitoring of the Dorset 'A' lakes continues to investigate the effects of anthropogenic stressors on aquatic ecosystems in Ontario.

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LANDSCAPE INFLUENCES ON WATER QUALITY IN THE BOREAL REGION OF MANITOBA: A LAKES SURVEY

There has been increased emphasis on modeling forest harvesting practices after natural disturbance. The assumption, which remains unverified, is that ecosystem integrity can be maintained if harvesting patterns imitate fire. Forest harvesting and fire is expected to increase rates of erosion and nutrient export into lakes. In Canada, the majority of research examining the effects of forest disturbance on lakes has occurred in Alberta and Quebec so the relevance to forest lakes in other regions is unknown. Preliminary research appears to indicate that lake water quality can be maintained if timber harvesting disturbance is limited to a low percentage of a watershed. Lakes in Manitoba, especially those on the sparsely populated east side of Lake Winnipeg, suffer from a chronic lack of baseline data and water quality monitoring infrastructure. This project is intended to address this knowledge gaps with a survey of approximately 100 lakes, with varying levels of watershed disturbance (harvested, burned, and reference), in the boreal forest of eastern Manitoba. Lakes were selected using aerial reconnaissance and remote sensing. A suite of physical and chemical water quality parameters, as well as basic bathymetry, were measured in mid-summer 2004. Relationships between water quality, historical patterns of land use, and landscape features will be investigated using multivariate statistical methods. An introduction to the study will be given. Preliminary results from the 2004 field season will be presented with emphasis on general limnological trends across the region.

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EFFECTS OF TERRITORY SHAPE AND COMPETITOR DENSITY ON ECONOMIC DEFENDABILITY AND GROWTH DEPENDANCE IN JUVENILE CONVICT CICHLIDS

While the effect of patch area on economic defendability has attracted considerable attention, there has been little research on patch shape. We manipulated food patch shape independent of patch area (square, 13.64 x 13.64 cm; rectangular, 46.5 x 4 cm; elongated, 93 x 2 cm) and competitor density (three, six, twelve fish) in a 3 X 3 factorial design. We tested the predictions that the frequency of aggression, degree of resource monopolization and size variation within groups would decrease as ratio of perimeter to surface area and competitor density increased. As predicted, increasing ratio of perimeter to surface area decreased the frequency of aggression and the degree of resource monopolization, but had no effect on growth dependence (size variability). We also found that increasing number of fish decreased the frequency of aggression, degree of monopolization and size variation within groups. Our study showed that increasing the ratio of perimeter to surface area had the same effect as decreasing economic defendability via increasing density of competitors. Our experiment suggests two practical ways of reducing aggression and growth dependence in aquaculture conditions: food patches of a thin elongated shape would decrease aggression, and large group size would decrease aggression and growth dependence.

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SEMINAL VESICLE OF THE ROUND GOBY: A PARTNER IN THE PRODUCTION OF REPRODUCTIVE PHEROMONES?

Pheromone communication may be important to the reproductive success of the round goby, *Neogobius melanostomus*, an invasive fish species in the Great Lakes. Our previous studies have shown that the testes produce steroidal compounds that are potent stimulants of olfactory sensory activity in female round gobies. In this study, we investigate the role of the seminal vesicle in pheromone production. The seminal vesicle of the round goby is a gonadal gland attached to the testis, and shares a common genital pore opening to the genital papillae. We have used histological, immunocytochemical and transmission electron microscopic techniques to localize steroid producing Leydig cells in this gland. Leydig cells, rich in smooth endoplasmic reticulum, were located in the proximal region of the seminal vesicle, adjacent to the testis. Biochemical analyses have revealed the ability of this gonadal gland to convert radioactive steroid, androstenedione, into 11-oxo-etiocholanolone, 11-oxo-androstenedione and 11-oxo-testosterone. These steroids, which elicit olfactory sensory responses in round gobies, may be constituents of a reproductive pheromone released by males to attract females for spawning.

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IMPACTS OF FALLING LAKE CALCIUM CONCENTRATIONS UPON CRUSTACEAN ZOOPLANKTON

Calcium (Ca) is a major component of the crustacean zooplankton carapace. Currently, Ca concentrations are falling in many boreal shield lakes that have a long history of acid deposition; as crustacean zooplankton

obtain the majority of their Ca from lake water this may result in a decline in Ca-rich taxa. Because there have been no comparative field studies of the Ca content of North American zooplankton fauna there is a need to identify zooplankton that may be vulnerable to this Ca decline. Further, there is a need to determine if the abundance of Ca-rich taxa might already be falling in Canadian Shield lakes in response to declines in ambient Ca concentrations. Our goals were to determine: (1) if body Ca concentration varies seasonally, (2) whether species identity or lake Ca concentration is the principal determinant of zooplankton Ca content, and (3) whether reductions in lake Ca availability have already resulted in long-term changes in the abundances of Ca-rich species. To address these goals, we analyzed the Ca concentration of eight crustacean zooplankton taxa, from nine Ontario lakes spanning a 0.4-35 mg•L⁻¹ Ca gradient. We then determined if the biomass of Ca-rich vs Ca-poor taxa had different long-term time trends in long-term data sets assembled by the Dorset Environmental Science Centre. Large differences in Ca concentrations were observed between taxonomic groups. Daphnid Ca concentration ranged from 2-8% of dry body weight, while concentrations of copepods and non-daphnid cladocera were much lower, at 0.2-0.4%. Seasonal variation in zooplankton Ca content was negligible. Although lake Ca concentration effects were significant the most important determinant of crustacean zooplankton Ca content was species identity. Examination of long-term data series showed falling lake Ca levels have not yet had a significant impact upon crustacean zooplankton abundance, however we hypothesize Ca-rich daphnids will be the first to be affected should Ca levels fall below a threshold value.

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REGIONAL AND TEMPORAL VARIATION IN THE THERMAL HABITAT OF GREAT LAKES STREAMS

The thermal characteristics of the streams and rivers that feed the Great Lakes play an important role in defining the species specific habitat supply available for fish populations. Regional and temporal differences in this habitat supply will largely determine the productive capacity of these waters. Climatic conditions and landscape conditions are the critical physical elements that in combination with species-specific thermal tolerances define these thermal habitats. The primary objective of this research: (i) consolidate existing time series data on water temperature and relate this to landscape characteristics and climate (ii) use species specific thermal tolerance information to evaluate how these regional and temporal differences in temperature patterns shape current levels of habitat supply for fish; (iii) exploit extremes in climate variation that occurred over the period 1990-2000 to develop empirical descriptions of the response of stream temperature regimes to current patterns of climate variation; (iv) couple these findings with up-to-date climate change scenarios to assess the likely long-term impacts of climate change on stream dependent salmonids across the basin. To date we have collected preexisting temperature data from various agencies and groups and deployed 100 loggers throughout the Great Lakes Basin.

