

**Canadian Conference for Fisheries Research
Conférence Canadienne de la Recherche sur les Pêches**

**Society of Canadian Limnologists
Société canadienne de limnologie**

**Society of Wetland Scientists
Société des scientifiques des zones humides**

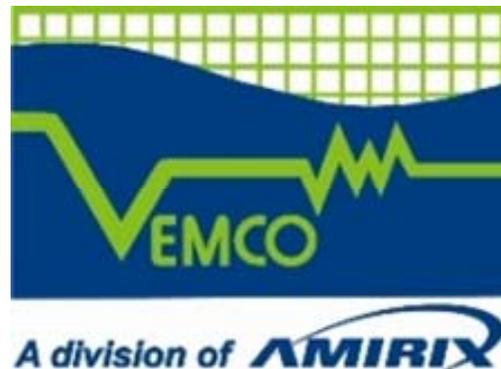


Winnipeg, 7-9 January, 2010

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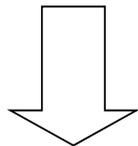
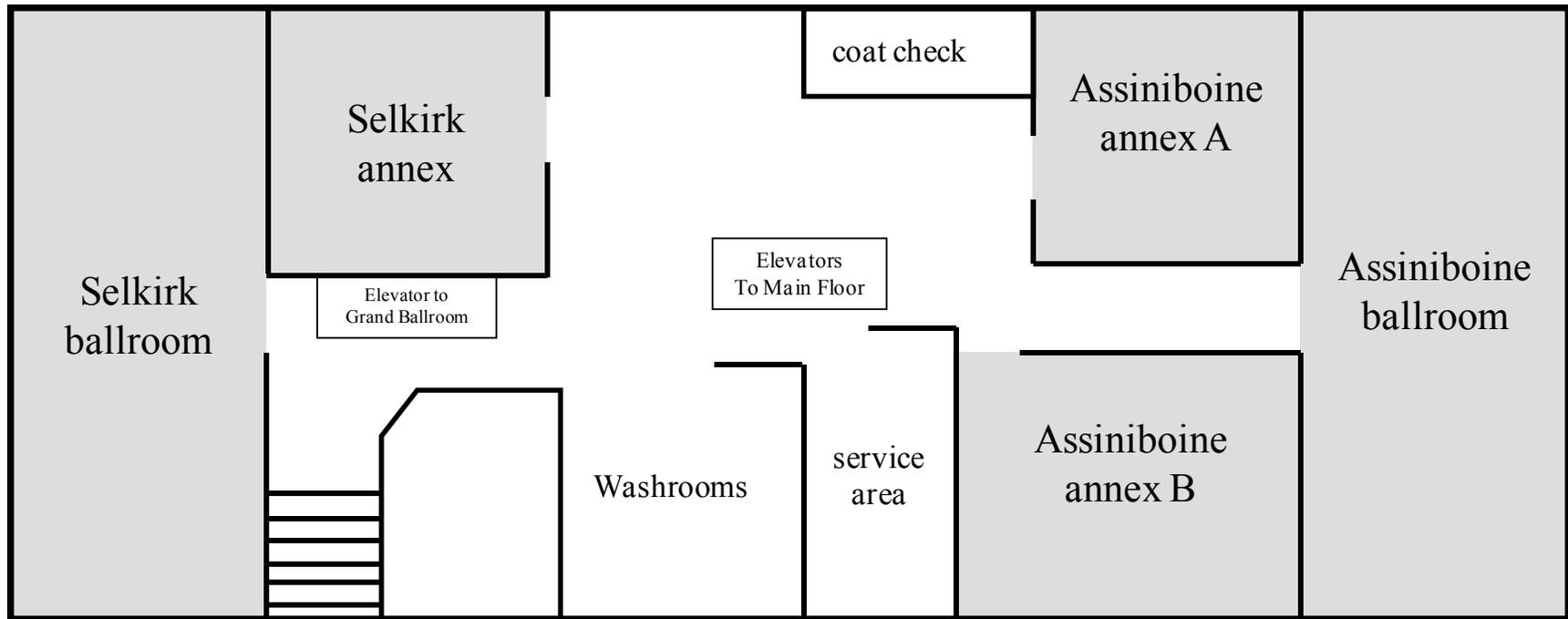


University of Northern British Columbia



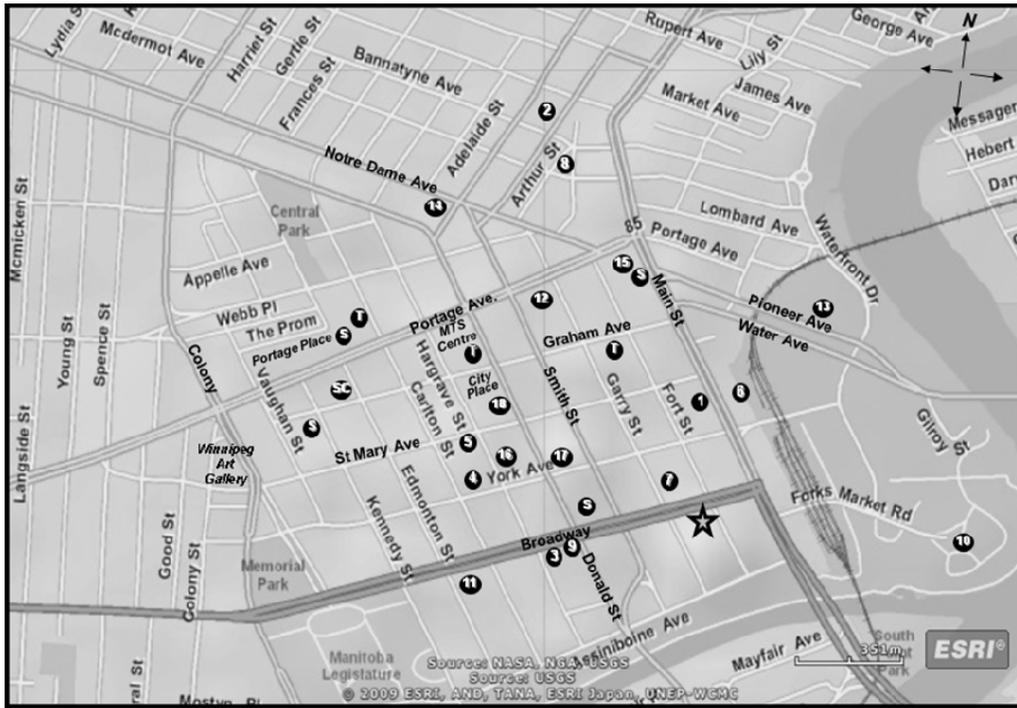
(continued on back cover)

Concurrent session rooms – 5th floor Fort Garry Place



stairs to Grand Ballroom
plenaries, posters, exhibit booths and coffee breaks

Guide to local restaurants



Under 10\$ per entree

- The Fyxx Espresso Bar (9) ^{L D}
- The Line Up (8) ^{ELD}
- Oscar's Deli (16) ^{A BL}
- Subway (11) ^{ABLD}
- The Chocolate Shop Restaurant (12) ^{ALD}
- The Yellow Dog Tavern (14) ^{PD}
- Carnegie's Coffee Bar and Delicatessen (14) ^{A BL}

10 – 15\$ per entrée

- Elephant & Castle (5) ^{PLD}
- Hu's on First (13) ^{ED}
- King's Head Pub and Eatery (2) ^{PLD}
- Mondragon Bookstore and Coffee House (8) ^{VL D}
- Shannon's Irish Pub (4) ^{PLD}

15-25\$ per entrée

- Blaze Bistro & Lounge (5) ^{ABLD}
- Bombolini Wine Bar (3) ^{ALD}
- Earls Restaurant (6) ^{ALD}
- East India Company Pub and Eatery (4) ^{ELD}
- Ivory Restaurant (1) ^{ELD}

25\$ and up per entrée

- Lobby on York (17) ^{A ELD}
- The Keg Steakhouse and Bar (7) ^{ALD}

E = Ethnic Food Selection	P = Pub food	A = American
V = Vegan options	L = Lunch	B = Breakfast
D = Dinner		



Areas with multiple restaurants

The Forks Market (10)

Beachcombers & Ba Ja Beach Club, Bidi's By Sarah, Bindy's Caribbean Delights, Chicken Express, Country Submarine, Danny's All Day Breakfast and Brunch, Human Bean Coffee & Tea, Fergies Fish 'N Chips & Seafood Market, Fro-Gurts, Maple Leaf Fudge, Mini Donut Factory, Neon Cone, Skinner's Restaurant, Smoothie Bar at the Forks, Sugar Mountain Express, Sushi Train, Sydney's at the Forks, Tall Grass Prairie Bread Co. & Deli, Taste of Sir Lanka, The Chilean Corner Taste of South America, The Old Spaghetti Factory, The Original Pancake House, Yudyta's Ukrainian Foods, Zorba's Pizza

City Place (18)

A&W, Breadworks Express Bakery & Café, Forbidden Flavours, Green Garden Restaurant, Koya Japan, Little Bangkok Thai, Manchu Wok, Marvellous Muffins, McDonald's Restaurant, Mrs. Vanelli's, Pasta La Vista, Subway, The Samosa Hut

Winnipeg Square (15) underground shopping centre

45th Ave. Fries, A & W Restaurant, Booster Juice, City Submarine, Cookies by George, Corner Kitchen, Garry's Deli, Gourmet Cup, Kernels Popcorn, Koya Japan, McDonalds Restaurant, Oriental Wok, Pizza and Pasta Della Piazza, Rodos Greek & French Eatery, Saigon Express, Starbucks, Taco Time, Taste of Sri Lanka

Starbucks Coffee Company (S)

Second Cup (SC)

Tim Horton's (T)



Fort Garry Hotel
Winnipeg, Manitoba

7-9 January 2010

Front Cover:

Biologist sampling the mesocosms for the brominated flame retardant project at the Experimental Lakes Area, Ontario. (Photo Credit: Alain Dupuis)

Rear Cover:

The MV *Namao*, owned and operated by the Lake Winnipeg Research Consortium (Photo credit: Katie Sheppard)

Setting up PIT tag arrays in Blind Channel in early May at the Delta Marsh Field Station, Manitoba (Photo credit: Melissa Pink)

CCFFR/SCL/SWS 2010 Themes/Thèmes

- 1) Trophic linkages in aquatic ecosystems
Relations trophiques dans des écosystèmes aquatiques
Gail Davoren (davoreng@cc.umanitoba.ca)
- 2) Divergent morphotypes in temperate species: resources and evolution
Morphotypes divergents chez des espèces tempérées: ressources et évolution
Margaret Docker (dockerm@cc.umanitoba.ca)
- 3) Habitat assessment and management in freshwater
Évaluation et gestion d'habitat dans les eaux
Doug Watkinson (Doug.Watkinson@dfo-mpo.gc.ca)
Ernie Watson (Ernest.Watson@dfo-mpo.gc.ca)
- 4) Conservation genetics: Applications in conservation and management
La génétique de la conservation : Applications dans la conservation et la gestion
Daniel Heath (dheath@uwindsor.ca)
- 5) Strength in numbers: Quantitative tools for enhancing research in fisheries and aquatic sciences
La force du nombre : Outils quantitatifs pour augmenter la recherche dans les domaines de la pêche et des sciences aquatiques
Marco Rodriguez (marco.rodriguez@uqtr.ca)
- 6) Including fishers in fisheries science
Inclure les pêcheurs dans les sciences halieutiques
Erin Carruthers (ehcarrut@mun.ca)
- 7) Arctic aquatic resources: unique species in a dynamic environment
Ressources aquatiques arctiques : des espèces uniques dans un environnement dynamique
Neil Mochnacz (Neil.Mochnacz@dfo-mpo.gc.ca)
- 8) Nutrients in aquatic ecosystems
Nutriants dans les écosystèmes aquatiques
Mohamed Mohamed (mmohamed@uwaterloo.ca)
Andrew Paterson (Andrew.Paterson@ontario.ca)
- 9) The Experimental Lakes Area: Celebrating 40 years of research
La région des lacs expérimentaux (ELA): célébration de 40 ans de
Mike Paterson (Michael.Paterson@dfo-mpo.gc.ca)
- 10) Wetlands
Marécages
Gord Goldsborough (ggoldsb@cc.umanitoba.ca)
Barry Warner (bwarner@sciborg.uwaterloo.ca)
- 11) General Session
Les sessions de présentations générales

CCFFR - SCL - SWS Annual Meeting 2010
Program at a Glance

	Hotel Lobby	Grand Ballroom	Selkirk Ballroom	Assiniboine Ballroom	Selkirk Annex	Assiniboine Annex A	Assiniboine Annex B	
Thursday Jan 7								
17:00-21:00	Registration							
19:00		Poster Set-up			Welcome Social - Fort Garry Club Room			
Grand Ballroom								
Friday Jan 8								
8:50	Registration/Help	Welcoming addresses						
9:00	"	J.F. Stevenson Lecture						
9:40	"	F.H. Rigler Lecture						
10:20	"	Break/Poster viewing						
10:40	"		ELA	Trophic Linkages	Arctic Resources	Divergent Morphotypes	Quantitative Tools	
11:00	"		"	"	"	"	"	
11:20	"	Poster Display	"	"	"	"	"	
11:40	"		"	"	"	"	"	
12:00		Lunch/Poster viewing						
13:20			ELA	Trophic Linkages	Arctic Resources	Divergent Morphotypes	Quantitative Tools	
13:40			"	"	"	"	"	
14:00		Poster Display	"	"	"	"	"	
14:20			"	"	"	"	"	
14:40			"	"	"	"	"	
15:00		Break/Poster viewing						
15:20			ELA	Trophic Linkages	Arctic Resources	Divergent Morphotypes	General (SCL)	
15:40			"	"	"	"	"	
16:00		Poster Display	"	"	"	"	"	
16:20			"	"	"	"	"	
16:40			"	"	"	"	"	
17:00-19:00		Poster Session						
17:00-18:00			CCFFR and SCL Business Meetings - Location TBA					
19:00-21:30			Banquet - 7th Floor Ballroom, Fort Garry Hotel					
Grand Ballroom								
Saturday Jan 9								
8:40			Nutrients	Conservation Genetics	Habitat Assessment	Wetlands	General Session	
9:00			"	"	"	"	"	
9:20		Poster Display	"	"	"	"	"	
9:40			"	"	"	"	"	
10:00			"	"	"	"	"	
10:20		Break/Poster viewing						
10:40			Nutrients	Conservation Genetics	Habitat Assessment	Wetlands	General Session	
11:00			"	"	"	"	"	
11:20		Poster Display	"	"	"	"	"	
11:40			"	"	"	"	"	
12:00		Lunch/Poster viewing	AFS Canadian Aquatic Resources Section (CARS) and AFS Mid-Canada Chapter (MCC) joint meeting - Salon A					
13:20			Nutrients	Conservation Genetics	Habitat Assessment	General Session	General Session	
13:40			"	"	"	"	"	
14:00		Poster Display	"	"	"	"	"	
14:20			"	"	"	"	"	
14:40			"	"	"	"	"	
15:00		Break/Poster viewing						
15:20			Nutrients	Fishers in Fisheries		General Session	General Session	
15:40			"	"		"	"	
16:00			"	"		"	"	
16:20		Poster Display	"	"		"	"	
16:40			"	"		"	"	
17:00			"	"		"	"	
19:30			Manitoba Moose vs Hershey Bears - MTS Centre					

PLENARY ABSTRACTS

J.C. Stevenson Memorial Lecture

THE MOLECULAR ECOLOGY OF ADAPTATION AND ENVIRONMENTAL SUSTAINABILITY

Bryan Neff

Department of Biology, University of Western Ontario, London, ON (email: bneff@uwo.ca)

Fish provide about twenty percent of the global demand for animal protein consumption, yet nearly forty percent of commercial fisheries have now collapsed or are in serious decline. In response to this collapse, governments have invested millions of dollars on enhancement breeding programs, but many have failed to rehabilitate wild stocks. My lab works on the molecular ecology of fish and our long term goal is to help provide the scientific data that are needed to effectively manage this important natural resource and ultimately to ensure the sustainability of our fisheries. We use genetic and molecular tools to examine ecological questions relating to population structure, host-parasite dynamics, and the conservation of biodiversity. Drawing on my lab's research with Chinook salmon and guppies, I will discuss (1) adaptations driven by the co-evolution of host immune genes of the major histocompatibility complex and local pathogen communities, (2) the quantitative genetics of fitness and the effectiveness of artificial breeding programs, and (3) domestication and multi-trophic, closed-containment "green" aquaculture. I will argue that a pluralistic approach combining effective enhancement of wild populations – i.e. breeding programs that target genetic fitness and not genetic diversity – with green aquaculture is required to ensure that the global demand for fish consumption is met while mitigating overexploitation and wild-population declines.