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DEVELOPMENT OF LIMNOLOGICAL PROXIES OF SEABIRD INFLUENCE ON PONDS FROM DEVON ISLAND, NUNAVUT, CANADIAN HIGH ARCTIC

The Canadian Arctic is an important breeding ground for many seabirds; however, wildlife officials charged with managing bird habitats are seriously limited by a lack of long-term data. Determining the histories of bird colonies is critical to understanding whether current fluctuations in seabird populations are within the

range of natural variability, as well as a suite of other scientific and management questions. Such data would also help set realistic management goals, and identify important, long-term bird habitats. As top predators in the marine environment, seabirds transport significant quantities of marine-derived nutrients to freshwater systems via their guano. This nutrient enrichment results in highly eutrophic aquatic ecosystems, which, in turn, result in distinctive algal communities within these ponds. Here, we assess the influence of seabirds on the present-day limnology of arctic ponds at Cape Vera, Devon Island, Nunavut. A large colony of northern fulmars (*Fulmarus glacialis*) nests in the cliffs along Cape Vera. Below these cliffs are many ponds that reflect a gradient of productivity that can be linked to seabird influence. Pond water (for nutrient and other water chemistry analyses) and surface sediment samples (for diatoms and $\delta^{15}\text{N}$) are analysed across a productivity gradient of 11 ponds from Cape Vera. We also present preliminary data calibrating diatoms and stable isotopes ($\delta^{15}\text{N}$) to varying levels of seabird influence. Once a link between seabird-derived nutrients, $\delta^{15}\text{N}$, and diatoms is established, fossil diatoms and $\delta^{15}\text{N}$ will be used to reconstruct seabird populations through time at Cape Vera, using paleolimnological techniques.

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INFLUENCE OF TEMPERATURE AND MOISTURE ON DISSOLVED ORGANIC CARBON EXPORT FROM CATCHMENTS

Stream and lake dissolved organic carbon (DOC) is primarily derived from autochthonous sources within the surrounding catchment. With an increased awareness of a changing climate, much focus has been directed towards understanding mechanisms controlling the production and source of aquatic DOC. We will evaluate the relative effects of temperature and moisture on DOC export from forested soils, forested wetlands and riparian soils at nine study sites across Canada spanning a gradient of current climatic conditions. Catchments located at higher latitudes (near Saskatoon, SK) are expected to contain greater quantities of 'potential' stored DOC, due to slower degradation resulting from lower mean annual temperatures. Southern catchments sites (located near Hamilton, ON) with higher natural rates of degradation may have lower quantities of potential DOC sources to streams and lakes. The relative partitioning of DOC extracted from leaf litter to the solid phase (absorbed to soils), dissolved phase (available for export to streams) and gaseous phase (microbial mineralization to CO_2), will be established by manipulating temperature conditions based on the Q10 factor. Temperature controlled experiments performed at field capacity will be conducted to examine the partitioning of extracted DOC into the solid, dissolved and gaseous phases for all nine sites under current soil temperature conditions, and a mean annual temperature increase of 7°C . DOC mobility from catchment soils is strongly controlled by hydrological flushing events. Hence, the production of DOC from catchment soils will be quantified based on sites with differing natural moisture conditions. In addition, drying-rewetting experiments of differing frequency and length will be conducted at the nine study sites to assess the response of catchment DOC production to drought.

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DIAMOND IN THE ROUGH: EVALUATING THE EFFECTIVENESS OF A HUMAN-MADE STREAM AS HABITAT COMPENSATION AT THE EKATI DIAMOND MINE

Habitat compensation is an important issue in the development of Northern Canada's emerging diamond industry, and it is important to use standard measures of productivity to assess effectiveness. The Panda Diversion Channel (PDC) is a human-made stream constructed as habitat compensation for the EKATI Diamond Mine. The PDC was designed primarily as spawning and rearing habitat for Arctic grayling and

as a migration route for other species. The PDC has been monitored for seven years to track the development of the stream as fish habitat, however comparisons between it and natural streams in the area has only taken place since 2003. The monitoring of the PDC included counting migrating spawners, assessing abundance, growth and survival of fry and assessing the size of the lake resident adult population. Results show that productivity of the PDC, in terms of biomass of grayling fry per square meter of stream habitat, is within the range of two other streams in the area, despite habitat being of lower quality. Previous studies have suggested that the PDC has clear deficiencies leading to poor growth and recruitment, and state that it is poor nursery habitat. Our results contradict this by estimating production using more conventional measures of density and growth. Overall, it appears that the PDC is an example of effective habitat compensation, and may become a model for similar projects in Canada's emerging diamond industry.

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FISH-HABITAT ASSOCIATIONS IN SHALLOW CANADIAN WATERS OF THE DETROIT RIVER

There are few quantitative studies on habitat requirements of fishes in large rivers because of the challenges of sampling these systems. In 2003, a 10 km reach of the Detroit River near Fighting Island was sampled to examine fish-habitat associations. Using underwater video and Ekman grabs, substrate was classified at 300 locations in depths < 3 m as either mud, sand, gravel, or vegetation on a soft or hard substrate. Fishes were sampled at a subset of 30 sites using a variety of gear. Combined seine and hoop net samples yielded the highest fish species diversity and abundance. Overall, 41 species were found in the study area including five nonindigenous species, and Spotted Sucker (*Minytrema melanops*), a species at risk. Banded Killifish (*Fundulus diaphanous*) was recorded as a new finding for the Detroit River. None of the 10 most common species was associated significantly with habitat. In 2004, fishes were sampled at 60 randomly selected sites (30 inshore, 30 offshore) representing three (upstream, middle, downstream) segments of the Detroit River in May, July and September. Shoreline features and riparian zone land use were recorded for onshore sites, and microhabitat features were measured at all sites. Six additional species were captured, including the previously unrecorded Longear Sunfish (*Lepomis megalotis*), and Pugnose Minnow (*Opsopoeodus emiliae*), a species at risk. Initial results suggest different assemblages are associated with microhabitat features, season, and onshore vs. offshore location. Associations with river segment and riparian features did not appear to be as strong.

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DIATOM COMMUNITY STRUCTURE AND WATER CHEMISTRY DATA: HOW SHOULD THE METRICS BE EXPRESSED?

Diatom indices are usually developed using community data expressed as relative abundance. However, the importance of abundant small species may be overestimated relative to less abundant large species. Relative biovolume is also used for comparing the contribution of diatom species and accounts for the size differences between species. Although biovolume is a good estimate of species contribution to the overall community, their importance may be overestimated by large-sized taxa with large vacuoles. Using relative biosurface is also an alternative that accounts for cell size, and might not overestimate the influence of large taxa as much as biovolume.

Another issue when developing indices is the way that diatom communities are related to environmental variables. Bioindicators are used as an addition to traditional water quality measurements to improve monitoring of ecosystem status by integrating environmental changes over longer periods of time.

However, actual water chemistry measurements are often used for modelling, leading to a circular situation: the indices might not reflect integrated water chemistry since communities are modelled using one-time chemistry measurements.

In this study, we evaluated the variance explained by diatom community expressed as relative abundance, biovolume and biosurface. We used water chemistry data averaged over different periods of time in order to obtain integrated chemistry. We also investigated whether we should combine spring and fall samples or keep them separated and develop a spring diatom index and/or a fall diatom index.

These investigations are essential to evaluate which metrics produce the most useful index.

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USE OF NORDIC ASSESSMENT TECHNIQUES TO EVALUATE THE EFFECTS OF INVASIVE SPECIES ON FISH COMMUNITIES RECOVERING FROM ACIDIFICATION

Lakes of the Sudbury Region recovering from acidification are now at the frontline of a northern movement of warm-water invasive species, such as smallmouth bass (*Micropterus dolomieu*). Our study is focused on the effects of invaders on stunted yellow perch (*Perca flavescens*) populations that currently inhabit many of the recovering lakes. The international NORDIC biodiversity assessment techniques are being used to evaluate the fish communities present in 26 Sudbury study lakes of three types: perch only ; perch with few predator ; perch with many predators. Reference data are available for an additional 117 lakes across Ontario for comparison. This depth-stratified quantitative method uses a geometric series of multimesh (5mm to 55mm) gillnets set at random locations to estimate relative abundance, size-distribution, biomass, and spatial distribution for the entire fish community. Preliminary results from the Nordic assessments in 2004 show that size distributions of yellow perch populations differ between test lakes. As the predator abundance increases, so does the abundance of young-of-the-year perch, suggesting that the invasive predators reduce intra-specific controls on recruitment. We hypothesize that there will also be distinct differences on life history characteristics (e.g. fecundity, growth rate, age of maturity), swimming activity (using activity levels of metabolic enzymes), body shape, habitat use, and behaviour of perch populations between lakes with different levels of predation from invasive species.

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PLANT MACROFOSSILS AS INDICATORS OF HYDRO-ECOLOGICAL CONDITIONS IN THE SLAVE DELTA, N.W.T

The Slave River Delta (SD), part of the Mackenzie River Drainage System, has broad ecological and cultural significance. It provides important feeding, staging and breeding grounds for a large number of waterfowl, muskrat and other wildlife as well as providing traditional employment opportunities for the local First Nation's community, including fishing, hunting and trapping. The SD is sensitive to prevailing climatic and hydrological conditions, specifically periodic high water and ice jam flooding which are believed to maintain and replenish water and nutrients in perched basins where precipitation and catchment run off are insufficient. It is these flood-influenced basins of the SD that provide vital habitat for a wide variety of wildlife. We assess the potential of plant macrofossils as paleoindicators of hydrological and limnological conditions in lakes of the SD to resolve relationships between assemblages of plant macroremains in surface sediments and modern environmental conditions. Macroremains have been analyzed from surficial sediment samples (0-1cm) of 40 SD ponds along a hydrological gradient from open- to

closed-drainage lake categories. Identified macro-remains include 41 specimen types representing 22 taxa, mostly of emergent and submergent aquatic plants. Relationships between the plant macro-remains and the environmental conditions were examined using multivariate direct gradient ordination techniques. Results of this analysis will be used to help interpret paleoecological records of plant assemblages from lake sediment cores. This project is part of a larger program of research relating to past and present hydro-ecology of the Mackenzie Basin Deltas. It will aid in assessing current and past ecological variability within the SD, which is crucial for predicting impacts of future climatic and human-induced changes on these sensitive northern ecosystems. The information gained through this analysis is key to interpreting macro-remains in the sedimentary records and allows for the reconstruction of past environmental conditions of the SD ponds.

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THE CONTRIBUTION OF TERRESTRIAL AND AUTOCHTHONOUS ORGANIC MATTER TO THE DIET OF ZOOPLANKTON.

Two sources of carbon are fuelling the food web of aquatic ecosystems: the allochthonous carbon, originating from the watershed and the autochthonous carbon, fixed by primary producers via photosynthesis.

We used a stable isotope approach to determine the contribution of both sources of carbon for zooplankton organisms, in a series of northern lakes and reservoirs. The carbon stable isotope signature of particulate organic carbon, dissolved organic carbon and zooplankton organisms was determined and entered into a simple process model from the literature to quantify the proportion of terrestrial carbon in both particulate matter and zooplankton. Results suggest that autochthonous carbon remains an important source of carbon for zooplankton even in ecosystems where large amount of allochthonous carbon are present. Variations in both sources of carbon are mainly related to the morphological characteristics of the lakes.

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ATLANTIC SALMON (*SALMO SALAR*) JUVENILE CHARACTERISTICS AND EMIGRATION STRATEGIES OF CLEARWATER BROOK

Atlantic salmon juveniles utilize two emigration stages, smolt and presmolt, when preparing to leave freshwater for ocean growth. Smolts undergo physiological changes to allow their immediate salt-water survival upon emigration to the ocean in the spring. Presmolts are essentially large parr migrating from headwater tributaries to larger rivers in the autumn. They may be looking for better over wintering habitat or be pushed out due to density dependence. Clearwater Brook, a headwater tributary of the Main Southwest Miramichi River, renowned for Atlantic salmon production, will be studied as a representative rearing stream. Survival and morphological differences between the two stages and the subsequent returning adults will be investigated. Two study sites (upper reach and mouth of the brook) within the brook will be assessed for differences in juvenile migration timing and biometric characteristics of the two migrant sub-populations of each. The juveniles will also be compared with a sister stream, Rocky Brook. Preliminary data of both brooks indicates differences in emigration timing. Initial results of juvenile characteristics will be discussed. A portion of the upper reach Clearwater Brook juveniles will be internally tagged with a passive integrated transponder, allowing identification of the individual upon its return from the ocean (to determine survival). Stable isotope analysis will be used to assess correlations between emigration strategies and rearing location within Clearwater Brook.

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REDUCING A GAP IN THE MAP – REDUCING THE RISK OF AQUATIC HABITAT DEGRADATION FROM LANDUSE IMPACTS

Application of best management practices can mitigate the effects of land use on aquatic habitat, but this requires effective planning and careful implementation of operations. However, planning effectiveness is limited by the accuracy and completeness of maps of natural resource values, such as small streams. Small streams, which are important brook trout habitat, are particularly vulnerable to impacts of land use because many are ephemeral and/or discontinuous, making them difficult to identify and map using aerial photographs. In an effort to develop GIS tools for locating unmapped streams, we used a digital elevation model (DEM) (25 m resolution) to generate flow accumulation paths and a topographic index of wetness (TI) for the Mackenzie River Watershed (369 sq km) located north of Thunder Bay, ON. We then used a high precision GPS to map the alternating pattern of channelized surface and dispersed subsurface flow along 49 drainage pathways. GPS locations (n = 998) were collected every 20 m (approx.) and at nodes where drainage expression changed (i.e. surface or subsurface flow). Channel morphology and riparian characteristics were collected at each GPS location. These data will be used to: 1) evaluate the completeness of the Provincial GIS stream layer for the study area, 2) measure the spatial accuracy of the derived flow accumulation paths relative to the streams, and 3) evaluate the utility of using the TI and other GIS data to model the expression of runoff across the study area.

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THE INFLUENCE OF LIGHT INTENSITY ON THE FEEDING BEHAVIOR AND HABITAT SELECTION OF WALLEYE (*SANDER VITREUS*) IN TWO NORTHWESTERN ONTARIO LAKES.

A recently developed walleye habitat suitability model (HSM) hypothesizes that light may be the primary abiotic controlling variable that determines the spatial and temporal dimensions of feeding in walleye (*Sander vitreus*). Therefore, anticipated changes in water clarities throughout many of Ontario's lakes and rivers are expected to influence walleye behavior, growth and survival. In order to evaluate the HSM and gain a better understanding of the optical and thermal environments that walleye inhabit, this study is using radio telemetry to track 20 walleye in two lakes with very different water clarities, during periods of changing light intensities. To date, approximately 50 days of hourly walleye movements have been collected along with corresponding light and temperature values at each walleye location. Measurements of light transmission at multiple locations in both lakes supported our secchi disk measurements indicating the transparencies of the two study lakes differed by a factor of two. Temperature profiles showed a large variability in the thermal environments within each lake, but no consistent differences between the two lakes. Preliminary analyses of walleye locations suggest that average fish depth is shallower in the darker lake. There is also a large degree of individual variability in the average distance traveled each hour in both lakes. This study will yield greater understanding of how walleye react to one of the main variables influencing their environment and, indirectly, their survival.