F.H. Rigler Memorial Award Lecture

PRODUCTIVE CAPACITY IN REGULATED RIVERS: LIMNOLOGICAL VS FISHERIES APPROACHES

Joseph Rasmussen

Department of Biological Sciences, University of Lethbridge, Lethbridge, AB (email: joseph.rasmussen@uleth.ca)

Limnologists and fisheries biologists share a common interest in productivity and trophic ecology; however, Frank Rigler argued that the two disciplines did not communicate effectively because they did not share a common paradigm. He argued that fisheries biology embraced a population-based framework that ignored underlying environmental variables; whereas limnology, while attempting to view the world from a more holistic, ecosystem-based framework, did not deliver focused and quantitative predictions that could be used for fisheries management. It is tempting to argue that a great deal has changed since Rigler's time; indeed, food web ecology has arrived on the scene, limnology has become much more predictive, and fisheries science has broadened its base.

However, a search of the literature shows that little has changed. There are in fact very few papers in either limnological or fisheries journals that reflect cross-talk between the two disciplines. Most of those that do exist are in the *CJFAS*. This journal, together with the long tradition of our two societies meeting together at the coldest time of year, is instrumental to maintaining this dialogue. In Canada, the need for dialogue is underscored by the central role of the *Fisheries Act* in environmental regulation, and the "No Net Loss" principle of productive capacity of habitats, as expressed in the *Policy for the Management of Fish Habitat* adopted by the DFO. A science-based definition of productive capacity should reflect both the ecosystemic perspective of limnology and the population perspective of fisheries science.

Whether we like it or not, Canada's waters are under increasing pressure to support greater economic activity, be it in the energy sector, agriculture, mining or urbanization, and "regulated rivers", which include both reservoirs and their downstream tailwaters, are and will be an increasing part of the limnological landscape, although they presently merit little more than a mention in any of the mainstream textbooks. In this talk I will attempt to clarify the meaning of the term productive capacity or potential, and outline some general limnological approaches linking the nutrient dynamics, the food web, and fish populations in regulated rivers, both upstream and downstream of storage and hydro dams. It is my hope that both limnologists and fisheries biologists will find at least some of these ideas interesting.

ORAL PRESENTATIONS FRIDAY JANUARY 8 (AM)

		9:00	9:40	10:40	11:00	11:20	11:40
Selkirk Ballroom	ELA	J.C. Stevenson Memorial Lecture The Molecular Ecology of Adaptation and Environmental Sustainability - Bryan Neff	F.H. Rigler Memorial Award Lecture Productive capacity in regulated rivers: limnological vs fisheries approaches - Joseph Rasmussen	How will changes in atmospheric mercury emissions affect bioaccumulation of methyl mercury in aquatic food webs? Results from the METAALICUS project. Paterson, M.J., P.J. Blanchfield, C. Podemski, J. Graydon, H.H. Hintelmann, R. Harris	Modelling the uptake of newly-deposited mercury by Yellow Perch (<i>Perca flavescens</i>) Hrenchuk, L.E., P.J. Blanchfield, M.J. Paterson, and H.H. Hintelmann	Fate of decabromodiphenyl ether added to in situ mesocosms at the Experimental Lakes Area Orihel, D., D. Muir, C. Darling, A. Dupuis, M. Paterson, V. Palace, B. Park and G. Tomy	Effects of whole lake additions of a potent estrogen on fishes Palace, V., P. Blanchfield, L. Tate, K. Mills, B. Park, K. Wautier, B. Evans and K. Kidd
Assiniboine Ballroom	Trophic Linkages			Diel vertical movement and foraging patterns of capelin (<i>Mallotus villosus</i>) in the northwest Atlantic Davoren	No recovery of cod in Atlantic Canada after fifteen years with little fishing: are cod trapped in a predator pit? Swain, D.P. and R.K. Mohn	Functional response and group dynamics of top predators foraging on capelin Allen, J. and G. Davoren	A new approach to investigate the link between food quality and secondary production in marine ecosystems Suchy, K.D. and J.F. Dower
Selkirk Annex	Arctic Resources			Role of cephalopods in the arctic ecosystem Gardiner, K.G. and T.A. Dick	An isolated population of three-spined stickle-back (<i>Gasterosteus aculeatus</i>) identified in Nueltin Lake, Manitoba and Nunavut: post-glacial dispersal and population relatedness Schroeder, B.S., R.D. Mooi and M.F. Docker	Variation, migration and population assessment in arctic fishes (I) Tallman, R.F. and K.L. Howland	Identifying the migration timing and type of a Canadian arctic fish – broad whitefish (<i>Coregonus nasus, pallas</i>) Pawlychyn, Z. A., R.F. Tallman, K.L. Howland and D. Gillis
Assiniboine Annex B	Divergent Morphotypes			Shape shifting yellow perch – is it better to flee or feed? Morgan, G.E., J.M. Gunn, C.W. Ramcharan, A. Luek, and B. Wissel	Plasticity in energy allocation of yellow perch (<i>Perca flavescens</i>): comparisons between stunted and normal-growing populations Jansen, W.A.	Common garden experiment shows differences in early life-history traits in beach and demersal spawning populations of capelin Penton, P. and G.K. Davoren	Genetic basis of flesh colour in chinook salmon Tymchuk, W.E., H. Sundvold, D.I. Våge, D. Higgs, D. Heath and R.H. Devlin
Assiniboine Annex A	Quantitative Tools			Synchronous recruitment among broadly separated geographic stock complexes of anadromous Arctic char (<i>Salvelinus alpinus</i>) Day, A.C., D.M. Gillis and B.J. Dempson	A limit reference point for fisheries-induced evolution Hutchings, J.A.	A decision analysis evaluating management options for the dam on the Black Sturgeon River Smyth, E., R. McLaughlin, and M. Koops	Performance comparison of traditional sampling designs and adaptive sampling designs for fishery-independent surveys Yu, H., Y. Jiao, Z. Su and K. Reid*

LUNCH

ORAL PRESENTATIONS FRIDAY JANUARY 8 (PM)

	13:20	13:40	14:00	14:20	14:40
Selkirk Ballroom	<p>ELA</p> <p>Long term emissions of greenhouse gases from peatland reservoirs has likely been underestimated</p> <p>Rudd, J.W.M., V. St. Louis, and C.A. Kelly</p>	<p>Modeling ELA reservoir studies and the relevance to Manitoba reservoirs</p> <p>Page, S.J., R.H. Hesslein, M. Paterson, G. Swanson and D. MacDonald</p>	<p>Environmental stability and lake plankton diversity – contrasting effects of chemical and thermal variability</p> <p>Shurin, J.B., M. Winder, R. Adrian, W. Keller, B. Matthews, A.M. Paterson, M.J. Paterson, B. Pinel-Alloul, J.A. Rusak, N.D. Yan</p>	<p>The relationship between climatic variables and phytoplankton community structure in a small boreal shield lake</p> <p>Findlay, D.L. and S.E.M. Kasian*</p>	<p>Extending the long-term limnological record of reference conditions at Lake 239: A paleolimnological perspective</p> <p>Cumming, B.F., M.T. Moos and K.R. Laird.</p>
Assiniboine Ballroom	<p>Trophic Linkages</p> <p>Sex-based differences in isotopic ratios of northern fishes</p> <p>Johnston, T.A., R.A. Cunjak, and W.C. Leggett</p>	<p>How do anadromous arctic charr (<i>Salvelinus alpinus</i>) affect the ecology of coastal arctic lakes?</p> <p>Swanson, H.K., K.A. Kidd, and J.D. Reist</p>	<p>Do food web disruptions alter predator-prey interactions in fish communities?</p> <p>Strecker, A.L., M.J. Fortin, S.W. Milne, M.S. Ridgway, D.A. Jackson, P.A. Abrams and B.J. Shuter</p>	<p>Spatial variation in summer diet of invasive rainbow smelt (<i>Osmerus mordax</i>) in lake winnipeg</p> <p>Olynyk, A.J., B.J. Hann and G.K. Davoren</p>	<p>Resource availability and behavioral interactions: challenges in food web dynamics and biological recovery of stressed lakes</p> <p>Luek, A., G.E. Morgan, B. Wissel, J.M. Gunn and C.W. Ramcharan</p>
Selkirk Annex	<p>Arctic Resources</p> <p>Challenges in establishing reference points for a precautionary approach in fishes from the genus <i>Salvelinus</i> (I)</p> <p>Gallagher, C., R. Tallman and C. Day</p>	<p>Hearing ability of northern fishes and potential for disturbance from on-ice industrial activities (I)</p> <p>Cott, P.A., D.A. Mann, D.M. Higgs and T.A. Johnston</p>	<p>Assessing environmental change in freshwater ecosystems in arctic and subarctic national parks</p> <p>Sweetman, J.N., S.E. Arnott, A. Balasubramaniam, A. Chute, J.M. Culp, R.A. Curry, R.I. Hall, D. McLennan, C. Ouimet, A. Ritcey, G. Scrimgeour, K. Thomas, K. Turner and B.</p>	<p>Potential climate impacts on lakes in Wapusk National Park</p> <p>Arnott, S., M. Pedruski and J. Sweetman</p>	<p>Diversity of lake trout, <i>Salvelinus namaycush</i>, in Great Bear Lake, Northwest Territories: occurrence of four shallow-water morphotypes</p> <p>Chavarie, L., K. Howland and W. Tonn</p>
Assiniboine Annex B	<p>Divergent Morphotypes</p> <p>Variation in migration rates of maturing female kokanee salmon in Meadow Creek, British Columbia</p> <p>Warren, M.A. and Y.E. Morbey</p>	<p>Alternative life histories in populations of lake superior brook trout provide strong support for partial migration</p> <p>Robillard, M.M., R.L. McLaughlin, J.M. Casselman, and R. Mackereth</p>	<p>Lake charr (<i>Salvelinus namaycush</i>) divergence among North America's largest lakes: evidence for sympatric origins of morphs</p> <p>Blackie, C., CC. Krueger, M.S. Zimmerman and P. Bentzen</p>	<p>Resource partitioning, growth and dispersal dimorphisms (I)</p> <p>Gibson, G.</p>	<p>Environmental determinants of threespine stickleback (<i>Gasterosteus aculeatus</i>) evolution and continued persistence</p> <p>Ormond, C., J. Rosenfeld and E. "Ricky Baby" Taylor</p>
Assiniboine Annex A	<p>Quantitative Tools & General Session</p> <p>Using a dynamic state variable model to predict the effect of temperature on survival probabilities of fathead minnows over an ice-free season</p> <p>Pink, M. and M.V. Abrahams</p>	<p>Multilevel zero-inflated regression for modelling species abundance in relation to habitat: a bayesian approach (I)</p> <p>Rodríguez, M.A., C.G.B. Demétrio, S.S. Zocchi, R. A. Leandro, J. Deschênes</p>	<p>Elements of personality form the behavioural basis underlying the propensity to disperse in young brook charr (I)</p> <p>Edelsparre, A.H., R. McLaughlin and M. A. Rodríguez</p>	<p>Effect of diet shift on the allometry of enzymatic activity in fishes from a shallow fluvial lake (I)</p> <p>Jacob, B., H. Glémet and M.A. Rodríguez</p>	<p>How to reliably assess a species' absence: guidelines for the endangered Blanding's turtle in Nova Scotia</p> <p>Bourque, G. and T. Herman</p>

B R E A K

15:20	15:40	16:00	16:20	16:40	17:00	19:00
<p>Monitoring the depth distribution of lake trout in two lakes with different food webs</p> <p>Cruz-Font, L., B.J. Shuter, P.J. Blanchfield, and L.S. Tate</p>	<p>Effect of net pen aquaculture on a lake ecosystem: Results from the ELA aquaculture project (I)</p> <p>Podemski, C.L., P. Azevedo, P.J. Blanchfield, D. Findlay, K.A. Kidd, M. Kullman, K.H. Mills, M.J. Paterson, R. Rooney and M. Wetton</p>	<p>Lake trout enhancement: a by-product of rainbow trout cage aquaculture</p> <p>Mills, K.H., S.M. Chalanchuk, D.J. Allan, and C.L. Podemski</p>	<p>Assimilation of freshwater salmonid aquaculture waste by native aquatic biota</p> <p>Kullman, M.A., K.A. Kidd, C.L. Podemski, M.J. Paterson, and P.J. Blanchfield</p>	<p>Dissolved oxygen dynamics during an experimental aquaculture operation in a small boreal lake: a modeling approach.</p> <p>Dupuis, A., M. Paterson, R. Hesslein and C. Podemski.</p>	<p>POSTER SESSION</p>	<p>BANQUET</p>
<p>Ontogenetic differences in isotopic signatures and crop contents of <i>Chaoborus</i></p> <p>Persaud, A.D. and P.J. Dillon</p>	<p>Quantifying trophic structures and food web variation in prairie lakes</p> <p>Cooper, R.N. and B. Wissel</p>	<p>Variable salinity controls on food web components in prairie lakes</p> <p>Wissel, B. and R.N. Cooper</p>	<p>The impact of turbidity on the dynamic balance between predators and their prey</p> <p>Abrahams, M.V. and J. Mitchell</p>	<p>Climate change effects on aquatic ecosystem health</p> <p>Starks, E., S. Chow and B. Wissel</p>		
<p>Old, Cold, Salty Lake Trout (<i>Salvelinus namaycush</i>): anadromous lake trout in the Canadian Arctic</p> <p>Swanson, H.K., K.A. Kidd, J.A. Babaluk, R.J. Wastle, P.P. Yang, N.M. Halden, and J.D. Reist</p>	<p>Ontogenetic shifts in gillraker morphology among lake cisco <i>C. artedii</i> from Great Slave Lake, NT: are individuals chameleons?</p> <p>Muir, A.M., P. Vecsei, J.D. Reist</p>	<p>Use of Laser Ablation-ICP Mass Spectrometry of otolith strontium distribution to determine initiation and frequency of arctic char, <i>Salvelinus alpinus</i>, seaward migration in high arctic lake systems</p> <p>Loewen, T.N., J. Veillette, J. Babaluk, W. Vincent, J. Reist, and N. Halden</p>				
<p>Integrating ecological genomics with field studies of natural selection in postglacial fishes (I)</p> <p>Rogers, S.M.</p>	<p>The genomic bases of reproductive isolation in incipient whitefish species</p> <p>Bernatchez, L.</p>	<p>Divergent feeding types in lampreys: the repeated evolution of nonparasitism</p> <p>Docker, M.F.</p>				
<p>Differences in crustacean zooplankton sedimentary assemblages from lakes of the boreal shield across a narrow Ca gradient</p> <p>Jeziorski, A., A.M. Paterson and J.P. Smol</p>	<p>Interactive effects of calcium decline and rising temperature on three native <i>Daphnia</i> spp.: an ecotoxicological assessment</p> <p>Linley, D.R., J. Sheard and N. Yan</p>	<p>Zooplankton composition of boreal lakes in Northern Saskatchewan, Canada and its vulnerability to acidification</p> <p>Anas, M.U.M., B. Wissel and K.A. Scott</p>	<p>Patterns of <i>Bythotrephes longimanus</i> distribution relative to native macroinvertebrates</p> <p>Jokela, A., S. Arnott and B. Beisner</p>	<p>CO₂ and CH₄ fluxes at Eastmain 1 Reservoir (Quebec, Canada) using three different methods</p> <p>Tremblay, A., J. Bastien, I. Strachan and M.C. Bonneville</p>		