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MULTI-DECADAL TO MILLENNIAL-SCALE SHIFTS IN DROUGHT CONDITIONS ON THE CANADIAN PRAIRIES OVER THE PAST SIX MILLENNIA

Drought is a recurring natural feature of climate and is considered as one of the most serious of natural disasters in terms of its environmental, economic, and social impacts. In the Canadian prairies, extreme droughts of regional to continental-scale such as the 1980s, has caused agricultural losses of 1.8 billion dollars. Recent research from the northern prairie region, demonstrated that abrupt shifts from one drought regime to another have been a prevalent feature on the northern prairies. Records from western Canada suggest that these shifts reoccur at a millennial-scale. However, evidence from the Canadian prairies for these reoccurring shifts in drought regimes is extremely limited. In order to assess these large-scale climate changes, we have selected three closed-basin lakes in the Canadian prairies (east-central Alberta, central Saskatchewan (SK) and south-central SK within the Palliser Triangle) that have been shown to be sensitive to recent climatic changes. Sediment cores from the three lakes have been extracted using a Livingstone piston corer and the diatom remains preserved in the lake sediments were used to track past climatic conditions at an approximately 20-year resolution. Our major objective is to reconstruct droughts (frequency, duration and intensity of droughts) in the Canadian prairies during the past 6000 years. The results of this project will provide novel high-resolution data enabling a more regional assessment of water availability, regional data for process-based models, and data for rigorous time-series analyses which will assess the significance of periodicities evident in the data, from which we will make future projections.

So far, we have analysed the diatom records covering the past 4,800 to 6,800 years from two of the three lakes. Estimates of changes in lake-water salinity and water depth were inferred from a modern-day calibration set of 287 lakes. The results showed clearly that major shifts in moisture regimes have changed between wet and dry conditions on decadal to multicentennial-scales. Millennial-scale fluctuations are also evident. In the last 3,500 cal. yrs BP the two prairie sites were predominantly arid with relatively short periods of wet climate, whereas between 3,500 and 6,800 cal. yrs. BP long periods with wet conditions prevail.

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ANTHROPOGENIC AND NATURAL CONTROLS OVER MERCURY CONCENTRATIONS IN SEDIMENTS OF SOUTH-CENTRAL ONTARIO LAKES

Mercury (Hg) is ubiquitous in our environment and fish are commonly found with Hg levels exceeding guidelines for safe consumption. As a volatile species, elemental mercury (Hg^0) has become a global pollutant and has contaminated lakes far from any point source. However, anthropogenic point sources are not the only mechanism by which Hg enters lakes; natural sources contribute significant amounts of mercury as well. In this preliminary study, top and bottom sediment samples from 35 lakes in south-central Ontario were examined to: 1) quantify the extent to which anthropogenic emissions have impacted lakes in south-central Ontario; 2) determine the relative contribution of natural emissions to lake sediments; and 3) to assess which physico-chemical properties most influence the degree of contamination. We find that present-day levels of Hg are 2 to 3-fold higher than natural concentrations, and that enrichment (presumably Hg of anthropogenic origin) appears to exhibit a west to east gradient. This geographic gradient may, in

part, be related to spatial differences in lake morphometry and catchment properties that have been observed by others in this region (Quinlan et al. 2003). Furthermore, as observed in other studies, Hg levels in lake sediments were best correlated to the amount of organic matter, measured as mass loss-on-ignition. By standardizing for organic matter, a comparison of Hg levels among catchments can be used to determine the underlying processes involved in sedimentation and enrichment. While background Hg levels are largely controlled by the size of the watershed, present-day levels corrected for organic matter are more strongly related to the concentration of silicates in the water column. This relationship may represent an increased flocculation of adsorbed Hg on charged particles during periods of increased atmospheric deposition.

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INFLUENCE OF TEMPERATURE ON YOUNG-OF-THE-YEAR YELLOW PERCH GROWTH

A temperature-based growth model for young-of-the-year yellow perch (*Perca flavescens*) was found to explain up to 99.6% of the variability in first year growth in three northern Alberta lakes. Temperature was measured by cumulative degree days greater than 13.5EC but less than 22.5EC, to account for the defined thermal limits of yellow perch growth. Models using data from two different years (1997 and 2000), were estimated and cross-validated against data from the opposite year. Attempts to include ration, measured as zooplankton biomass, as an explanatory variable in estimated growth models failed, as prey availability was not found to be a limiting factor in the studied environments. Specific growth rates were observed to fall as a function of Calendar day. To relate observed growth dynamics to physiologically-based measures of yellow perch performance in lacustrine environments, stable isotope analyses of $\delta^{13}\text{C}$ were used. A significant correlation between cumulative degree days and the $\delta^{13}\text{C}$ signatures of YOY fish was observed with $\delta^{13}\text{C}$ signatures becoming more enriched as cumulative degree days increased. The results of the study suggest that temperature markedly influences YOY fish growth for species at the fringe of their distribution, and that seasonal dietary drift in $\delta^{13}\text{C}$ signatures are coupled directly to temperature-induced changes in length.

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MODELING MERCURY MASS BALANCES AND ACCUMULATION IN FISH FOR LAKES OF THE MUSKOKA RIVER WATERSHED

Although atmospheric mercury (Hg) deposition is uniform over large geographic areas, Hg levels in fish of the same species and age class (e.g. yearlings) can vary between remote lakes of a region. We hypothesize that variation of fish concentrations between lakes is significantly related to differences in Hg loadings (from watersheds) to lakes of a large region, the Muskoka River tertiary watershed (MRW, 5000 km², 859 lakes) located in Southern Ontario. The objectives of this study were to 1) create a Hg mass balance model for the region from a dissolved organic carbon (DOC) mass balance model and 2) investigate the relationship of fish Hg with Hg loading.

The loading of dissolved organic matter (DOM), and the subsequent loading of complexed Hg, to a lake from its surrounding watershed depends on characteristics of the watershed including ratios of watershed, lake and wetlands areas. Watershed spatial attributes (e.g. wetland areas) derived through GIS techniques were linked with published DOC mass balance models to create a predictive lake DOC model for the MRW. Using values from the model and a published relationship between DOC and Hg fluxes, a semi-empirical Hg mass balance model at the landscape level was developed. Lakewater Hg samples from 20

lakes were collected in summer (2004) and total Hg concentrations were compared with model estimates.

Juvenile fish were collected in 2003 from 15 lakes in the MRW. Concentrations of 100-900 ppb dry weight (18-148 ppb wet wt) were measured from whole fish samples and these results were compared empirically with watershed Hg loadings from the model. The same was done for average concentrations of a selected species and size of adult fish from the Ontario Sport Fish Contaminant database. Lakewater chemistry (e.g. pH, DOC, sulfur) affects Hg speciation and biological uptake, so these variables were also included in statistical tests of the relationships.

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REGENERATION OF THE SPATIAL REFERENCE DATASET FOR ONTARIO'S SHIELD LAKES

Freshwater systems are rapidly being altered by a variety of natural and anthropogenic stressors. However, our ability to assess and document stressor-induced environmental change is severely limited by inadequate historical data detailing pre-impacted abiotic and biotic ecosystem states. A primary goal of the Ontario Ministry of the Environment's Dorset Environmental Science Centre (DESC) is to create and maintain the long-term datasets necessary to quantify changes in freshwater systems on the Canadian Shield. Of these changes, one of the most widespread and drastic has been lake acidification and metal contamination due to mining. Between 1983 and 1988, the chemistry and plankton of 56 lakes varying in acidity were sampled to 1) determine regional zooplankton composition and variation in "minimally impacted" lakes, 2) identify thresholds of acidification damage, 3) create empirical models predicting the impacts of acidification on zooplankton and 4) set a restoration target for assessing the recovery of impacted lakes. The results of this study have been used extensively to assess lake damage and recovery; however, continued monitoring of a small subset of the original lakes suggests that significant changes have occurred in the lakes over the last 20 years. Growing seasons are longer, SO₄, TP, Ca, and chlorophyll have declined, pH has increased, phytoplankton and fish species composition have changed, and invasive species are spreading. These findings suggest our 1980's spatial reference set may no longer be adequate for characterizing Shield lakes. In recognition of this problem, York University and the DESC, in partnership with six universities in Ontario, Quebec and Pennsylvania have reinitiated physico-chemical and biological sampling of the original lake set. This work will allow us to quantify abiotic environmental change corresponding to changes in the plankton and determine whether changes are widespread. We will then identify current "minimally impacted" lakes to use as recovery targets for historically damaged lakes and be able to accurately assess damage from novel stressors.

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LANDSCAPE SCALE CHARACTERISTICS INFLUENCING THE PRESENCE AND RELATIVE ABUNDANCE OF BROOK TROUT (*SALVELINUS FONTINALIS*) IN BEAVER PONDS IN NORTHERN ONTARIO

Beaver ponds are a ubiquitous part of northern Ontario stream ecosystems and may serve as habitat and refugia for brook trout, influencing their life history characteristics. The objective of this study was to examine beaver ponds at both local and landscape scales and determine factors related to the presence, relative abundance and size distribution of brook trout. Mean brook trout size was significantly greater in beaver ponds (mean = 199.15 +/- 40.0 mm, n = 370) than in the adjacent streams (mean = 90.97 +/- 41.02 mm, n = 1050) in the study area (F = 1658.209, P < 0.01). Beaver ponds and their adjacent streams were stratified based on upstream catchment area (UCA). Brook trout size in streams was positively related to

UCA, whereas brook trout size in beaver ponds exhibited a negative relationship. In addition, CPUE in beaver ponds was positively related to UCA. Beaver pond characteristics, such as maximum depth, mean and minimum temperature and TI value (relative potential for groundwater discharge along the stream-terrestrial interface) are associated with brook trout presence and relative abundance. Higher TI values and deeper ponds may provide the environmental characteristics and refugia for over-winter survival as well as the necessary year round habitat requirements for brook trout. A watershed approach to forest management guidelines could be used to tie landscape scale hydrological processes identified in a G.I.S. to the protection of brook trout habitat from potential land use impacts.

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SELECTION AND THE EVOLUTION OF COORDINATED PLASTIC RESPONSES DURING EARLY ADAPTIVE DIVERGENCE

Colonization of a novel environment can result in adaptive divergence when selection favors a new phenotypic optimum. If the novel environment induces substantial phenotypically plastic responses and genetic variation exists in the form of these responses, then selection may initially favor the coordination of functionally useful plastic responses. Sunfish ecomorphs that have colonized the pelagic habitat of postglacial lakes consistently show more coordinated and fairly similar plastic responses, distinct from their sympatric ancestral littoral ecomorphs. Genetic variation in the coordination of plastic responses exists within and among populations. In addition, pelagic ecomorphs from two populations exhibited stronger plastic responses compared to the sympatric littoral ecomorph. These results indicate that some of the earliest evolutionary changes that can occur during adaptive divergence involve changes in the coordination and magnitude of phenotypically plastic traits. Here, the developmental systems of sympatric sunfish ecomorphs have diverged in how they plastically respond to environmental cues. In addition to providing insights into how populations can change during the earliest stages of divergence, this method holds excellent potential as a tool for stock identification, especially in those species where population subdivision is complicated by significant phenotypic plasticity.

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HERITABLE VARIATION IN BODY FORM AMONG DIVERGENT BROOK STICKLEBACK (*CULAEA INCONSTANS*) POPULATIONS

In a series of post-glacial lakes, brook sticklebacks occur both allopatric from and sympatric with ninespine sticklebacks. Prior studies have shown that sympatric brooks have generally more benthic body forms than allopatric brooks. Variation in body form influences the competitive effects of ninespines, with competition being most severe between the allopatric brook form and ninespines, as expected under an ecological character displacement process. Here we test for heritable variation in the body form of allopatric and sympatric brook sticklebacks. Families of artificially crossed brooks made within two sympatric and two allopatric populations were raised in a common lab environment. An analysis compares the morphology between parents and offspring, and among families and populations to test for heritable variation. Heritable variation in morphology suggests the evolutionary nature of character shifts in this system.

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UV AND TEMPERATURE EFFECTS ON PLANKTONIC ROTIFERS AND CRUSTACEANS IN NORTHERN TEMPERATE LAKES.

Anthropogenic stressors such as climate change, ozone depletion and acidification may act in concert to alter UV and temperature regimes in freshwater ecosystems. These physical and chemical changes will inevitably affect zooplankton community dynamics, but little is known about their relative effects on different species in natural communities. During spring, species that migrate to surface waters to take advantage of warmer temperatures may be especially vulnerable since ultraviolet (UV) levels can be high. The objective of this study was to investigate the *in-situ* effects of UV and temperature on a natural assemblage of planktonic rotifers and crustaceans during the spring. We performed *in-situ* exposure experiments in two lakes with different surface temperatures. Exposure to UV had a significant effect on the abundance and/or reproduction of 4 rotifers: *Gastropus* spp., *Kellicottia bostonensis*, *Kellicottia longispina*, *Keratella* spp.; 2 cladocerans: *Holopedium gibberum*, *Daphnia catawba*, and one copepod: *Leptodiaptomus minutus*. Incubation under cooler temperatures had a negative effect on *K. longispina* and *H. gibberum*. Temperature and UV had a significant interactive effect on abundance and/or reproduction of *L. minutus* and *Ploesoma truncatum*. Our results indicate that changes in underwater UV and temperature can significantly influence the composition of the zooplankton community and ultimately food web dynamics.

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ENVIRONMENTAL FLUCTUATIONS DISRUPT THE RELATIONSHIP BETWEEN SPECIES RICHNESS AND COMMUNITY VARIABILITY IN MULTI-TROPHIC AQUATIC MICROCOSMS

If species respond more similarly to external sources of environmental fluctuations as the amplitude of fluctuations increases, the stabilizing effect of increasing species richness on community stability should also weaken under more variable environmental conditions. Using naturally occurring multi-trophic aquatic communities inhabiting tropical rock pools, we manipulated both species richness and the extent of environmental fluctuations that communities were exposed to by replicating species richness manipulations in natural rock pools, artificially constructed rock pools, and laboratory microcosms. Aggregate community variability decreased with increasing species richness in the laboratory microcosms. By contrast, there was no relationship between species richness and community variability in either the artificial rock pools or the natural rock pools. Lower community variability in more speciose laboratory pools was due to an increase in community evenness with increasing species richness, which increased the strength of statistical averaging, and to decreases in population variability with increasing species richness. Environmental fluctuations likely disrupted the relationship between species richness and community variability seen under constant conditions in the laboratory microcosms by disrupting the effects of species richness on summed variances and covariances as well as by increasing the amplitude of covariances.

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CHIRONOMIDS AS INDICATORS OF HYPOLIMNETIC OXYGEN DECLINE IN NOVA SCOTIA BROOK TROUT LAKES: A PALEOLIMNOLOGICAL STUDY

Sport fishing is a multi-million dollar industry in Nova Scotia, of which brook trout (*Salvelinus fontinalis*) comprises a large component. In an effort to design and implement sound lake management programs for Nova Scotia's freshwater lakes, we are using a multi-proxy paleolimnological approach to reconstruct historic lake environments throughout the province. One component of the 5-year Queen's Trends in Eutrophication and Acidification in the Maritimes (TEAM) project involves the investigation of eutrophication in Nova Scotian brook trout lakes. Consistent long-term water chemistry data are not available for many Nova Scotian lakes, as data have only been collected sporadically over the past twenty-five years. This provides insufficient information for Inland Fisheries to monitor lake health and properly manage these brook trout lakes. As such, paleolimnological techniques are being applied to these lakes in an effort to reconstruct the historic lake environments, thereby providing the necessary tools to formulate sound management decisions. Thirty-seven lakes from across the province were selected for this component of the TEAM study based on usage patterns, environmental concern or economic importance. This study addresses the following questions: Have hypolimnetic oxygen levels decreased in these lakes; If so, when and by how much? Chironomidae have been long considered useful indicators of deepwater dissolved oxygen levels. This is due to the excellent preservation of their chitinous head capsules in sediment, and their species specific tolerances of different levels of dissolved oxygen. As such, Chironomidae are the proxy used in this investigation. These data will shed new light on the applicability of Chironomidae as indicators of eutrophication in freshwater lakes and the subsequent implications for lake management.