ORAL PRESENTATIONS SATURDAY JANUARY 9 (AM)

	8:40	9:00	9:20	9:40	10:00
Selkirk Ballroom	<p>Nutrients</p> <p>Paleolimnological evidence of the timing, extent, and potential causes of the eutrophication of Lake Winnipeg's South basin</p> <p>Bunting, L., P.R. Leavitt*, B. Wissel, K.R. Laird, A. St. Amand and D.R. Engstrom</p>	<p>Eutrophication , algal microfossils and cyanobacteria in central Canadian lakes</p> <p>Kling, H., G. McCullough, M. Stainton, D. Findlay and S. Watson</p>	<p>Climate, flooding and nutrient loading to Lake Winnipeg</p> <p>McCullough, G.K., S. Page, R.H. Hesslein and M.P. Stainton</p>	<p>Nutrient sequestration in lakes and reservoirs in the Lake Winnipeg watershed</p> <p>Parker, B.R. and D.B. Donald</p>	<p>Spatial and temporal trends in water quality and total phosphorus concentrations in the Lake of the Woods</p> <p>Paterson, A.M., K. Rühland, C.V. Hyatt, J.P. Smol, B.J. Clark, A.M. DeSellas, K. Hargan and P.J. Dillon</p>
Assiniboine Ballroom	<p>Conservation Genetics</p> <p>Mitochondrial and nuclear genetic markers suggest several cryptic brook lamprey species (Genus <i>Lampetra</i>) on the west coast of North America (I)</p> <p>Docker, M.F., D.A. Boguski, D.H. Goodman, and S.B. Reid</p>	<p>Genetic and behavioural assessments of the cultus pygmy sculpin (<i>Cottus</i> sp.) as a designatable unit under SARA</p> <p>Woodruff, P. and E. Taylor</p>	<p>Genetic variation in an endangered minnow throughout its native range</p> <p>McCusker, M.R., N.E. Mandrak and N.R. Lovejoy</p>	<p>American eel population genetics assessed by molecular and experimental approaches</p> <p>Côté, C.L., V. Bourret, M. Castonguay and L. Bernatchez</p>	<p>Yellow perch larval survival in the western basin of Lake Erie estimated using genetic analysis</p> <p>Carreon-Martinez, L., S. Ludsins, T. Johnson and D.D. Heath</p>
Selkirk Annex	<p>Habitat Assessment</p> <p>Evaluating habitat compensation in the freshwaters of Newfoundland: what have we learned</p> <p>Clarke, K.D.</p>	<p>If you build it, will they come (or stay)? Summary and assessment of Great Lakes Aquatic Protected Areas</p> <p>Hedges, K.J., N.E. Mandrak, M.A. Koops and O.E. Johannsson</p>	<p>Evaluating the effects of agricultural drain maintenance on grass pickerel, a species of special concern (I)</p> <p>Mandrak, N.E., J.Barnucz, and K. Hedges</p>	<p>Restoration of Delta Marsh, Manitoba: exclusion of common carp (<i>Cyprinus carpio</i>) (I)</p> <p>Wrubleski, D.</p>	<p>Successful use of fish telemetry for an environmental impact assessment: kutcho project Bull trout telemetry study 2007-2008</p> <p>Wagner, G.N. and S. Jennings</p>
Assiniboine Annex B	<p>Wetlands</p> <p>Use of satellite imagery and an automated classification method to assess changes to fish habitat in coastal wetlands of eastern Georgian Bay</p> <p>Midwood, J. and P. Chow-Fraser</p>	<p>Relative importance of macrophyte community versus water-quality variables for predicting fish assemblages in coastal wetlands of the Laurentian great lakes</p> <p>Cvetkovic, M., A. Wei, P. Chow-Fraser</p>	<p>Changes in fish community composition and habitat structure in response to declining water levels in eastern Georgian Bay coastal marshes</p> <p>Midwood, J. and P. Chow-Fraser</p>	<p>Road density as a simple indicator to assess habitat quality of coastal marshes of the Laurentian great lakes</p> <p>Cvetkovic, M., R. De Catanzaro, P. Chow-Fraser</p>	<p>Forest and wetland organic matter as a subsidy for recovering invertebrate communities in a Sudbury lake</p> <p>Szkokan-Emilson, E.J. and J. Gunn</p>
Assiniboine Annex A	<p>General Session</p> <p>Reaction norms of cod sperm performance as a function of temperature</p> <p>Purchase, C.F., I.A.E. Butts, A. Alonso-Fernández and E.A. Trippel</p>	<p>Sperm competition and secondary sexual characters in Coho salmon</p> <p>Pitcher, T.E., S.M. Doucet, and D.D. Heath</p>	<p>Movements of stream "resident" brook charr (<i>Salvelinus fontinalis</i>) within and among Lake Superior tributaries</p> <p>Coppaway, C., R. McLaughlin and R. Mackereth</p>	<p>The influence of circulating blood physiology on migratory behaviour and fate of an imperiled stock of Chinook salmon</p> <p>Hasler, C.T., R.P.B. Sunder, M.R. Donaldson, E.Guimond, D. Patterson, B. Mossop, S.G. Hinch and S. J. Cooke</p>	<p>Unintended consequences and trade-offs of upstream fish passage</p> <p>McLaughlin, R. L., L. A. Vélez-Espino, T. Pratt, M. Jones, and E. Smyth</p>

B R E A K

10:40	11:00	11:20	11:40
Total phosphorus and P sedimentation; implications for lake homeostasis and lake management (I) Mohamed, M.N., S. Bruce and W.D. Taylor*	Internal load and sedimentation in phosphorus mass balance models Nürnberg, G.K.	Application of two hypolimnetic oxygen profile models to lakes in Ontario Lin, Z.H., P.J. Dillon and L.A. Molot	Total phosphorus and hypolimnetic oxygen modelling in northern coldwater bays of the Lake of the Woods, Ontario Hargan, K., A.M. Paterson, and P.J. Dillon
Using microsatellite and mitochondrial DNA variation to investigate population structure of walleye (<i>Sander vitreus</i>) in Lake Winnipeg, MB, and surrounding areas Backhouse, S. and M. Docker	Genetic structure and diversity among populations of muskellunge (<i>Esox masquinongy</i>) in Lake Huron and Georgian Bay Wozney, K., A. Liskauskas, and C. Wilson.	An assessment of the subsistence mixed-stock fishery for broad whitefish, <i>Coregonus nasus pallus</i> , in the Mackenzie River system using microsatellite DNA: conservation implications for sub-sistence fishery management Harris, L.N. and E.B. Taylor	Experimental conservation genetics of Atlantic salmon restoration in Lake Ontario (I) Wilson, C.
Modelling Dolly Varden (<i>Salvelinus malma</i>) habitat in the western Arctic, Canada in support of ecosystem based management Mochnac*, N.J., H. Ghamry, E.C. Enders, and J.D. Reist	The influence to stream thermal variability on fish distribution and community structure in northwestern Ontario. McKee, L. and R. Mackereth	Baker Creek arctic grayling: assessing fish habitat use in a reconstructed stream (I) Vecsei, P. and H. Machtans	Effects of airgun seismic activity on riverine fishes Cott, P.A., A.N. Popper, D.A. Mann, and J.K. Jorgenson
Does land use dictate methylmercury concentrations in Saskatchewan wetlands? Hall, B.D.	Developmental history of a cupriferous swamp in New Brunswick MacDonald, S. and B.G. Warner	Effect of glyphosate on amphibian tadpole abundance in northern prairie wetlands Donald, D.B. and N. Glozier	An assessment of progress of recovery of the wetlands in southern Iraq Warner, B.G., A. Douabul, T. Asada, and J. Abaychi
Spatial and temporal variation in burrowing mayfly nymphs (Ephemeroptera: <i>Hexagenia limbata</i> and <i>H. rigida</i>) after recolonization of the western basin of Lake Erie Green, E., L.D. Corkum and J.J.H. Ciborowski	Using landscape approach to evaluate the impact of the lake catchment deforestation on benthic invertebrates' community of the lakes in north and central Ontario, Canada Namayandeh, A., K.M. Somers, P.J. Dillon, J. Schulenburg, R.E. Girard, R.A. Reid and S.M. David	Long-term changes in the benthic invertebrate community of Lake Simcoe, Ontario Rennie, M.D. and D.O. Evans	Long-term declines in crayfish diversity and abundance: the relative influence of climatic, biological, and physical-chemical processes Rusak, J.A., K.M. Somers, B. Edwards, R.A. Reid and D.A. Jackson

LUNCH

ORAL PRESENTATIONS SATURDAY JANUARY 9 (PM)

	13:20	13:40	14:00	14:20	14:40
Selkirk Ballroom	<p>Nutrients</p> <p>Paleolimnological investigation of temporal and spatial changes in water quality in Lake of the Woods, Ontario</p> <p>Hyatt, C.V., K.M. Rühland, A.M. Paterson and J.P. Smol</p>	<p>A comparison of planktonic phosphorus regeneration rates in marine & freshwater ecosystems (I)</p> <p>Hudson, J., F. Thingstad, T. Tanaka and T. Moutin</p>	<p>Photo-inhibition of phosphate uptake in uvr exposed plankton assemblages: rate of recovery and influence of cell size</p> <p>Sereda, J.M., D.M. Vandergucht and J.J. Hudson</p>	<p>Phosphorus deficiency indicators in lakes</p> <p>Vandergucht, D.M., J.M. Sereda and J.J. Hudson</p>	<p>The case for phosphorus limitation in Lake Simcoe</p> <p>North, R.L., V. Hiriart-Baer, J. Winter and P.D. Dillon.</p>
Assiniboine Ballroom	<p>Conservation Genetics</p> <p>Inbreeding and outbreeding depression in endangered populations of Atlantic salmon</p> <p>Houde, A.S., D.J. Fraser, P. O'Reilly and J.A. Hutchings</p>	<p>Identifying bull trout populations and the origin of migrant individuals using genetic clustering methods and traditional assignment tests in tandem</p> <p>Warnock, W. and J. Rasmussen</p>	<p>Genetic compatibility and mate choice for jack versus hooknose male Chinook salmon</p> <p>Helou, L., T. Pitcher, and D.D. Heath.</p>	<p>The influence of an alternative male mating strategy on egg fertilization and genetic diversity in Atlantic salmon</p> <p>Weir, L.K., J.A. Hutchings and D.D. Heath</p>	<p>Genetic correlates to growth and survival in Chinook salmon (<i>Oncorhynchus tshawytscha</i>)</p> <p>Falica, B.K., D.D. Heath, D.M. Higgs and T.E. Pitcher</p>
Selkirk Annex	<p>Habitat Assessment</p> <p>Effects of decelerating and accelerating flows on juvenile salmonid behavior</p> <p>Enders, E.C., M.H. Gessel, J.J. Anderson and J.G. Williams</p>	<p>Small lake salmonid biomass and habitat relationships for Newfoundland lakes</p> <p>Cote, D., B.K. Adams and K.D. Clarke</p>	<p>Comparison of electro-fishing and visual surveys for the description of fish assemblages in Laurentian streams</p> <p>Chamberland, J.-M. and D. Boisclair</p>	<p>Seasonal movement and habitat use of a lacustrine population of Brook charr (<i>Salvelinus fontinalis</i>) using ultrasonic telemetry</p> <p>Tibble, B.J., S. Peake, D. Cote, and B.K. Adams</p>	<p>Natural reproduction sites of Chinook salmon in Lake Huron: the use of otolith microchemistry as a fisheries management tool</p> <p>Marklevitz, S.A.C., Y.E. Morbey and B.J. Fryer</p>
Assiniboine Annex B	<p>General Session</p> <p>Habitat effects on energy equivalence and self-thinning in juvenile salmonids</p> <p>Rosenfeld, J.</p>	<p>Adaptations to seasonality: energy allocation strategies in juvenile rainbow trout in whole-lake experiments</p> <p>Lea, E.V., J.R. Post and E.A. Parkinson</p>	<p>Behavioural responses of juvenile Atlantic salmon (<i>Salmo salar</i>) when exposed to juvenile exotic salmonids</p> <p>Van Zwol, J., B. Neff, and C. Wilson</p>	<p>Differential growth rates in early and late-spawned yoy pumpkinseed sunfish (<i>Lepomis gibbosus</i>) in Lake Ontario embayments</p> <p>Rooke, A, N. Collins and S. Murphy</p>	<p>Controls of productivity and respiration dynamics in saline prairie lakes</p> <p>Scott, D., Z.J. Quiñones-Rivera and B. Wissel</p>
Assiniboine Annex A	<p>General Session</p> <p>Killing sea lampreys to protect Lake sturgeon in the Great Lakes</p> <p>Christie, G.C. and M.J. Seifkes</p>	<p>Behaviour of sea lamprey approaching traps on the St. Marys River</p> <p>Bravener, G. and R. McLaughlin</p>	<p>Round goby (<i>Neogobius melanostomus</i>) attraction to conspecific and heterospecific egg odours</p> <p>Yavno, S. and L.D. Corkum</p>	<p>Signalling results in successful spawning of the invasive round goby</p> <p>Corkum, L.D., B. Meunier and S. Yavno</p>	<p>Contrasting mercury deposition and bioaccumulation in lakes near two major Canadian atmospheric emitters</p> <p>Bielefeld, K., M. Evans, D. Muir, J. Kirk and J. Keating</p>

B R E A K

	15:20	15:40	16:00	16:20	16:40	17:00
Nutrients	Reconstructing the trophic history of Lake Simcoe, Ontario: a paleolimnological study of a multiple stressor system Hawryshyn, J., K.M. Rühland, D.L. Rodé, R. Quinlan and J.P. Smol	Declining sulfate, phosphorus and iron concentrations in Dorset lakes between 1981 and 2005 (I) Molot, L., P.J. Dillon and A. Paterson	The impact of thawing permafrost on lakes of the Mackenzie Delta Houben, A., R. Deison, T. French, L.E. Kimpe, M. Pisaric, J. Thienpont, J.P. Smol and J.M. Blais*	The nutritional status of subarctic lakes in Wapusk National Park Symons, C., S. Arnott and J. Sweetman	Differential effects of urea fertilization on algal and bacterial production in prairie lakes Bogard, M.J., D.B. Donald, M.J. Waiser, V.P. Tumber, K. Finlay and P.R. Leavitt	Contrasting effects of urea, nitrate, and ammonium on phytoplankton dynamics and microcystin levels in a eutrophic lake. Donald, D.B., M.J. Bogard, K. Finlay and P.R. Leavitt.
Fishers in Fisheries	Bioeconomic evaluation of harvest control rules for Lake Erie walleye fishery Tsiplova, K, Y. Jiao, K. Reid* and T. Nudds	Evaluating Canada's Species at Risk Act: a case study of three species of wolffish in the northern Gulf of St. Lawrence (I) Dawe, J., B. Neis, K. Blanchard and D. Schneider	Merging aboriginal traditional knowledge and western science to assess diversity in ciscoes (<i>Coregonus</i> spp.) Muir, A.M., P. Vecsei, H. Machtans, K. Floress, T. Slack and J. Drygeese	Dispersal and survival of aquaculture escapees: new insights from angler returns in Lake Huron (I) Patterson, K., P.J. Blanchfield and D. Geiling	Fishing decisions, fish behaviour and determining the scope for bycatch mitigation (I) Carruthers, E.H., B. Neis and J.D. Neilson	
General Session	The coastal-zone skate (<i>Leucoraja</i> sp) of the southern Gulf of St Lawrence – an undescribed endemic? Hanson, J.M.	Semmens et al. - Semmens, J., D. Webber*, E. Forbes, J. Lyle and C. Buxton	The use of refuge sites by sea lamprey <i>Petromyzon marinus</i> Lower, N., D.G., McDonald, and R.L. McLaughlin	Spatial and temporal viral dynamics in lakes are influenced by trophic status and regional climatic conditions Clasen, J.L. and C.A. Suttle		
General Session	Seasonal distribution and abundance of small fishes in the offshore waters of Lake Winnipeg Lumb, C.E., W.G. Franzin and D.A. Watkinson	Initial findings of a large-scale, American eel stocking experiment in Lake Ontario Pratt, T.C., R.W. Threader, and L.M. O'Connor	Homeless and hunted: is this the fate of Macquarie perch in Cotter Reservoir, Australian capital territory? Ryan, K., M. Lintermans, R. Norris and B. Ebner	Subfossil Chaoboridae and Chironomidae assemblages to reconstruct past changes in lake thermal regimes in the Experimental Lakes Area Quinlan, R., M.J. Paterson, D.W. Schindler and J.P. Smol		