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EVALUATING DISTANCE MEASURES FOR CLASSIFYING REFERENCE SITES IN THE REFERENCE CONDITION APPROACH.

Standard methods have yet to be established for classifying reference sites into groups, as the first step in the Reference Condition Approach (RCA) for bioassessments. Four distance measures that characterize relative Benthic Macroinvertebrate (BMI) community structure were evaluated to determine which would be most valuable in classifying reference sites from streams on the Precambrian Shield in south-central Ontario (Muskoka). Jaccard, Chi-square, Bray-Curtis on BMI taxa abundances, and Bray-Curtis on benthic indices were the four distance measures evaluated. The prediction is that one distance measure will score higher against five criteria than the other three distance measures. Prior to the evaluation, a land-use variable was created, as each sample was coded with respect to land-use type: forest, clear-cut, turf establishment, and operational golf course. Physical-geographic attributes of longitude, stream width, and site elevation were estimated at each site. Analysis involved calculating Non-metric MultiDimensional Scaling (NMDS) to ordinate the relative distances of BMI and physical-geographical attributes onto three axes. The most valuable BMI measure were described as having 1) the greatest percentage of BMI taxa (abundance or presence/absence) or indices that were highly correlated with the first three corresponding NMDS axes (Pearson correlation); 2) the greatest separation between land-use groups based on group mean NMDS scores, measured by the average distance in a pair-wise Euclidean matrix; 3) having no significant seasonal or annual effects (two-factor MANOVA); 4) the greatest number of significant (+ve) Mantel tests and Partial Mantel tests correlating BMI distance matrix and the land-use distance matrix, holding

corresponding differences in physical-geographic attributes constant and; 5) the greatest number of non-significant (+-ve) Mantel tests between BMI distance matrix and physical-geographic distance matrix. Overall, Bray-Curtis distance measure based on benthic indices scored highest against the five criteria. A rational has now been developed for using the Bray-Curtis distance measure based on benthic indices as a method to describe the relative BMI community among reference samples in Muskoka. The distance matrix could then be summarized using an ordination method to retrieve multivariate indices and plotted for classifying reference sites in a RCA to assess stream impacts on BMI communities.

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LAKE TROUT ASSESSMENT 2000-2003: LAKE NIPIGON

Lake Nipigon is a large (448 060 ha) coldwater lake located approximately 123km north east of Thunder Bay. Biinjitiwabik Zaaging Anishinabek (BZA) First Nation approached the Anishinabek/Ontario Fisheries Resource Centre (A/OFRC) to conduct a comprehensive lake trout assessment. Data has been collected over the period of 2000-2003. The population consists of at least 23 consecutive year classes. Lake trout grow at a rapid rate and mature rapidly. Males mature between 4 and 5 years and females mature between 5 and 7 years of age. The mean, estimated rate of total mortality for male and female lake trout is 20% and 24%, respectively. Condition, the relationship between weight and length, is high. Rainbow smelt are the primary food source during the summer period however lake herring and burbot play an increasingly important role in diet as lake trout grow older. Lake trout rate of growth and condition is similar to Lake Simcoe lake trout, where rainbow smelt also represent an important forage component. Results suggest that Lake Nipigon lake trout stock is healthy relative to criteria set out by the Lake Nipigon Fisheries Assessment Technical Committee. Changes in the dynamics of this lake trout population in the future should be considered in relation to rainbow smelt dynamics as well as sport and commercial harvest data. These index netting results should provide a good template to use in designing future index netting projects.

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ACTUAL SITUATION OF BONY FISHES OF SOUTH CASPIAN SEA COASTS

Bony fishes of the Caspian Sea Iranian coasts are weak in biodiversity. In spite of clupeids other species are counted among littoral stocks, therefore they have low biomass and density. Most of the Caspian boney fishes have low body volume because of their anadromous behavior. Most of their natural spawning areas in rivers and wetlands has been destroyed. In the other hand during the last decade low stocks biomass and overfishing caused a forcing pressure on the stocks and they are decreasing progressively. Most of the increase in fisheries belongs to th Rutil (*Rutilus frisii kutum*), Mulet (*Mugil auratus*) Gardon (*Rutilus rutilus*) and Common Carp (*Cyprinus carpio*). The fisheries of Perch (*Lucioperca fluviatilis*) and Brame (*Abramis brama*) in spite of some millions released issued from artificial fish propagation has not changed anymore. Barber (*Barbus brachycephallus*) contains a very few populations and it risks the extinction.

Destruction of Caspian sea fish stock is because of factors as bellow:

- Legal and illegal overfishing is high and boney fish stocks are forced.
- Unsuitable situation of natural spawning areas.
- The introduction of invader comb jelly (*Mnemiopsis leidyi*) into the Caspian sea and its bloom in recent years.
- Neglected standards of fishing nets by fishermen thus catching of immature and young fishes.

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HISTOLOGICAL AND HISTOCHEMICAL STUDY OF PYLORUS, PYLORIC CAECUM AND INTESTINES IN STELLATE STURGEON

Amongst the sturgeons, *Acipenser stellatus* as one of the most precious caviar producing fishes, is well reared artificially in Iran. In this study a total number of twenty sturgeons were prepared from Caspian sea fishing regions. The pylorus, pyloric caecum and intestines were removed from alimentary canals and fixed in 10% buffered formalin. By a tissue processor routine histological procedures were done and the paraffin blocks provided, sectioned at 6 microns which were subjected to routine and special staining methods including, Hematoxylin and Eosin, PAS, Dane's method, Toluidine blue, Alcian blue and Orange G, and combination of Alcian blue-PAS.

The pylorus as a dependent spherical stomach had an epithelium of tall simple to pseudostratified columnar with very deep pits. A characteristic feature of this organ is its highly thick musculature in several complicated layers. The pyloric caecum was lobulated triangular organ located between pylorus and the proximal intestine. The epithelia of pyloric caecum, proximal, medial and distal intestines, were of pseudostratified with many goblet cells containing mucus secretions, which their mucigen granules clearly stained with PAS- Alcian blue and Dane's method. In laminae propria of caecum and intestines too many intestinal saccular glands possessed the same mucosal epithelia with goblet and secretory cells and between them many mastocytes were present which stained with Toluidine blue as Johnson's method, H&E, PAS and Alcian blue. Finally it was concluded that the mucus secretions of goblet and columnar cells and also the enzymatic secretions of the other glandular cells contained different neutral and acidic polysaccharides and glycoproteins staining with the various chemical methods, which the former protect the mucosae against pathogens and the latter cause digestion and besides many lymphatic tissues throughout the canal provides defense against the pathogens.