POSTERS-AT-A-GLANCE
Grand Ballroom
Friday January 8, 17:00-19:00

Trophic linkages in aquatic ecosystems		
P1	Brinkmann	HIGH LEVELS OF MERCURY IN BIOTA OF A NEW PRAIRIE IRRIGATION RESERVOIR WITH A SIMPLIFIED FOOD WEB IN SOUTHERN ALBERTA, CANADA
P2	Persaud	ENVIRONMENTAL DRIVERS OF CARBON TRANSFER AND TROPHIC DYNAMICS WITHIN BENTHIC COMMUNITIES OF TEMPERATE LAKES
P3	Sheppard	TROPHIC LINKAGES AMONG ZOOPLANKTON, THE INVASIVE RAINBOW SMELT (<i>OSMERUS MORDAX</i>) AND WALLEYE (<i>SANDER VITREUS</i>) IN LAKE WINNIPEG
Divergent Morphotypes in temperate species: resources and evolution		
P4	Davoren	SPAWNING HABITAT SELECTION OF CAPELIN (<i>MALLOTUS VILLOSUS</i>) IN THE NORTHWEST ATLANTIC
P5	McFarlane	DETECTION OF SELECTION FOR FEEDING TYPE IN PAIRED LAMPREY SPECIES
Habitat assessment and management in freshwater		
P6	Davies	THE USE OF RISK ASSESSMENT ANALYSIS TO IDENTIFY QUALITY AND AT RISK HABITAT FOR THE SASKATCHEWAN RIVERS LAKE STURGEON (<i>ACIPENSER FULVESCENS</i>) POPULATION
P7	Mackereth	THE INFLUENCE OF TERRESTRIAL LINKAGES ON SMALL STREAM HABITAT AND BIOTA
P8	Paszkowski	CONSTRUCTED PONDS AS BREEDING HABITAT FOR THE HORNED GREBE IN THE PEACE PARKLAND, CANADA
P9	Phillips	DAM-RELATED THERMAL POLLUTION IN THE SOUTH SASKATCHEWAN RIVER AND IMPLICATIONS FOR THE BENTHIC ECOSYSTEM
P10	Trembath	TESTING A HABITAT SUITABILITY INDEX MODEL FOR LAKE STURGEON (<i>ACIPENSER FULVESCENS</i>) IN THE RAINY LAKE SYSTEM OF NORTHWESTERN ONTARIO
Conservation Genetics: Applications in conservation and management		
P11	Spice	POPULATION STRUCTURE OF PACIFIC LAMPREYS (<i>ENTOSPHEMUS TRIDENTATUS</i>) ALONG THE WEST COAST OF NORTH AMERICA
Including fishers in fisheries science		
P12	Adams	FOR FOOD OR FOR FUN? A HUMAN DIMENSIONS APPROACH TO UNDERSTANDING ANGLER ACCEPTANCE OF MANAGEMENT REGULATIONS IN YUKON
P13	van der Lee	"FISHING THE LINE" AROUND REGULATORY CLOSURES
Arctic aquatic resources: unique species in a dynamic environment		
P14	Burt	ATMOSPHERIC MERCURY DEPLETION EVENTS: A POTENTIAL SOURCE OF MERCURY TO BIOTA IN THE AMUNDSEN GULF?
P15	Dorn	THE EFFECTS OF GROWTH RATE, TROPHIC POSITION, AGE, AND SIZE ON MERCURY ACCUMULATION IN ARCTIC CHARR
P16	Godard	PATHOLOGICAL ASSESSMENT OF EXPLOSIVE BASED INSTANTANEOUS PRESSURE CHANGE (IPC) ON FISH

P17	Lynn	SPECIES ASSEMBLAGES, SPATIAL DISTRIBUTIONS, AND HABITAT ASSOCIATIONS OF MARINE FISH IN THE CANADIAN BEAUFORT SEA – THE CCGS <i>NAHIDIK</i> FISHING PROGRAM 2006-2009
P18	Sawatzky	INVESTIGATING FLUCTUATING ASYMMETRY IN CHAR: A POTENTIAL INDICATOR FOR MONITORING PROGRAMS
P19	Vecsei	TAXONOMIC DIVERSITY OF CISCOES IN GREAT SLAVE LAKE
P20	Vecsei	INTERSPECIFIC AND INTRASPECIFIC OSTEOLOGICAL VARIATION IN SYMPATRIC CISCOES, YELLOWKNIFE BAY, GREAT SLAVE LAKE
P21	Wong	DOES MACKENZIE RIVER PLUME INFLUENCE DISTRIBUTION OF ARCTIC LARVAL FISH?
Nutrients in aquatic ecosystems		
P22	Bradley	THE EFFECTS OF HISTORICAL INDUSTRIAL DAMAGE AND CURRENT URBANIZATION ON PHYTOPLANKTON COMMUNITIES IN FRESHWATER LAKES
P23	Campbell	USING A GRADIENT-BASED MIXING MODEL FOR $\delta^{13}C$ TO ESTIMATE THE TERRESTRIAL CONTRIBUTION TO A TAILWATER FOODWEB DOWNSTREAM FROM THE OLDMAN RIVER, DAM, ALBERTA
P24	Paterson	REGIONAL TRENDS IN TOTAL PHOSPHORUS AND CALCIUM CONCENTRATIONS IN RECREATIONAL LAKES ACROSS ONTARIO
P25	Nürnberg	CYANOBACTERIA BLOOMS IN BRIGHT LAKE, IRONBRIDGE, ON: HOW A LAKE ASSOCIATION TRIES TO CLEAN UP ITS LAKE
P26	Lin	COMPARISONS OF TWO HYPOLIMNETIC OXYGEN DEPLETION MODELS
The Experimental Lakes Area: Celebrating 40 years of research		
P27	Hrenchuk	RELATIVE UPTAKE OF DIETARY AND WATERBORNE MERCURY BY YELLOW PERCH
P28	Putt	CHANGES IN THE DISTRIBUTION OF LAKE TROUT AND THEIR PREY <i>MYSIS RELICTA</i> IN RESPONSE TO AN EXPERIMENTAL FRESHWATER AQUACULTURE OPERATION
P29	Tate	SEASONAL HABITAT SELECTION BY LAKE TROUT IN A BOREAL LAKE
P30	Wall	SHIFTS IN FORAGE BASE ALTER LAKE TROUT HABITAT USE
General Session		
P31	Carroll	EXAMINING ZINC DISTRIBUTION IN OTOLITHS TO DESCRIBE REPRODUCTIVE FAILURE IN LAKE TROUT FROM PIPESTONE BAY, ONTARIO
P32	Farwell	EFFECTS OF CONTAMINANTS ON FEMALE REPRODUCTIVE TRAITS IN THE BROWN BULLHEAD (<i>Ameiurus nebulosus</i>)
P33	Hanisch	BACI ANALYSIS REVEALS MINIMAL EFFECTS OF STOCKED TROUT ON NATIVE FORAGE FISH IN BOREAL FOOTHILLS LAKES OF ALBERTA
P34	Hill	EFFECT OF VARYING FAMILY SURVIVORSHIP ON EFFECTIVE POPULATION SIZE (N_e) OF CAPTIVE SALMONID BROODSTOCKS
P35	Keith	EFFECT OF AGE TRUNCATION ON RECRUITMENT AND POPULATION SIZE ACROSS TAXA
P36	McDougall	COURSE SCALE MOVEMENT PATTERNS OF JUVENILE/SUBADULT LAKE STURGEON IN A SMALL WINNIPEG RIVER RESERVOIR
P37	Patterson	SITE FIDELITY PATTERNS OF FARMED RAINBOW TROUT ESCAPED FROM AQUACULTURE OPERATIONS IN LAKE HURON
P38	Robillard	CURRENT STATUS AND TEMPORAL TRENDS IN THE NEARSHORE FISH COMMUNITY OF LAKE SIMCOE IN LATE SUMMER
P39	Roux	A PRODUCTIVITY-SUSCEPTIBILITY RISK ANALYSIS FOR THE EFFECTS OF FISHING ON ARCTIC CHARR (<i>SALVELINUS ALPINUS</i>) STOCKS FROM THE NUNAVUT TERRITORY

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ABSTRACTS

63rd Meeting of the

Canadian Conference for Fisheries Research
Conférence Canadienne de la Recherche sur les Pêches

Society of Canadian Limnologists
Société canadienne de limnologie

and

Society of Wetland Scientists
Société des scientifiques des zones humides

Winnipeg, Manitoba

7-9 January 2010

**Abstracts for oral and poster presentations are combined and in alphabetical
order by presenter**

THE IMPACT OF TURBIDITY ON THE DYNAMIC BALANCE BETWEEN PREDATORS AND THEIR PREY

Abrahams*, M.V. and J. Mitchell

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Water turbidity can have a major impact upon fish communities. Turbid conditions limit the ability of vision-dependent prey species to detect and avoid predators, potentially tilting the predator-prey balance towards the predator. But those same conditions also limit the ability of vision-dependent predators to detect prey. We use an animated computer model to explore the consequences of varying the abilities of predators and prey to detect one another. The model gives us insights into mechanisms through which perturbations in the physical environment can affect the dynamic balance between predators and their prey.

Oral CCFR (Trophic Linkages)

FOR FOOD OR FOR FUN? A HUMAN DIMENSIONS APPROACH TO UNDERSTANDING ANGLER ACCEPTANCE OF MANAGEMENT REGULATIONS IN YUKON

Adams, D.

Department of Geography & Environmental Studies, Wilfrid Laurier University, Waterloo Ontario (email: adam1990@wlu.ca)

Fisheries are an important resource to many in the Yukon, including recreational anglers. Recent studies have determined that recreational fisheries are playing a significant role in the decline of global fish populations, and in response, fisheries management is looking toward diverse methods of regulation in an attempt to make recreational fisheries sustainable. Human Dimensions of Fish and Wildlife Research serves as an approach to understanding those that use the resource in an effort to improve management and decision-making. In Yukon, territorial fisheries managers have attempted to implement new regulations to control fish populations. However, not all stakeholders have shown interest in these new regulations as they are perceived to negatively impact angling experiences. In the summer of 2009, in collaboration with Yukon Government Fisheries Division, 1551 surveys were mailed to a stratified random sample of anglers who purchased a Yukon fishing license in 2008. Through analyzing these data, the researcher will explore angler attitudes toward regulations, noting any correlations between attitudes and beliefs. In the end, this research will reveal opportunities for improved communication between anglers and the Fisheries Division, while highlighting potential areas for further education of anglers. This research will add to current discourse of recreational fisheries management, Human Dimensions of Fish and Wildlife, ultimately improving the management of a complex resource.

Poster CCFR (Including fishers in fisheries science)

FUNCTIONAL RESPONSE AND GROUP DYNAMICS OF TOP PREDATORS FORAGING ON CAPELIN

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To understand ecosystem functioning, it is critical to know the functional response of the predator-prey relationships within that ecosystem. Capelin is the focal forage fish species for most large predators in the Northwest Atlantic. During the summer in Newfoundland, capelin migrate from offshore overwintering grounds to coastal areas to spawn. The breeding seasons of many capelin predators in coastal Newfoundland, such as common murre and northern gannets, overlap with this inshore spawning migration. The density patterns of non-breeding predators, such as cod, shearwaters and whales, generally match the inshore arrival of pre-spawning capelin. In this system, the abundance of prey has a swamping effect on predators and, thus, we predict that the aggregative response will closely approximate the functional response. A fine-scale hydroacoustic survey was repeated (n=12) near the Funk Island Seabird Ecological Reserve on the northeast Newfoundland shelf to quantify both predator and prey density and distributional patterns over the capelin spawning season (July-August 2009). The density of murre, gannets, shearwaters and whales showed a curvilinear relationship with capelin; relationships between each predator and capelin density were all parabolic, except northern gannets which displayed a negative parabolic relationship. This suggests a threshold response at which predators become prey-swamped for capelin dependent predators, while northern gannets prey switch and appear to be indicators of capelin moving into the region, as their numbers increased just prior to the arrival of capelin, as did whales. Murre and shearwater densities increased within days of the bulk of capelin arriving to spawn. By examining functional responses, we can better understand marine food webs and ecosystem processes and predict how changing prey densities may reverberate through the foodweb.

Oral CCFR (Trophic Linkages)

ZOOPLANKTON COMPOSITION OF BOREAL LAKES IN NORTHERN SASKATCHEWAN, CANADA AND ITS VULNERABILITY TO ACIDIFICATION

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Lakes in northern Saskatchewan are vulnerable to acidification because local soils have minimal buffering capacity and the area is downwind of the Alberta Oil Sands Region, a continuous significant source of SO₂ and NO_x emissions. In addition, these lakes may also be susceptible to changes in physiochemical properties due to long-term climate change. As a result, food-web structures of these lakes may undergo dramatic changes in the near future. As a part of a large scale survey to evaluate the current status of lakes within 300 km of the point source, 147 lakes were surveyed for their current status of watershed characteristics, water chemistry, algal biomass, and zooplankton species composition. Canonical Correspondence Analysis was performed to identify those physiochemical parameters and other lake characteristics that significantly influenced the zooplankton composition. *Chaoborus americanus* as indicator of fishless lakes and *Daphnia pulex* had their optima at higher concentrations of nitrate and TP, while optima of *Skistodiaptomus*, *Microcyclops*, *Asplanchna* and *Daphnia rosea* occurred at below average values of these variables. Species optima of *Bosmina*, *Asplanchna*, *Kellicottia*, *Keratella* and other copepods were highly correlated with average concentrations of K, Sb and TN, while *Diaphanosoma* and *Ceriodaphnia* showed optima at higher concentrations of K. Furthermore, daphnids did only occur at Ca concentrations large than 1.5 mg L⁻¹, which eliminated these species from approximately 40% of all study lakes. Due to these dynamic responses, zooplankton composition may act a good indicator for future changes in food-web structure in these lakes due to acidification and climate change.

Oral SCL (General Session)

POTENTIAL CLIMATE IMPACTS ON LAKES IN WAPUSK NATIONAL PARK

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Climate change is expected to have large impacts in northern regions over the next few decades. This may be especially true in subarctic regions where thawing permafrost is expected to result in changes in landscape hydrology and the cycling of nutrients and organic matter. The response of biota will depend on changes in the local environment as well as regional processes that influence lake connectivity and the movement of organisms among lakes. In 2008, we surveyed 92 lakes and ponds within three regions across Wapusk National Park, near Churchill, Manitoba: coastal fens, interior peatlands, and spruce lichen forests. At each site we assessed water chemistry, lake morphology, and zooplankton community composition. In an effort to understand how aquatic ecosystems in subarctic regions will respond to future climate change, we determined the local (e.g., water chemistry) and regional (e.g., dispersal) factors influencing zooplankton community composition. Variation in zooplankton community structure associated with each of these factors was partitioned to determine their relative and combined influences. The absence of a significant influence of regional factors (e.g., inter-lake distance relationships) would indicate that dispersal is not limiting zooplankton community composition. We found that local factors (e.g., conductivity, nutrient concentrations, and lake morphology) were important determinants of zooplankton community composition. We found limited evidence of dispersal limitation in ponds in this region. This suggests that species lost as a result of changing environmental conditions, may be readily replaced by more tolerant species from the regional species pool, enabling the maintenance of ecosystem functioning.