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STUDY OF HISTOCHEMISTRY OF GLANDS AND SECRETORY CELLS OF ESOPHAGUS AND GLANDULAR STOMACH OF BELUGA (*HUSO HUSO*) (P)

Beluga as the largest sturgeon and an at risk specie is considered to be a valuable and important fish for caviar production. A total number of ten beluga fished from southern Caspian sea, were subjected to this study. After removing the organs and fixation in 10% buffered formalin, the specimens histologically were processed, paraffin blocks were sectioned at 6 microns and some special stainings such as, PAS, Johnson's method for Toluidine blue, Alcian blue, Orange G, Dane's method and some combinations were carried out. The mucosa of esophagus was covered by a non-keratinized stratified squamous epithelium. In the upper half, there were many spherical secretory cells which stained well with Alcian blue, Johnson's and Dane's methods as well as PAS. Whereas the glandular stomach had an epithelium of simple to pseudostratified columnar with secreting mucoid substances shown by PAS- Alcian blue. In lamina propria many tubular gastric glands were present with two distinguished cell types. Some of them staining well with Orange G, and others which stained with Toluidine blue, Alcian blue, and PAS methods, were more abundant. As a conclusion, presence of mucus secreting cells in esophagus is due to the role of it as a passage for food stuffs which should be lubricated and protection of mucosa by enzymes. Also secretion of mucus in gastric mucosa more has a protective role. While the cells stained with Orange G or parietal cells secrete acid chloridric and the other cells or chief cells secrete some digestive enzymes such as pepsin and proteolytic enzymes, which stain with the other staining methods. In esophagus and stomach the cells containing

mucigen granules were composed of neutral and acidic mucopolysaccharides, which with the mentioned methods stain magenta.

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DETERMINING THE CURRENT DISTRIBUTION OF DEEPWATER SCULPIN (*MYOXOCEPHALUS THOMPSONI*) IN CANADA

The deepwater sculpin is one of the most poorly understood freshwater fishes in Canada. Its deepwater, lacustrine habitat has been very poorly sampled outside the Great Lakes basin where it is listed as Threatened. Most information on their range-wide distribution is limited to data from incidental catches. Therefore, an intensive field sampling program targeting deepwater sculpin was conducted between May and October, 2004, using minnow traps, gillnets, and trawls. The survey included lakes with previously known occurrences and candidate lakes with suitable bathymetry and postglacial history. A total of 37 lakes were sampled and deepwater sculpin were collected in 20 of these lakes. Sampling efforts and site occurrences spanned most of the known distribution of deepwater sculpin, ranging from Alexie Lake in the Northwest Territories in the northwestern portion of its range, to Lac des Trente et Un Mille in Quebec in the extreme east, and Upper Waterton Lake in Alberta in the extreme southwest. Some lakes, where deepwater sculpin were previously reported, were sampled intensively without finding a single individual. However, deepwater sculpin were collected for the first time in four lakes in northwestern Ontario and Manitoba, including Second Cranberry Lake; the first record of deepwater sculpin in the Nelson River drainage.

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COMPUTER SOFTWARE TO TRACK FISH MOVEMENTS

We have developed computer software to directly track the movement of a fish, eliminating the burden of detailed analysis of videotapes. The system reads image sequences of a moving fish, obtained by a digital camera connected to a Personal Computer, and determines the trajectory and the velocity of the fish as it moves through the scene. The system was developed using Microsoft Visual C++ 6.0, Matrox Imaging Library software and Qt GUI toolkit. Our tracking algorithm relies on a preliminary change detection that is based on pixel difference through consecutive frames. This step allows the identification of an interest region corresponding to the region covered by the fish during its movement. The interest region is segmented into blobs (bounding box), delimiting the position of the fish. Shadows and undesirable noise effects are removed by repeatedly increasing a threshold value whenever the resultant image indicates pixels that do not belong to the moving object. The direction and velocity of the fish between each pair of frames are used to predict the position of the object in the next frame. Finally, assuming the trajectories to be continuous and the position of the fish changing at a small rate, distance moved and average velocity of the fish are calculated using several key points identified during the segmentation procedure. This step requires the calculation of motion-plane/image transformation that is performed prior to the tracking procedure using a calibration pattern. This software, developed for tracking fish in flumes, has applications to other organisms and situations.

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DO AGRICULTURAL DRAINS PROVIDE FISH HABITAT?

This research addresses whether agricultural drains act as natural systems in terms of supporting fish assemblages and what effect drain maintenance has on fish assemblages. If drains act as natural systems, then numbers and abundances of fish species were expected to be similar between drains and natural watercourses. Fish species richness and abundance were examined in 30 agricultural drain sites paired with 30 similar sites on natural watercourses in southwestern Ontario. Pairs were defined by similarity in size, order and location within the same watershed. Sampling effort was standardized within each pair using electrofishing and/or seining to collect fishes. All fishes were identified to species and, for each species, total length was measured for the first 30 individuals to provide estimates of biomass. At each site, the physical attributes of the stream and flow, hydraulic head, substrate and riparian cover were measured to test for differences in instream or riparian habitat. Findings of this study will be used by fishery and drain managers to improve drain management guidelines in ways that consider the needs of agriculture, while preserving fish biodiversity.

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NATURAL LAKE TROUT STRAIN IDENTIFICATION IN LAKE HURON

Considerable financial commitments have been made since the 1960's to restore lake trout to the Great Lakes. Lake trout rehabilitation is still one of the primary goals of restoration and management programs. Although successful natural reproduction of lake trout in the Great Lakes outside of Lake Superior has been limited, reproduction has occurred in Lake Huron. Knowing the origin of naturally produced fish in Lake Huron will provide valuable direction for management efforts. The information can be used to ensure that future stocking of unsuccessful strains does not continue and will provide significant direction for strain usage in Lake Huron and other Great Lakes.

Procedures for genetic stock identification were applied to lake trout samples from Lake Huron to assess the contribution of different lake trout strains to successful natural reproduction. Hatchery strains developed from lake trout from within Lake Huron had higher survival and contributed more to natural reproduction than those developed from lake trout from Lake Superior. Splake and splake backcross stocking programs had mixed success in different parts of Georgian Bay. Genetic data can now be combined with other fisheries data such as stocking records, age data, stable isotope analysis, and other assessment data to detect biological characteristics of hatchery strains that allow them to succeed.

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STATUS OF THE ROUND GOBY INVASION IN SOUTHERN GEORGIAN BAY, ONTARIO

The round goby (*Neogobius melanostomus*), an eastern European benthic fish, appeared in the St. Clair River and Lake Erie 14 years ago and has achieved astounding population sizes in Lake Erie. The round goby was then detected in southern Lake Huron in 1994 and in Georgian Bay in 1997 or 1998. We sampled shallow areas of Severn Sound (< 3 m deep) in southern Georgian Bay in spring, summer, and fall of 2004 to determine the efficiency of different sampling methods, and to assess the current status of the goby population. Seining during day or night in all seasons yielded substantially more gobies per unit of researcher time than fyke nets, small-mesh gillnets, minnow traps, home-made funnel traps, or angling. Gobies collected ranged from 27 to 102 mm TL, 0.26 to 15 g round weight, 0 to 3 years of age (using scales and lapillar otoliths), and had a male to female sex ratio of 2:1. Conservative density estimates (fish/m²), based on underwater transect counts in sites where gobies were detected visually, ranged from 0.06 +/- SE

0.06 (N=4) to 7.17 +/- SE 1.82 (N=7), with most sandy or rocky sites yielding estimates > 1/m². Further analyses are aimed at (1) quantitative comparisons of growth and maturation schedules in Severn Sound with those in Lake Erie and (2) use of stable isotopes to determine whether fish eggs become a significant component of goby diets during the nesting season for smallmouth (*Micropterus dolomieu*) and largemouth bass (*Micropterus salmoides*).