Oral SCL (Arctic resources)

USING MICROSATELLITE AND MITOCHONDRIAL DNA VARIATION TO INVESTIGATE POPULATION STRUCTURE OF WALLEYE (*SANDER VITREUS*) IN LAKE WINNIPEG, MB, AND SURROUNDING AREAS.

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Walleye (*Sander vitreus*) are the main contributor to Manitoba's multi-million dollar commercial fishery, with Lake Winnipeg providing the largest and most profitable catch. Walleye spawn in river mouths and lake shoals, and in some (but not all) systems, show evidence of returning to the same spawning site each spring, a behaviour known as natal homing or philopatry. The spatial segregation of gene flow that occurs when philopatry is present provides potential for multiple genetically discrete spawning groups to exist throughout a lake. This study used nine microsatellite loci and one mitochondrial restriction fragment length polymorphism (RFLP) assay to investigate the degree of genetic differentiation present among 13 spawning sites in Lake Winnipeg, and compared these to walleye collected from two hatchery locations, other locations in northern and eastern Manitoba, Lake of the Woods and the Laurentian Great Lakes, and sauger (*Sander canadensis*). Little population structure was found within Lake Winnipeg, although Grand Rapids and the Icelandic River showed slight but significant differentiation from other Lake Winnipeg sampling locations ($F_{st} = 0.0066$ to 0.0457). Great genetic differentiation was found between walleye and sauger ($F_{st} = 0.1346$ to 0.2693). Slight to moderate genetic differentiation was found between Lake Winnipeg walleye and sampling locations outside of Lake Winnipeg ($F_{st} = 0.0037$ to 0.1054). The lack of genetic differentiation found in Lake Winnipeg possibly indicates a low degree of natal philopatry, an amount of straying sufficient to obscure genetic structure, or obscured structure as a result of historical and current stocking.

Oral CCFRR (Conservation genetics)

THE GENOMIC BASES OF REPRODUCTIVE ISOLATION IN INCIPIENT WHITEFISH SPECIES

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In contrast to the large amount of ecological information supporting the role of natural selection as a main cause of population divergence and speciation, an understanding of the genomic basis underlying those processes is in its infancy. In this presentation, I will review recent findings of a long-term research program that we have been conducting on the ecological genomics of sympatric forms of lake whitefish (*Coregonus clupeaformis*) engaged in the process of speciation. We present this system as an example of how applying a combination of approaches under the conceptual framework of the theory of adaptive radiation has yielded substantial insight into evolutionary processes in a non-model fish species. We also discuss how the joint use of recent biotechnological developments will provide a powerful means to address issues raised by observations made to date. Namely, we present data illustrating the potential offered by genomewide gene expression analysis and next generation sequencing technologies to reveal the genomic bases of adaptive divergence and reproductive isolation. Given increasing access to these new genomic tools, we argue that the investigation of divergent morphotypes in whitefish and other temperate fish species will play an increasingly important role in generalising knowledge of speciation.

Oral CCFFR (Divergent morphotypes)

CONTRASTING MERCURY DEPOSITION AND BIOACCUMULATION IN LAKES NEAR TWO MAJOR CANADIAN ATMOSPHERIC EMITTERS

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Under the Clean Air Regulatory Agenda (CARA), a regulatory framework for air emissions, Canada is committed to reducing atmospheric mercury (Hg) emissions, particularly by major Hg emitters. Our study is investigating the factors affecting spatial and temporal variability in Hg levels in sediments, water, and aquatic food webs of lakes near two such major Hg emitters in western Canada – coal fired power plants in the Wabamun Lake area of central Alberta and the base metal smelting and mining complex in Flin Flon, Manitoba. For the Flin Flon area, Hg concentrations in sediments were extremely high in lakes within a few kilometers of the smelter but decreased rapidly with distance (ranging from 0.109 - 29.9 µg/g), suggesting either rapid deposition of particulate-bound species or atmospheric dilution. In contrast, Wabamun Lake and nearby lakes had sediment Hg concentrations which did not differ greatly from background (ranging from 0.064 - 0.123 µg/g) indicating a different type of Hg emission than in the Flin Flon area, i.e., perhaps less particulate bound-Hg. Interestingly, Hg concentrations in water were low (mean THg of 0.56 ± 0.32 ng/L in Alberta and 1.48 ± 0.85 ng/L near Flin Flon) in both study areas with little spatial variability. Our ongoing research will characterize and contrast Hg biomagnification in biota from plankton and benthos to northern pike, the top predator.

Oral SCL (General session)

LAKE CHARR (*SALVELINUS NAMAYCUSH*) DIVERGENCE AMONG NORTH AMERICA'S LARGEST LAKES: EVIDENCE FOR SYMPATRIC ORIGINS OF MORPHS

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Distinguishing models of speciation can be problematic, particularly for species with complex evolutionary histories. We investigated the relative roles of historical contingency versus contemporary evolution for lake charr (*Salvelinus namaycush*) morphs in North America's Great Lakes (Superior, Mistassini, Great Slave and Great Bear). We used mitochondrial (RFLP) and nuclear genetic markers (microsatellites) to identify patterns of gene flow between glacial lineages and morphs over different time scales (i.e. glacial history versus contemporary divergence). Several lines of evidence suggested sympatric origins of the morphs, including: 1) no association between a single glacial race and a particular morph; 2) a phenogram clustered morphs together based on lake, rather than ecological specialization; 3) a hierarchical AMOVA partitioned more of the observed genetic variation at the level of population and morph rather than glacial race; and 4) Bayesian estimates of migration rate suggested reduced gene flow among sympatric morphs over time. While our results cannot exclude historical factors as important in the divergence of lake charr morphs, they do suggest extensive introgression among glacial lineages as well as divergence via contemporary selection pressures.

Oral CCFRR (Divergent morphotypes)

THE IMPACT OF THAWING PERMAFROST ON LAKES OF THE MACKENZIE DELTA

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Total permafrost in the Northern Hemisphere currently occupies an area of 26 million km², and by 2100, this area is expected to decrease by 19-35%. In the Mackenzie Delta, NWT, temperatures are projected to rise by 4 to 5°C in the next 50 years, and thawing permafrost will be particularly severe. Despite these drastic and rapid changes projected for the cryosphere in the coming decades, remarkably little is known about the geochemical and biological consequences of thawing permafrost. We are testing the hypothesis that the presence of retrogressive thaw slumps in the Mackenzie Delta (north of Inuvik, NWT) is affecting nutrients (total and dissolved N and P), persistent organic pollutants, metal concentrations, and phytoplankton community assemblages in small tundra lakes. Preliminary results from 2009 indicate that dissolved organic carbon, total phosphorus, soluble reactive phosphorus, and total mercury were lower in lakes with retrogressive thaw slumps than reference lakes, possibly due to deeper water infiltration through clay-rich tundra soils. In addition, we are tracking changes in the lake's biota over time using fossil diatoms in lake sediment cores. Striking changes in diatom assemblages over time may be linked to past changes in melting permafrost. Future studies will investigate the effect of thaw slumps on microbial transformations of mercury, the transfer of persistent organic pollutants to surface waters, and limnological responses to the changing permafrost status.

Oral SCL (Nutrients)

DIFFERENTIAL EFFECTS OF UREA FERTILIZATION ON ALGAL AND BACTERIAL PRODUCTION IN PRAIRIE LAKES

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Agricultural use of urea ((NH₂)₂CO) as a fertilizer has increased at near-exponential rates since 1970, yet relatively little is known of its potential effects on aquatic ecosystems. For instance, over 50% of all N fertilizer used in Saskatchewan is applied as urea (500,000 tonnes per year), with 5-30% entering nearby aquatic ecosystems in a chemically-intact form. To quantify effects of urea fertilization on both algal and bacterial production, we conducted a series of 3-week long mesocosm (3000 L) experiments in hypereutrophic Wascana Lake (>250 µg P L⁻¹) during July, August and September of 2009. Urea was added weekly at 5 concentrations (0, 1, 3, 8, and 18 mg N L⁻¹) with 3 replicates at each level. During each month's experiment, algal biomass and production (as Chl, ¹⁴C fixation, O₂ evolution) increased with urea concentrations to a plateau at 3-5 mg N L⁻¹, whereas bacterial production (³H-thymidine uptake) increased with increasing urea concentrations. Similarly, during each experiment, algal productivity initially increased, and plateaued at day 7 in treatments ≥ 3 mg N L⁻¹. Bacterial production, although remaining at background levels until day 7, increased in a linear manner thereafter. At the 8 and 18 mg N L⁻¹ treatment levels, bacterial production was sufficient to deplete O₂ by the end of the experiment and shift the mesocosm to net heterotrophy. We conclude that, in P- rich lakes, urea pollution at concentrations < 3 mg L⁻¹ may enhance net autotrophy of a lake, while urea additions > 3 mg L⁻¹ may increasingly favor net heterotrophy.

Oral SCL (Nutrients)

HOW TO RELIABLY ASSESS A SPECIES' ABSENCE: GUIDELINES FOR THE ENDANGERED BLANDING'S TURTLE IN NOVA SCOTIA

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A major challenge of conservation biology and of ecology is to assess species distributions. Being able to state that a species is clearly absent from a site is a huge responsibility and it is often easy to conclude about absence when sampling effort is not suitable to the species. The endangered Nova Scotia population of Blanding's turtle (*Emydoidea blandingii*) has a patchy distribution, can occur in very low densities, and determining species distribution, abundance patterns and habitat patch occupancy are keys to the species recovery strategy. In this study, we used unstandardized trapping events to identify optimal sampling effort and conditions necessary to reliably assess the absence of Blanding's turtles from wetland patch units. Our specific objectives were to: 1) identify key variables influencing detectability, 2) identify the best performing and most parsimonious model to assess whether conditions are suitable and effort is sufficient to reliably assume that the species, when not detected, is absent from a site, and 3) develop guidelines for field workers and managers. A model incorporating three threshold values best assessed suitable conditions and sufficient effort to reliably assume that lack of detection indicated absence. Turtles, if present, would be caught with a minimum of 19.5 trap•days per km of trappable habitat, a mean cloud cover < 72.5 % and in June, July or August rather than in May or September.

Oral CCFRR (Quantitative tools)

THE EFFECTS OF HISTORICAL INDUSTRIAL DAMAGE AND CURRENT URBANIZATION ON PHYTOPLANKTON COMMUNITIES IN FRESHWATER LAKES

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Sudbury, Ontario is a city disturbed by historical acidification and metal contamination and is currently undergoing both recovery and urbanization. Consequently, lake communities in the area have been subjected to a multitude of environmental disturbances. A sensitive indicator of environmental change in lakes is the phytoplankton community. The objective of this study is to quantify the influence of physical, chemical, and biological variables on the biomass and community assemblage of phytoplankton in Sudbury urban lakes using 30 years of temporal data. We will test the hypothesis that phytoplankton communities in Sudbury urban lakes are significantly different than a set of reference lakes, under a much lower urban influence. We predict that this difference among lake types will be expressed as an increase in the cyanobacteria, and will be a result of increased nutrient levels due mainly to urbanization. Additionally, we will examine the extent to which chemical variables (pH, nutrients, metals, etc.), physical variables (water temperature, weather, water clarity, etc.) and biological variables (herbivory, grazer biomass) explain the changes in the phytoplankton assemblage using various multivariate analyses. Results from related studies suggest that phytoplankton biomass increases with increasing nutrient levels, despite continued metal contamination. There are also long-term changes in phytoplankton assemblages across Ontario lakes, with an increase in cyanophytes in more eutrophic systems as well as an overall increase in chrysophytes and a decrease in diatoms in many lakes. These findings allow us to better understand the phytoplankton community dynamics in historically acidified urban lakes.

Poster SCL (Nutrients)

BEHAVIOUR OF SEA LAMPREY APPROACHING TRAPS ON THE ST. MARYS RIVER

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This study combined acoustic and radio telemetry, passive integrated transponder (PIT) telemetry, and underwater video to examine the behaviour of sea lamprey approaching traps in the St. Marys River. The sea lamprey is an invasive species in the Great Lakes and the target of a bi-national control program. Trapping could be an important control option for large rivers if trapping success can be improved. In 2008 and 2009, acoustic and radio telemetry were used to obtain 3-dimensional movement paths for individual sea lamprey and test whether individuals moved upstream in the boundary layer or exhibited vertical zig-zagging behaviour (casting). PIT telemetry and video were used to test whether arrival times and time spent near a trap differed between sexes and classes of sea lamprey and how individual sea lamprey behaved at the trap entrance and inside the trap. Preliminary analyses suggest that individual sea lamprey differ markedly in their movement paths, but may not exhibit casting. Males arrived at traps significantly earlier than females in 2009, but not 2008. Fertile lamprey arrived significantly earlier than sterile males in 2008, but 2009. In both years, sexes and classes of sea lamprey did not differ significantly in availability or susceptibility to capture. Trap retention was 100%. Our findings suggest that trapping success could be improved by deploying multiple traps at strategic locations, because of the individual variation in movement paths, and by modifying traps in ways that increase the number of available sea lamprey that enter the trap.

Oral CCFRR (General Session)

HIGH LEVELS OF MERCURY IN BIOTA OF A NEW PRAIRIE IRRIGATION RESERVOIR WITH A SIMPLIFIED FOOD WEB IN SOUTHERN ALBERTA, CANADA

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This study examined mercury levels in northern pike (*Esox lucius*) from the Twin Valley reservoir in southern Alberta, two years after construction in 2003. The hypothesis was tested that mercury concentrations in pike from the reservoir are significantly higher than in pike from the nearby Oldman River. Mercury concentrations in muscle tissue (0.37ppm to 1.54ppm) generally exceeded the consumption guideline of 0.5ppm total mercury (THg), and were significantly higher (3.5-fold) than northern pike mercury concentrations in the Oldman River. In addition, these levels exceeded (up to 2-fold) previously published data from other reservoirs of the northern hemisphere. Gill-netting followed by stomach contents and stable isotope analysis revealed a very simple food web. No zooplanktivorous fish species were present, and the benthic fish community contained only few white sucker (*Catostomus commersoni*). Thus the reservoir almost completely lacked forage fish, and the pike fed primarily on amphipods (*Gammarus lacustris*, *Hyaella azteca*), whose average mercury concentrations were 0.21ppm. An observed low growth trajectory of northern pike in this reservoir may reflect low growth efficiency as a result of their invertebrate diet.

Poster CCFR (Trophic linkages)

ATMOSPHERIC MERCURY DEPLETION EVENTS: A POTENTIAL SOURCE OF MERCURY TO BIOTA IN THE AMUNDSEN GULF?

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Atmospheric mercury (Hg) depletion events (AMDEs) have been observed to occur in the Arctic during polar sunrise. While some of the mercury (Hg (II)) deposited onto the snow and ice surface has been shown to photo-reduce back to the atmosphere as Hg(0), it is unknown to which extent the AMDE-deposited Hg enters the marine food web.

As part of the International Polar Year (IPY) - Circumpolar Flaw Lead (CFL) System Study, we report here the distribution of Hg in the zooplankton populations in the Amundsen Gulf throughout the 2008 spring-time AMDEs. The purpose of this research is to identify and quantify whether or not atmospheric deposition of reactive gaseous mercury (RGM) is leading to an increase of Hg in the biotic food web. Zooplankton species were sampled in Amundsen Gulf throughout the 2008 spring-time sunrise simultaneously with real time measurements of atmospheric gaseous elemental mercury (GEM), particulate, and RGM. Total Hg (THg), methyl Hg (MeHg), and dissolved GEM in snow, ice, and water were analyzed on board the CCGS Amundsen under clean room conditions (PILMS; Portable In-situ clean room Laboratory for Mercury Speciation).