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DIFFERING RESPONSES OF BENTHIC AND PLANKTONIC ALGAL ASSEMBLAGES TO REDUCED STRESS

We hypothesized that there would be little lag in the rate of recovery of algal assemblages as pH increased in a previously acidified boreal lake. We evaluated this premise in both planktonic and benthic algal assemblages of a boreal lake (L302S) at the Experimental Lakes Area in northwestern Ontario, Canada. The study lake endured large changes in habitat during a decade of pH recovery following a prior decade of acidification from pH 6.7 to 4.5. To account for region-wide changes during the experiment, we compared changes seen in L302S with those seen in a nearby reference lake (L239) using a BACI design. Although there were no pH-related changes in total planktonic photosynthesis, partitioning of photosynthesis between the epilimnion and hypolimnion varied markedly during the study. In contrast, the photosynthetic potential of epilithon (biofilm on rock surfaces), which had declined during acidification because of increasing carbon limitation, recovered as both pH and DIC increased. However, the acidification-related increase in epilithic respiration continued despite increasing pH, signifying that pH control of respiration was indirect. Acidification-related shifts in taxonomic composition of both assemblages persisted for varying periods during pH recovery. In the phytoplankton, Dinoflagellates increased during the pH recovery phase to levels higher than had previously been seen. In the epilithon, both the decline in Cyanobacteria and the increase in diatoms that had occurred during acidification lagged pH recovery. Similarly, blooms of metaphytic filamentous green algae occurred at higher than their onset pH. Recovery of biodiversity was also dissimilar between the assemblages. The progressive decline in taxonomic richness of phytoplankton was reversed only partially as pH rose. In contrast, epilithic taxonomic richness was resilient in response to acidification, though some taxa remained absent while some acid-tolerant taxa persisted to higher than their onset pH. Because these assemblages form the base of aquatic food webs, lags in their recovery have the potential to amplify delays in the restoration of aquatic food webs from acidification. Because patterns of recovery often differed between the benthic and planktonic assemblages, understanding algal responses to habitat changes can not be inferred from only one assemblage.

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INTERPRETATION OF ELASTICITY PATTERNS OF GREAT LAKES FISHES AS A MANAGEMENT TOOL: INSIGHTS INTO THE EFFECT OF SEASONALLY OPERATED SEA LAMPREY (*PETROMYZON MARINUS*) BARRIERS ON POPULATION DYNAMICS OF NON-TARGET SPECIES

We conducted an elasticity (i.e. relative importance of vital rates) meta-analysis for Great Lakes fishes using deterministic projections of Leslie (age-structured) and Lefkovich (stage-structured) matrices. Perturbations in transition matrices were simulated with the double intention of showing how to interpret and use elasticities for management purposes and at the same time gaining insights into a real management challenge currently taking place in the Great Lakes: the control of the sea lamprey (*Petromyzon marinus*). According to elasticity patterns three distinct strategies are exhibited by Great Lakes fishes, and can be summarized as follows: *i*) species with medium to high values of age at maturity whose population growth rates are more sensitive to perturbations in overall survival; *ii*) species with medium values of age at maturity whose population growth rates are more sensitive to perturbations in juvenile survival; and *iii*) species with low values of age at maturity whose population growth rates are more sensitive to perturbations in fecundity and juvenile survival. Although studies with mammals have shown that elasticity patterns are slackly dependent on phylogeny, in the present study we found a dependence of taxonomic affiliations on elasticity clusters. The significance of this dependence was mainly driven by the families Catostomidae and Esocidae whose species displayed life-history strategies fully characterized by higher sensitivity to changes in juvenile survival. The effect of different blocking scenarios (i.e. different periods of seasonally operated barriers) of sea lamprey spawning migration on population dynamics of non-target species grouped by elasticity strategies were simulated as demographic perturbations on reproductive success. Management implications are discussed.

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CHANGING LAKE TROUT (*SALVELINUS NAMAYCUSH*) AND LAKE CISCO (*COREGONUS ARTEDII*) IN LAKE OPEONGO: 60 YEARS OF SAMPLING CAST NEW LIGHT ON THE IMPACTS OF AN INTRODUCTION

The immediate and long-term implications of species introductions for freshwater systems have rarely been observed and quantified. In this study, we describe the long term (>40 years) impact of the introduction of a large pelagic prey item, the lake cisco (*Coregonus artedii*), on the biology of lake trout (*Salvelinus namaycush*) in an oligotrophic Ontario lake. Cisco were introduced in 1948 and quickly became the dominant prey item for lake trout. Lake trout responded through increases in both individual growth rate and size at maturity. By the 1990's, cisco densities were high and the size structure of the cisco population had decreased. These changes were reflected in increases in the number (1.8 to 2.5 cisco) and decreases in the size (16.8 cm to 14.4 cm fork length) of cisco found in lake trout stomachs. These changes in prey and diet were accompanied by a reduction in growth of individual lake trout: the asymptotic size dropped from 74 cm to 62 cm fork length, and the size structure of the population shifted downward to favor smaller fish. We discuss possible mechanisms for this, particularly the role of increased foraging costs imposed by the disappearance of larger prey items.

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INFERRED LARVAL GROWTH RATES OF WHITEFISH SPAWNING STOCKS IN LAKE ONTARIO

At least two hypothesized spawning stocks of lake whitefish (*Coregonus clupeaformis*) inhabit the eastern basin of Lake Ontario. One stock spawns in the Bay of Quinte while another spawns along the basin's north shore. Age-0 fish reside in nurseries associated with their respective spawning ground during the first 6 months on life. We examined length-at-estimated age of larvae collected from each nursery over 6 weeks in each of 2003 and 2004. Cohorts of larvae hatched on different dates were inferred from gaps in length

distributions measured weekly, and were analyzed separately. Larvae reared in the Bay of Quinte had faster growth rates relative to those reared along the shore of Lake Ontario. We use these results to estimate and compare size-selective mortality between hatching cohorts at each nursery, and between offspring of hypothesized spawning stocks.

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EXPERIMENTAL LAKE MIXING: SIMULATING GLOBAL CLIMATE CHANGE EFFECTS ON SHIELD LAKES

A three year experiment was conducted in the Sudbury region using a solar powered lake mixer (SolarBee10000) to increase the thermocline depth and overall heat content of a small (3.4 ha) lake with a maximum depth of 14.5 m. This experiment was designed to simulate the effects of potential climate warming on the Boreal Shield aquatic ecosystems. The mixing project was preceded by two years of physiochemical (DO, temperature, clarity, chlorophyll) and biological (phytoplankton, zooplankton) sampling of the treatment lake and two nearby reference lakes. In the first year of the experiment, testing of various power augmentation methods, such as adding batteries, to enhance the SolarBee10000 output were also conducted. In year one, the mixer significantly increased the depth of the thermocline and reduced the anoxic zone in the experimental lake. Zooplankton analysis, including depth distribution and species composition are ongoing but will be reported at the conference.

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BIO-LOGGING OF CORE BODY TEMPERATURE OF LAKE TROUT TO ASSESS THERMAL HABITAT USE AND CLIMATE CHANGE EFFECTS

Lake trout (*Salvelinus namaycush*) is considered the classic glacial relict species and is often thought to be confined to cold strata of deep lakes in summer. We used surgically implanted data loggers to record core body temperature (every 1.5 hours) for free-swimming lake trout, for a period of 1-2 years, to study lake trout thermal regime. Fish were captured, anesthetized, implanted with the tags during spawning season, and later recaptured at similar sites. Air temperature and DO/temperature depth profiles were recorded during the study. This study revealed that lake trout make extensive use of littoral zones in mid-summer in this dimictic lake. A laboratory experiment using dead fish of different sizes (implanted with tags) and 5 water baths (5, 10, 15, 20, and 25C) were used to calculate and correct for thermal mass/temperature lag effects.