By comparing the spatial and temporal differences between ice-covered and open-water systems, the relative contribution of AMDE-deposited Hg bioaccumulated at the lower trophic levels of the arctic ecosystem is assessed. Understanding the processes by which toxic contaminants such as Hg are transferred to lower trophic levels in the Arctic Ocean, especially under rapid climate warming conditions, will help to advise remediation and adaptation strategies so as to minimize the adverse impact of contaminants on the health of marine ecosystems and Indigenous People.

Poster CCFR (Arctic resources)

USING A GRADIENT-BASED MIXING MODEL FOR $\delta^{13}\text{C}$ TO ESTIMATE THE TERRESTRIAL CONTRIBUTION TO A TAILWATER FOODWEB DOWNSTREAM FROM THE OLDMAN RIVER, DAM, ALBERTA

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The contribution of terrestrial energy input to stream invertebrates and fish can be estimated from their $\delta^{13}\text{C}$ signatures; however, the approach has often been confounded by overlap between aquatic and terrestrial producer signatures. A gradient-based mixing model can estimate mixture proportions of aquatic and terrestrial inputs as long as the spatial gradients of the two endpoint signatures are distinct, even though endpoint signatures may overlap. The $\delta^{13}\text{C}$ signatures of benthic algae exhibit a strong gradient downstream from the Oldman River Dam, however, signatures of terrestrial plants and insects exhibit little or no signature gradient. The abundance and productivity of benthic algae are very high downstream from the dam, likely reflecting a combined effect of ice-free winter conditions and the nutrient-rich hypolimnetic water released from the dam. The mixing-model results suggest that despite their high abundance and productivity, benthic algae make only a minimal contribution to the signatures of both benthic invertebrates (herbivore/grazers, filter-feeders and collector-gatherers) and benthivorous fish (longnose dace and white sucker). Although consumer signatures along this gradient indicate a strong terrestrial influence, there are few shredders in the benthic community, suggesting that fine particulate matter derived from the riparian flood plain is likely the main energy source driving this tailwater food web. The results also indicate that the algal species that achieve high biomass, at sites immediately downstream of the dam, are of little nutritional value to the primary consumers in this food web.

Poster CCFR (Nutrients)

YELLOW PERCH LARVAL SURVIVAL IN THE WESTERN BASIN OF LAKE ERIE ESTIMATED USING GENETIC ANALYSIS

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Variation in recruitment of Yellow perch (*Perca flavescens*) (YP) is not yet fully understood. The western basin of Lake Erie is an important rearing habitat for YP. The western basin of Lake Erie receives input from two main tributaries (Maumee and Detroit River), that differ greatly in their nutrient and sediment loading. Turbidity and nutrient levels are elevated in the Maumee River plume, and YP recruitment is correlated with Maumee River discharge. The objective of this project was to use population genetic analyses to estimate YP larval survival in the Maumee and Detroit River plumes. We genotype larval and age 0+ YP from the western basin of Lake Erie at 8 microsatellite DNA loci over multiple years. We use those data to; 1) determine genetic divergence between larvae from the two plumes, 2) genetically assign age 0+ juveniles to their original larval plume habitat, and 3) test for a genetic signature of effective population size changes in the two plumes. Based on abundance estimates of the larvae in each plume, coupled with the source determination for the juvenile YP, we estimate first-year survival for the YP from the two larval nursery areas. Preliminary results showed that genetic analysis is a viable tool to estimate survival of yellow perch larvae and that first-year survival of yellow perch is higher in the waters of the Maumee plume. Further analysis will include spatial variation in survival within each plume.

Oral CCFR (Conservation genetics)

EXAMINING ZINC DISTRIBUTION IN OTOLITHS TO DESCRIBE REPRODUCTIVE FAILURE IN LAKE TROUT FROM PIPESTONE BAY, ONTARIO

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Over the last decade a decline in the once renowned lake trout (*Salvelinus namaycush*) population from Red Lake, Ontario has been documented, coincident with an apparent recruitment failure. Since 2001, a collection of spawning assessments, surveys and bioassays directed at their primary breeding shoals on Pipestone Bay have been conducted to assign a causal agent for the ongoing recruitment failure. The Red Lake area has a history of gold mining, and metals associated with gold mining warrant special attention as the driver of low recruitment. A retrospective analysis of zinc (Zn), copper (Cu), cadmium (Cd), manganese (Mn), lead (Pb), and nickel (Ni) in archived lake trout otoliths was performed using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). The aim of the study was to determine if temporal increases in any of these metals was associated with the timing of lake trout recruitment failure. Concentrations for Cu, Cd, Pb and Ni were generally below 6 ppm and Mn concentrations were generally below 10 ppm. Zn concentrations ranged from 5.5 ppm to 92 ppm. Zn distribution patterns were oscillatory and well defined compared to all other analyzed metals. The oscillatory patterns were well defined in the earlier years of lake trout development, however, in later years the oscillations for Zn were unusually abated. This suggests that an episode or environmental disturbance could have occurred, resulting in altered exposure conditions for the lake trout. However, results could also suggest another source of altered exposure such as diet. Previous studies have proposed that Zn can be incorporated into the otoliths as a result of dietary influence.

Poster CCFR (General Session)

FISHING DECISIONS, FISH BEHAVIOUR AND DETERMINING THE SCOPE FOR BYCATCH MITIGATION

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Fishing decisions, such as targeting practices and choice of fishing grounds, affect catch rates and distribution patterns of both retained and discarded catch (bycatch). Commercial fisheries data are used to identify bycatch hotspots, to develop mitigation strategies, and to assess bycatch species' population status. Stock assessments for target species often standardize catch rates to account for regional or targeting differences. However, local differences in catch diversity or temporal changes in targeting decisions, in response to changing regulations and markets, are rarely considered in bycatch species' assessments. Using logbook, fisheries observer and semi-structured interview data, we identify targeting practices, determine associations among retained and discarded species, and investigate effects of regulatory and market changes on fishing decisions, and therefore, the effects on catch rates and distribution patterns of species caught in the Canadian pelagic longline fishery. Interviews with longline fishers not only provided detailed information on fishing decisions, but more importantly, allowed fishers to question fisheries science decisions. Questioning both fisheries scientists' methodologies and fishers' decisions will lead to improved understanding of the fishery and of bycatch mitigation opportunities.

Oral CCFR (Including fishers in fisheries science)

COMPARISON OF ELECTRO-FISHING AND VISUAL SURVEYS FOR THE DESCRIPTION OF FISH ASSEMBLAGES IN LAURENTIAN STREAMS

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We evaluated the relative performance of electro-fishing and underwater visual surveys for estimating the density of combinations of fish species and size classes in rivers. We also assessed the effect of environmental conditions on potential differences between the results obtained using these two sampling methods. Sampling sites consisted in 11 sections of 20 m in length distributed in two watersheds of the Laurentian region of Québec. Both methods were used while river sections were blocked with nets. Visual surveys were performed by 2-3 calibrated snorkellers that swam the river sections upstream while identifying and counting fish of each species and size-classes. Electro-fishing was performed using three passes. Analyses indicate that greater densities of fish were observed by visual counts than by electro-fishing in all environments. We related the ratio of total densities (visual/electro-fishing) to environmental characteristics using regression trees and observed that sites with a riverbed consisting of finer substrate and with slower flow velocities had a ratio closer to 1. When modelling the ratio of total Cyprinid densities (the most abundant family) using the same method, sites with a finer substrate and more branches had a ratio closer to 1. We also modeled the Hellinger distance between fish community structures obtained using the two sampling methods. The results suggest that the Hellinger distance is smaller (communities are less different) in sites with a higher flow velocity. Our results indicate that visual sampling may be more adequate in our systems and that environmental characteristics may affect the difference between the two sampling methods.

Oral CCFFR (Habitat assessment)

DIVERSITY OF LAKE TROUT, *SALVELINUS NAMAYCUSH*, IN GREAT BEAR LAKE, NORTHWEST TERRITORIES: OCCURRENCE OF FOUR SHALLOW-WATER MORPHOTYPES

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Great Bear Lake (Northwest Territories, Canada) is the largest lake within Canada, ninth largest in the world and the most northerly lake of its size. In contrast to other large lake trout lakes, such as Laurentian Great Lakes, the pristine natural environment and largely unimpacted communities of Great Bear Lake facilitate investigations of intra-specific variation. However, little is known of the extent to which lake trout polymorphism occurs in other large northern Canadian lakes, such as Great Bear Lake. Although studies in more southerly and impacted lakes have shown lake trout morphs to be generally segregated by depth, the reported occurrence of multiple shallow water morphotypes of lake trout in Great Bear Lake provides an exceptional system to investigate the origin and the maintenance of sympatric phenotypic diversity in lake trout. For the first objective of this project, we are combining classical morphometric/meristic measures with shape analysis (geometric morphometrics) to quantify morphological differences among the lake trout of Great Bear Lake. Preliminary results suggest the presence of up to four sympatric morphs in the shallow-waters of Great Bear Lake (<30m). Our research will not only advance understanding of sympatric polymorphism in northern lakes, it should also contribute to a comprehensive stock productivity model that will have implications for management.

Oral CCFFR (Arctic resources)

KILLING SEA LAMPREYS TO PROTECT LAKE STURGEON IN THE GREAT LAKES

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Application of selective pesticides, called lampricides, to streams infested with larvae has resulted in effective and sustained suppression of sea lampreys in the Laurentian Great Lakes. The suppression of this primitive, parasitic fish, native to the Atlantic Ocean, has increased survival of native fish and has been a major factor determining the success of restoration efforts. The selectivity of the lampricides and techniques for applying them to reduce the collateral mortality of other fish species has been the focus of intense research and development throughout the half century of stream treatments. Lake sturgeon populations in the Great Lakes have recently been designated as threatened under Ontario's Endangered Species Act and are under consideration for listing under Canada's Species at Risk Act. Like lampreys, sturgeon are phylogenetically primitive fish and, as such, are more sensitive to lampricides than are other teleosts. Efforts to modify lampricide concentrations to protect lake sturgeon allow more sea lampreys to survive and escape to the lakes where they kill more fish, including lake sturgeon. The negative effect of increased mortality of adult lake sturgeon from parasitism by sea lampreys in the lakes outweighs the effects of the limited mortality of larval lake sturgeon that may occur during intermittent treatments of streams with lampricides. Sea lamprey control benefits efforts to restore lake sturgeon by protecting adult lake sturgeon in the Great Lakes.

Oral CCFFR (General Session)

EVALUATING HABITAT COMPENSATION IN THE FRESHWATERS OF NEWFOUNDLAND: WHAT HAVE WE LEARNED?

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Habitat compensation is necessitated when a development project is expected to negatively impact fish habitat. The main goal of any compensation program is to offset the lost 'productive capacity' which stems from the 'no net loss' guiding principle outlined in the *Policy for the Management of Fish Habitat*. In Newfoundland, a number of compensation programs have been the subject to detailed scientific evaluations. An overview of these results will be presented and discussed with respect to the 'no net loss' principle. The lessons learned from these projects, as well as other habitat related research, have lead to some generalizations about habitat population linkages within the freshwater habitats of Newfoundland. These will be outlined to allow a discussion on moving habitat compensation from a purely 'physical habitat' perspective to one that focuses more on 'production'. The change in focus will be necessary as compensation plans become more complicated.

Oral CCFFR (Habitat assessment)

SPATIAL AND TEMPORAL VIRAL DYNAMICS IN LAKES ARE INFLUENCED BY TROPHIC STATUS AND REGIONAL CLIMATIC CONDITIONS

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In lakes, phytoplankton community composition is influenced by physical, chemical and biological variables; these include light, temperature, nutrient concentrations and zooplankton grazing. To assess the role eukaryotic phytoplankton viruses (*Phycodnaviridae*) play in structuring phytoplankton communities, the temporal and spatial variations of these viruses in three lakes in the Experimental Lakes Area, Canada were investigated over the ice-free season of 2004. Viral abundance and richness were determined in Lake 227, Lake 239 and Lake 240. Richness of the Phycodnavirus community was assessed using denaturing gradient gel electrophoresis (DGGE) of algal virus specific (AVS-1 and 2) amplified PCR products. Each lake was distinct in both viral abundance and richness. The eutrophic Lake 227 had substantially higher abundances of viruses ($p < 0.0001$) and overall viral richness than the other two lakes. Among the lakes, there were synchronized temporal patterns in both viral abundance and richness, including an association between viral abundance and chlorophyll *a* concentrations in the spring and early summer. Analyses indicated that the Phycodnavirus communities in the spring and early summer months were richer (14 OTUs) than those present during the fall months (9 OTUs), further suggesting that eukaryotic phytoplankton infections are ecologically important in the spring and early summer. Our data imply that the overall Phycodnavirus community richness is influenced by trophic status; whereas patterns of richness are affected by regional climatic conditions. Since richness can directly affect host-virus interactions, these results have potentially important implications for understanding the influence viruses have on phytoplankton communities.

Oral SCL (General Session)

QUANTIFYING TROPHIC STRUCTURES AND FOOD WEB VARIATION IN PRAIRIE LAKES

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Prairie lakes encompass large gradients for many environmental parameters, including salinity, nutrients, and morphometry, all of which are known to significantly influence food-web composition and species diversity. The goal of this project was to not only determine trophic dynamics that are associated with changes in food-web composition, but also to understand their variations across and within lakes over large environmental gradients in Prairie lakes. Twenty lakes were selected throughout south-central Saskatchewan, representing fresh to hypersaline lakes with high variability in nutrient contents and lake morphometry. Fish, zooplankton, benthos, and water quality parameters were identified, quantified and analyzed for stable isotopes of carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$). Circular statistics were used to quantify the seasonal trophic variation, and community-wide stable-isotope-based metrics were used to investigate among-lake variability in trophic dynamics. Circular statistics revealed systematic changes in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ associated with specific time intervals, as intra-annual variation identified a significant increase in productivity from early to late summer. Community-wide measurements demonstrated that freshwater lakes had greater trophic diversity and increased number of trophic levels, as well as higher trophic redundancy. In contrast, saline lakes lacked any secondary pelagic consumers and showed low trophic redundancy. Salinity was the key environmental parameter in regulating food webs, followed by nutrient availability. Littoral habitats seemed more resistant to the effects of salinity and likely contribute to the resilience of local food webs to changes in salinity.

Oral SCL (Trophic Linkages)

MOVEMENTS OF STREAM “RESIDENT” BROOK CHARR (*SALVELINUS FONTINALIS*) WITHIN AND AMONG LAKE SUPERIOR TRIBUTARIES

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This study investigated the nature of stream residency in migratory populations of brook charr (*Salvelinus fontinalis*) from Lake Superior. Migratory systems can be complex, with individuals differing in their propensity to migrate and the form and timing of their migratory movements. Some populations of Lake Superior brook charr have two ecotypes: a small form that purportedly remains in the stream environment throughout its life and a large ecotype that migrates from the stream to the lake (partial migration). We used electro-fishing surveys and passive integrated transponder tags, and stable isotopic tissue analysis to test whether individuals captured in a tributary remained in that tributary (resident), made diel foraging migrations from the tributary to the lake, or moved from tributary to tributary (vagrant stream specialist). Data analysis from this two year study suggests most tagged individuals remained in the same tributary some moved from the tributary to the lake and returned to the tributary, with few moving between tributaries. This data indicates that the movement ecology of purported stream residents may be more complex and important to the management of Lake Superior brook charr than was previously appreciated.

Oral CCFRR (General Session)

SIGNALLING RESULTS IN SUCCESSFUL SPAWNING OF THE INVASIVE ROUND GOBY

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Fish are known to communicate in many ways and commonly use acoustic, olfactory and visual signals. We present the first report of spawning by the invasive bottom-dwelling Round Goby in the laboratory. Observations of egg deposition, fertilization and parental care were recorded (www.uwindsor.ca/goby). During nest defence, males produced agonistic vocalizations and aggressive displays to dissuade intruders from entering their nests. Inside the nest, males inspected and ventilated eggs, and in some cases, cannibalized eggs. We also investigated the flow field patterns by the nest-guarding male in the lab by describing and quantifying the fanning currents generated by pectoral and caudal fin activity. Using a flow visualization technique, particle image velocimetry, we showed that the male pumped waste water and/or odours out of the nest by repeated tail flippings ($36.7 \text{ mL}\cdot\text{s}^{-1}$) and propagated a current as far as 35 cm from his nest over a surface area of 987 cm^2 with limited vertical (50 mm) propagation. In contrast, pectoral fanning did not result in any outflow from the nest; only weak currents entered the nest. Caudal fanning always followed pectoral fanning. We suggest that male Round Goby use pectoral fanning to stir solid wastes that settled in the nest cavity (i.e. faeces, sediments) and facilitate their transport by the exiting current generated during caudal fanning. We assume that male Round Goby exploit these currents to better “cast” their reproductive scents and attract a larger number of mates.

Oral CCFRR (General Session)

SMALL LAKE SALMONID BIOMASS AND HABITAT RELATIONSHIPS FOR NEWFOUNDLAND LAKES

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Lake morphology and water chemistry were analyzed as predictors of brook trout and total salmonid biomass in waterbodies of Newfoundland. Lake morphology variables included surface area, depth, perimeter and catchment area while water chemistry variables included conductivity, alkalinity, total dissolved solids, and pH. The broadly used Morphoedaphic Index was also assessed. Fish biomass/ha varied by an order of magnitude in the study lakes, despite similar water chemistry. Multiple regression analysis suggested that surface area best explained the variance of both brook trout and total salmonid biomass in the relatively small, unproductive waterbodies of Newfoundland. In contrast, the Morphoedaphic Index performed poorly. The results suggest that biomass relationships with easily measured habitat variables such as surface area provide useful information, especially in management of waterbodies under similar climate and nutrient regimes.

Oral CCFFR (Habitat assessment)

AMERICAN EEL POPULATION GENETICS ASSESSED BY MOLECULAR AND EXPERIMENTAL APPROACHES

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American eel have drastically declined in abundance over the last decades. Population enhancement may help mitigating this decline but the genetic consequences of translocation are poorly documented. In this study, we tested the general hypothesis of panmixia in American and assess the effect of origin and rearing environment on patterns of growth and gene expression. 2600 eels from 35 locations were collected from Florida to Newfoundland with an emphasis on the St. Lawrence water system. Those samples were genotyped at 20 highly polymorphic microsatellite markers. No evidence of genetic differentiation was observed both among locations within life stage and between life stages. We also compared growth patterns in controlled conditions for a period of 30 months between glass eels collected from two locations characterised by distinct sex-ratio at the adult stage. Striking differences in growth was observed between eels from different origins. Finally, we also compared patterns of gene expression by means of microarray analysis between these two groups at two different developmental stages. We observed significant differences in patterns of expression at many genes, both between glass eels in natural conditions collected just prior entry in freshwater and between elvers reared in identical controlled conditions for 7 months. Altogether, these results reveal no population structuring in American eel and yet pronounced quantitative genetic differences in patterns of gene expression and growth. We will propose an explanation for this apparent paradox and discuss the relevance of these results for eel management and conservation.

Oral CCFFR (Conservation genetics)

EFFECTS OF AIRGUN SEISMIC ACTIVITY ON RIVERINE FISHES

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Airguns are commonly used to conduct seismic exploration for hydrocarbons, particularly in marine environments. Little is known regarding the potential impacts to aquatic life, with almost no information available for freshwater systems. A proposal to conduct an airgun seismic program along the Mackenzie and Liard rivers in the NWT led to considerable public concern and prompted the Department of Fisheries and Oceans to initiate a study, in collaboration with academic partners, on potential impacts to fishes. The two-component study was designed to test for impacts on the physiology and behaviour of riverine fishes *in situ*. The physiological component assessed impacts on the hearing of three species of fish after exposure to airgun noise. Fishes were captured, penned, and subjected to airgun noise and their hearing ability was assessed for evidence of hearing loss and recovery. The inner ears of these fishes were subsequently assessed for physical trauma at the cellular level using scanning electron microscopy. To assess behavioural impacts, free swimming fish were observed using hydroacoustics to detect evidence of startle response or herding behaviour when subjected to typical airgun operations. Results indicate temporary hearing loss for some species with evidence of recovery. No evidence of herding behaviour associated with airguns was detected. This information allowed regulators to advise project proponents on the means to mitigate effects on fishes, as well as provided new insights on the effects of sound on fishes in lotic environments.

Oral CCFFR (Habitat assessment)

HEARING ABILITY OF NORTHERN FISHES AND POTENTIAL FOR DISTURBANCE FROM ON-ICE INDUSTRIAL ACTIVITIES

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Fishes living in the far north must endure harsh conditions such as prolonged periods of ice-cover. This same frozen landscape permits access by resource developers, via ice-roads, into remote locations that would otherwise be inaccessible. Resource exploration and development is widespread across the north, with many industrial activities occurring directly on the ice surface. These activities produce sounds that have the potential to disturb overwintering fishes. Acoustic disturbances could be especially important for species such as Burbot (*Lota lota*), which spawn during this ice-covered period. Large data gaps exist regarding the general ecology of fishes in northern environments, with information regarding fish hearing abilities scant, making assessment of possible acoustic impacts difficult. Here, we discuss recent research on the hearing abilities of eleven species of freshwater fish that occur in northern environments, with an investigation of possible ontogenetic shifts for four of these species. Potential impacts due to under-ice anthropogenic noise, typical of northern developments, will be assessed relative to the hearing abilities of these fishes to determine if these noises could impede the ecological function of these species.

Oral CCFFR (Arctic resources)

MONITORING THE DEPTH DISTRIBUTION OF LAKE TROUT IN TWO LAKES WITH DIFFERENT FOOD WEBS

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Acoustic telemetry has become a useful tool for studying spatial behaviour of aquatic organisms. This technique allows continuous tracking and monitoring of fish species through the use of implanted acoustic tags that send depth and/or temperature information to receivers that are deployed in the water bodies and store that information. Recent technological advances incorporate acceleration sensors inside the acoustic tags that measure the acceleration of the fish in two or three axis and report a root mean square of that acceleration. This method offers an additional advantage in studying fish behaviour, as it is possible to correlate the acceleration information with the depth distribution. This study reports the results of the recent use of these tags in studying lake trout (*Salvelinus namaycush*) behaviour in two lakes in the Experimental Lakes Area, Northwestern Ontario, Lake 373 and Lake 626. Lake trout rely on different prey items in each lake: in 373 there are no pelagic fish species, but *Mysis* is abundant and is a primary lake trout diet item; in 626, *Mysis* is absent and lake trout feed on yellow perch. This study was conducted during the month of August, when stratification of the lakes imposes a reduced habitat on lake trout: surface waters are warmer than their preferred temperature and the deeper waters have the lowest oxygen concentrations of the year.

Oral CCFFR (Experimental Lakes Area)

EXTENDING THE LONG-TERM LIMNOLOGICAL RECORD OF REFERENCE CONDITIONS AT LAKE 239: A PALEOLIMNOLOGICAL PERSPECTIVE

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One of the main challenges associated with future climate change is assessing changes in water quantity and quality, as well as changes in terrestrial phenomena, such as fire regimes. These issues are of fundamental importance in north-western Ontario, a transitional region between the arid west and the humid east. Climatically, this region has warmed ~1.2 degrees Celsius since the early 1900s, and model projections suggest that this trend will continue. Long-term limnological research has been ongoing at the Experimental Lakes Area (ELA) in north-western Ontario, and the main reference lake, Lake 239, has been the subject of well documented limnological changes (e.g., decreased DOC, increased water residence times, changes in thermal structure) associated with a drought in the mid-to-late 1980s. To develop a longer-term perspective on changes in lake level and water quality, we have developed a network of surface sediments, near-shore and deep-water cores from Lake 239. The near-shore cores have been used to reconstruct changes in water level, whereas the deep core was used to assess changes in lake production and changes in the terrestrial environment (pollen, charcoal). Over the past ~2,000 years, changes in lake level from the near-shore cores suggest sustained lake levels much lower than today (~2.0-2.5 m lower) as recently as 1500 years ago. Inferred changes in the mid-Holocene include lake-levels that are at least 8 m lower than today (or a ~58% decrease in lake volume). Pollen at this time indicates that the boreal forest became more open with increases in many non-arboreal taxa (e.g., juniper, ambrosia, artemisia), and much greater concentrations of charcoal, and the diatoms indicate that the lake was mesotrophic in comparison to the oligotrophic nature of this lake today.

Oral SCL (Experimental Lakes Area)

RELATIVE IMPORTANCE OF MACROPHYTE COMMUNITY VERSUS WATER-QUALITY VARIABLES FOR PREDICTING FISH ASSEMBLAGES IN COASTAL WETLANDS OF THE LAURENTIAN GREAT LAKES

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Fish have been shown to be sensitive indicators of environmental quality in Great Lakes coastal wetlands. Fish composition also reflects aquatic macrophyte communities, which provide them with critical habitat. Although investigators have shown that the relationship between water quality and fish community structure can be used to indicate wetland health, we speculate that this relationship is a result of the stronger, more direct relationship between water quality and macrophytes, together with the ensuing interconnection between macrophyte and fish assemblages. In this study, we use data collected from 115 Great Lakes coastal marshes to test the hypothesis that plants are better predictors of fish species composition than is water quality. First we use canonical correspondence analysis (CCA) to conduct an ordination of the fish community constrained by water-quality parameters. We then use co-correspondence analysis (COCA) to conduct a direct ordination of the fish community with the plant community data. By comparing the statistic 'percent fit', which refers to the cumulative percentage variance of the species data, we show that plants are consistently better predictors of the fish community than are water-quality variables in three separate trials: all wetlands in the Great Lakes basin (Whole: 21.2% vs 14.0%; n = 60), all wetlands in Lakes Huron and Superior (Upper: 20.3% vs 18.8%; n = 32), and all wetlands in Georgian Bay and the North Channel (Georgian Bay: 18% vs 17%; n = 70). This is the largest study to directly examine plant-fish interactions in wetlands of the Great Lakes basin.

Oral CCFFR (Wetlands)

ROAD DENSITY AS A SIMPLE INDICATOR TO ASSESS HABITAT QUALITY OF COASTAL MARSHES OF THE LAURENTIAN GREAT LAKES

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Using a GIS process we calculated the road density (RD; meters of all roads/ha watershed area) of 59 Great Lakes coastal watersheds that included heavily impacted areas of Lakes Erie and Ontario, and relatively unimpacted areas of Georgian Bay, Lake Huron. RD was an effective measure of human disturbance, as primary nutrients and conductivity increased significantly with RD ($p < 0.05$), both when data were analyzed separately for Georgian Bay and when they were combined with more degraded sites in Lakes Erie and Ontario. Number of exotic fish and plant taxa correlated significantly with RD, as did index scores of three published ecological indices. While RD in Georgian Bay watersheds was on average 6 times lower than RD in the Lower Lakes, a few wetlands with heavy surrounding cottage development showed symptoms of water-quality impairment similar to those in settled areas of the lower Great Lakes. Wetlands showed signs of degradation above a RD threshold of $14 \text{ m} \cdot \text{ha}^{-1}$ and we recommend that this level be used to guide conservation efforts to protect Great Lakes coastal marshes.

Oral CCFFR (Wetlands)

INTERACTIVE EFFECTS OF CALCIUM DECLINE AND RISING TEMPERATURE ON THREE NATIVE DAPHNIA SPP.: AN ECOTOXICOLOGICAL ASSESSMENT

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There is a growing awareness that climate change and declining calcium (Ca) levels are adversely affecting the biota of Canadian Shield lakes, but much uncertainty remains. It is unclear if the effects are linear or non-linear, if taxa have different tolerances, or if Ca and temperature interact. Current knowledge is based mainly on *D. pulex*, a hard water, pond species, and bioassays have been conducted in high conductivity media. These results may be suspect if applied to the soft water lakes of the Canadian Shield. Previous work has determined that the reproductive capacity of *Daphnia pulex* declines with declining Ca levels leading to sharp population crashes and potential extirpation when lake Ca levels fall below 1.5 mg/L. Climate change is an additional stress on *Daphnia* populations, with changes in the timing of ice-out, thermal stratification and summer maximum temperatures all affecting zooplankton community composition. We investigated both thermal and low-Ca thresholds of three native *Daphnia* species at 20, 23, 26, 29 °C, and calcium concentrations of 0.5, 1.0, 1.5, 2.0, 2.5, 5.0 mg L⁻¹ both separately and in a multiple stressor scenario in the lab. Increasing temperature improved the reproductive capacity of *Daphnia* up to 26 °C but reproduction ceased or was severely impaired at 29 degrees. We confirmed the Ca results of earlier work, but with native, pelagic species in soft water assays, i.e. reproduction declined with falling Ca with an approximate 1.5 mg L⁻¹ threshold. Increasing temperature may initially offset the effects of declining calcium levels, but as temperatures continue to increase and as calcium continues to decline, a tipping point may be reached and *Daphnia* may lose their position as dominant pelagic herbivores in the limnetic food webs.

Oral SCL (General Session)

THE USE OF RISK ASSESSMENT ANALYSIS TO IDENTIFY QUALITY AND AT RISK HABITAT FOR THE SASKATCHEWAN RIVERS LAKE STURGEON (ACIPENSER FULVESCENS) POPULATION

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Saskatchewan Watershed Authority completed a survey of the Saskatchewan Rivers in 2008 with the purpose of identifying foraging sites considered valuable to lake sturgeon, and associated fish species. A primary focus of this study was to identify critical sites at risk due to changes in river flow rates. The sturgeon within Saskatchewan's borders is one of the least studied and understood populations in North America. The lake sturgeon has great aesthetic and cultural value, was once an important sport and commercial species but is now endangered or threatened in all areas where it occurs. Recovery of the sturgeon populations to former levels will be a significant challenge requiring an increase in our knowledge of the ecology and biology of the species. The Lake Sturgeon within the Saskatchewan River system is listed as threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and is being considered for listing under the Species At Risk Act. To better understand challenges confronting the Saskatchewan River population, 15 sites were surveyed with respect to flow impact, high quality foraging habitat, and food item abundance (macroinvertebrates). Data collected from the 15 sites were analyzed and added to a risk assessment model to assess which sites were most valuable and at risk. Five sites were identified as sites of interest. In the summer of 2009 these five sites were studied in greater detail to predict flow impacts on foraging resources using River 2D models.

Poster CCFR (Habitat Assessment)

DIEL VERTICAL MOVEMENT AND FORAGING PATTERNS OF CAPELIN (*MALLOTUS VILLOSUS*) OFF THE NORTHEAST NEWFOUNDLAND COAST

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The normal pattern of diel vertical migration (DVM) involves residing in deeper water during daylight and shallower depths at night. Moving into shallow water during dark is thought to increase foraging opportunities without a high predation risk (predator evasion hypothesis). I investigated the DVM and foraging patterns of capelin, the focal forage fish in the Northwest Atlantic. Capelin preys on zooplankton and is in turn preyed on by most large predators, including birds, mammals and fish. A fine-scale study, centered on a large concentration of post-spawning capelin, was conducted August 10-14, 2005. A radial hydroacoustic survey repeated throughout the diel cycle (n=18, 543 km) revealed that capelin underwent a regular DVM pattern; however, some fish did not migrate. Targeted trawls indicated that 89 % of deep (~200 m), daylight tows (n=11) primarily consisted of large (>120 mm) fish, whereas 80 % of shallow (~30 m), dark tows (n=5) and one shallow, daylight tow primarily consisted of small (< 120 mm) fish. Stomach content analysis (n=216 stomachs, 9-15 fish/trawl) revealed that copepods (0.5-3 mm) were numerically dominant in 100 % of the non-empty stomachs of small fish. Copepods also dominated 100 % of large fish stomachs during deep, daylight tows, whereas euphausiids (17–23 mm) dominated 50-100 % of stomachs immediately after dusk and dawn. Euphausiids were present during dark zooplankton tows (0-100 m) but were absent during daylight tows (0-220 m). Overall, larger, more conspicuous capelin appeared to undergo regular DVM to feed on larger prey near the surface at night, whereas smaller, less conspicuous, capelin remained near the surface throughout the diel cycle. This supports the predator evasion hypothesis and suggests that the trade-off between foraging opportunities and predation risk differs for capelin of varying size.

Oral CCFR (Trophic linkages)

SPAWNING HABITAT SELECTION OF CAPELIN (*MALLOTUS VILLOSUS*) IN THE NORTHWEST ATLANTIC

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Capelin (*Mallotus villosus*), the focal forage fish in the Northwest Atlantic, is the major prey item of marine birds, mammals and fish. High-density aggregations of capelin elicit an aggregative response in predators, resulting in the formation of 'biological hotspots', where energy transfer among trophic levels is maximized and, thus, ecosystem processes are maintained. We recently discovered that hotspots on the northeast Newfoundland coast were driven by off-beach (demersal) spawning of capelin, where capelin were thought to primarily spawn on beaches. Together with divergent egg development, larval emergence and morphological traits (e.g. liver mass) of beach relative to demersal spawning capelin, we hypothesized that capelin do not select spawning habitat, but instead represent reproductively isolated subpopulations of obligate beach and demersal spawners represent (H_0). The alternate hypothesis is capelin select spawning habitat in a given year based on physical conditions (H_A). To test these hypotheses, we combined field-based bio-physical monitoring and fish tagging techniques with lab-based common garden experiments and molecular, morphometric and otolith analytical techniques. Acoustic tagging in 2009 revealed that capelin visit both habitat types during one season. Fish sometimes remained at demersal spawning sites for several days but subsequently moved to beach spawning sites where temperatures were more suitable for successful spawning. Although this provides evidence against H_0 , this was the first in 10 years of research that capelin did not spawn at demersal sites in the study area. The Strontium concentrations in the otolith core of beach and demersal spawning fish differ, suggesting that it may be possible to determine whether fish spawned within a habitat type return to spawn in that type (philopatry), a potential mechanism of reproductive isolation. Morphometric characters (e.g. liver mass) differ between the two spawning modes, suggesting that local adaptations to each habitat may be present. Overall, this simultaneous investigation of spawning habitat selection and stock structure of capelin will determine the capacity of capelin populations to respond to and tolerate rapidly changing ocean-climate conditions. With the reliance of top predators on capelin, this will increase our capacity to quantitatively predict the ecological consequences of environmental change at the ecosystem-level.

Poster CCFR (Divergent morphotypes)

EVALUATING CANADA'S SPECIES AT RISK ACT: A CASE STUDY OF THREE SPECIES OF WOLFFISH IN THE NORTHERN GULF OF ST. LAWRENCE

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Three Atlantic species of wolffish – the Atlantic, Northern, and Spotted – are currently listed under the Canadian Species at Risk Act. A common bycatch species, they are now protected in Canadian waters; Northern and Spotted wolffish must be released live and Atlantic are a monitored species. The listing decision was based on scientific data and limited behavioural ecology data derived from the stock assessment process lumped together from waters around Newfoundland, the Gulf of St. Lawrence, and the Scotian Shelf; harvesters' Local Ecological Knowledge (LEK) was not incorporated.

This presentation will review preliminary findings from research in the Northern Gulf of St. Lawrence on the Wolffish listing and subsequent developments. LEK interviews with experienced fish harvesters along Newfoundland's west coast looked at harvester's knowledge of the listing and of Wolffish biology, abundance, and distribution. These were combined with DFO statistical sources and sentinel data to reconstruct trends in Wolffish populations in the Northern Gulf (pre- and post-listing). Preliminary results suggest that most of the study area populations have appeared to remain stable or increasing, both pre- and post- the listing. Distribution in shallow waters has also increased in many areas. This has led to questions about the listing itself by harvesters, and whether or not time and funds should be spent on other species of greater commercial importance. In all study areas there was criticism for the listing of the Atlantic Wolffish; opinions on the Spotted and Northern Wolffish vary as interactions with these species are more variable.

Oral CCFFR (Including fishers in fisheries science)

SYNCHRONOUS RECRUITMENT AMONG BROADLY SEPARATED GEOGRAPHIC STOCK COMPLEXES OF ANADROMOUS ARCTIC CHAR (*SALVELINUS ALPINUS*)

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Annual samples dating to the early 1970's have been collected from arctic char commercial fisheries for 3 geographic stock complexes along the Labrador coast and 4 geographic stock complexes in Wellington Bay (Nunavut). Virtual population analysis (VPA) was used to generate temporal patterns of recruitment of char into their respective fisheries. Recruitment trends spanned a period from the early 1970's to early 1990's. Autocorrelation analysis indicated that recruitment trends of all stock complexes of arctic char were non random. A state space model, the Kalman filter, was used to predict "best estimates" of VPA generated recruitment trends. Cross correlation analysis of smoothed filter estimates indicated that recruitment has been synchronous between Wellington Bay and Labrador coast char populations which are situated approximately 2500 kms apart. The influence of broad scale climate indices (Arctic and North Atlantic Oscillation indices) and degree days on recruitment synchrony was examined by cross correlation analysis of smoothed Kalman filter estimates of recruitment trends and climate trends. In most cases, climate trends were correlated with recruitment trends at lag 0.

Oral CCFFR (Quantitative tools)

DIVERGENT FEEDING TYPES IN LAMPREYS: THE REPEATED EVOLUTION OF NONPARASITISM

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In most lamprey genera, “paired” species exist in which the larvae are morphologically similar but the adults differ dramatically, becoming parasitic on teleost fishes or nonparasitic (i.e. nontrophic) following metamorphosis. Conspicuous morphological (e.g., adult body size, relative eye and oral disc size) and histological (e.g., lack of a functional digestive tract) differences distinguish nonparasitic adults from parasitic forms, and most lamprey taxonomies recognize feeding type as a species-specific characteristic. However, facultative parasitism has been observed in some nonparasitic lamprey species, and molecular data on a number of species show no genetic differentiation between sympatric species pairs. I will discuss the repeated and independent evolution of nonparasitism in different lamprey genera and even within species, the evidence for feeding type plasticity within species, the potential for hybridization between paired species, and whether lamprey pairs should be considered a single species. The tentative answer is that there likely is not a single answer for all lamprey species pairs; different species pairs represent speciation at different stages. Some pairs appear to be distinct species according to both the biological and phylogenetic species concepts (i.e., they are reproductively isolated and show reciprocal monophyly), although each is not necessarily fixed for feeding type. In contrast, other pairs may represent incipient speciation and others yet may be experiencing ongoing gene flow. Parallels are therefore drawn between different lamprey species pairs and the divergent trophic types found in many invertebrate taxa (e.g., echinoids and polychaetes) and other temperate fish species (e.g., benthic and limnetic whitefish and sticklebacks).

Oral CCFRR (Divergent morphotypes)

MITOCHONDRIAL AND NUCLEAR GENETIC MARKERS SUGGEST SEVERAL CRYPTIC BROOK LAMPREY SPECIES (GENUS *LAMPETRA*) ON THE WEST COAST OF NORTH AMERICA

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Several brook lamprey species (i.e., non-parasitic, non-migratory lampreys) have been described in the genus *Lampetra*, but the number appears to be underestimated since many isolated populations are often considered the same species due to their conserved morphology. For example, a single species – the western brook lamprey (*Lampetra richardsoni*) – is commonly thought to occur from Alaska to California. A second species – the Pacific brook lamprey (*Lampetra pacifica*) – was described in 1973, but has since been synonymized with *L. richardsoni*. Mitochondrial DNA sequence data suggest that the Kern brook lamprey (*Entosphenus hubbsi*) also belongs in this genus, but this has not yet been formally recognized. In this study, we compared complete cytochrome b sequences among 42 *Lampetra* brook lamprey populations from Alaska to California (including the type locales for *L. richardsoni*, *L. pacifica*, and *L. hubbsi*). Our results showed that *L. richardsoni* as currently recognized is polyphyletic and genetically very diverse, and we concluded that *L. pacifica* is a valid species and that as many as five cryptic species are present in Oregon and California (e.g., in Kelsey Creek, California, where cytochrome b sequence differed by 8% from *L. richardsoni* from its type locale). Further analysis on the five most divergent brook lamprey populations using sequence data from two additional mitochondrial and two nuclear genes, as well as microsatellite and amplified fragment length polymorphism (AFLP) markers, supported the genetic distinctiveness of these populations. This study demonstrates the importance of using molecular data to help recognize otherwise cryptic taxa in need of conservation.

Oral CCFRR (Conservation genetics)

CONTRASTING EFFECTS OF UREA, NITRATE, AND AMMONIUM ON PHYTOPLANKTON DYNAMICS AND MICROCYSTIN LEVELS IN A EUTROPHIC LAKE.

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Eutrophication of lakes is a widespread problem that reduces aquatic ecosystem integrity and degrades water quality for human use. The role of phosphorus (P) in controlling phytoplankton growth is well known but there is uncertainty surrounding the importance of nitrogen (N) inputs to phosphorus rich systems. To compare the effects of different nitrogen forms on phytoplankton abundance, toxicity and community composition, we conducted replicated mesocosm (3000 L) experiments in a eutrophic lake located in the Northern Great Plains. Experiments were run for three weeks each during July, August and September, and treatments consisted of weekly additions of urea, nitrate, or ammonium (each 6 mg N L⁻¹). Relative to the control, all N treatments increased chlorophyll-a and toxic microcystin levels by 1-3 fold and 1-6 fold respectively. Comparison between treatments revealed that urea amendments produced the highest total biomass and toxin levels, while nitrate additions elevated biomass-specific toxin concentrations in August and ammonium in September. In general, ammonium favoured the growth of chlorophytes and cyanobacteria, while nitrate favoured cryptophytes and diatoms. Urea however, varied seasonally in its effects on the major algal groups. In all cases, high microcystin concentrations were associated with the cyanobacterial genus *Microcystis*. We conclude that N pollution can degrade water quality in P-rich systems by stimulating toxic cyanobacteria, and that the timing and type of nitrogen is important in determining the major algal response. This is particularly important for agricultural areas where fertilization can saturate soils with P, and N inputs have increased 15-fold since 1970.

Oral SCL (Nutrients)

EFFECT OF GLYPHOSATE ON AMPHIBIAN TADPOLE ABUNDANCE IN NORTHERN PRAIRIE WETLANDS

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In the wetland – agriculture landscapes of the northern great plains of North America, minimum tillage farming practices and genetically modified canola production are common. Both require use of glyphosate to control weeds in croplands. Mean catch per effort for wood frog tadpoles was significantly greater in wetlands on organic farms than on farms that use herbicides. Glyphosate was detected less frequently and at substantially lower concentration in wetlands on organic farms compared with farms that use herbicides. For these farms, the correlation coefficient between wood frog tadpole abundance and glyphosate was low but significant. Wood frog and chorus frog tadpole abundance was reduced by up to 74% in wetlands that had glyphosate concentrations 1000 times lower than levels that are known to be toxic to tadpoles. In mesocosm experiments, glyphosate reduced periphyton and phytoplankton production. This toxic effect of glyphosate to primary production may cause a trophic cascade response in wetlands resulting in reduced tadpole abundance. More glyphosate is used throughout the globe than any other pesticide, suggesting that this herbicide may contribute to the global decline in amphibians.

Oral SWS (Wetlands)

THE EFFECTS OF GROWTH RATE, TROPHIC POSITION, AGE, AND SIZE ON MERCURY ACCUMULATION IN ARCTIC CHARR

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Although standard monitoring studies of high Arctic lakes have demonstrated relationships between total mercury (THg) content in Arctic charr and trophic position, size, $\delta^{15}\text{N}$, and age in many populations, the strength of the associations varies by population. Small sample sizes may preclude examination of physiological factors likely to influence THg accumulation rates. Key among physiological considerations is growth rate. The availability of a large ($n > 300$) sample of Arctic charr from Heintzelman lake ($81^{\circ}42'\text{N}$, $66^{\circ}56'\text{W}$) Ellesmere island, Nunavut that included multiple age-classes displaying high variability in within age-class growth facilitated the explicit testing of the growth dilution hypothesis as an explanation of within lake variability in THg measures. Total trace Hg in dorsal muscle tissue was determined using a DMA-80 direct mercury analyser for a stratified sub-sample of the fish displaying differences in growth rate at age. As a secondary line of evidence, information on the trophic position and carbon sources of individuals was obtained from stable isotope analysis of nitrogen ($\delta^{15}\text{N}$) and carbon ($\delta^{13}\text{C}$), and trends in THg within the population with respect to age, trophic position and growth rate were examined. Multi-factor models that included combinations of the measured variables were also considered. Preliminary data indicated a negative correlation between THg and growth rate, a weak positive age-related correlation and no apparent trophic correlation. Multiple regression models including all factors were further tested as a means of determining the relative importance of growth rate, trophic position and age as explanations of within population variation in measured THg tissue concentrations.

Poster CCFRR (Arctic resources)

DISSOLVED OXYGEN DYNAMICS DURING AN EXPERIMENTAL AQUACULTURE OPERATION IN A SMALL BOREAL LAKE: A MODELING APPROACH

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The effects of an experimental rainbow trout aquaculture operation on dissolved oxygen concentrations was studied on a small boreal lake, Lake 375, at the Experimental Lakes Area (ELA), Ontario. From 2003 to 2005, three production cycles of fish were cultured in an open-pen operation during the open-water seasons. Concurrent with the aquaculture operation, mean hypolimnetic oxygen concentrations in September have declined substantially from 4.1 mg/L in 2003 to 1.5 mg/L in 2005. We investigated whether the change in oxygen concentrations during the experiment was related to factors associated with the aquaculture operation (e.g. an increase in decomposing phytoplankton biomass), or to factors associated with physical mixing of the lake. A one-dimensional model was developed to simulate the vertical distribution of dissolved oxygen prior to and during the cage operation. An oxygen sub-model included gas exchange with the atmosphere, primary production and system respiration (i.e. sediment and biota). A thermal/mixing sub-model was calibrated using meteorological data collected at the ELA. Results suggest that decreasing hypolimnetic oxygen concentrations can primarily be attributed to increased sediment oxygen demand and incomplete physical mixing in spring. Impacts of the oxygen depletion in the hypolimnion of Lake 375 may be associated with the decline in *Mysis relicta*, a small crustacean restricted to habitat with oxygen concentrations > 1 mg/L and water temperatures $< 12^{\circ}\text{C}$.

Oral CCFRR (Experimental Lakes Area)

ELEMENTS OF PERSONALITY FORM THE BEHAVIOURAL BASIS UNDERLYING THE PROPENSITY TO DISPERSE IN YOUNG BROOK CHARR

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We tested whether individual variation in dispersal behaviour in young of the year (YOY) brook charr (*Salvelinus fontinalis*) is related to activity during foraging and risk taking, measures reflecting two aspects of personality in this fish. Long standing hypotheses have postulated that dispersal and migration evolve from routine daily activities. Yet, surprisingly little is known empirically about how these behaviours are related, despite considerable interest in linking statistical methods of characterizing dispersal to underlying behavioural mechanisms. The proportion of time individual YOY brook charr spent moving while searching for prey was quantified using focal observations in the field. Individuals were captured and risk taking was quantified by measuring exit times from a refuge into a novel stream environment in the presence and absence of a novel object. Propensity to disperse was measured in a lab apparatus consisting of 15 equal sized, sequential compartments. Markovian movement models were used to test whether individual differences in foraging and risk taking behaviour were useful predictors of dispersal in the lab. Propensity to disperse was linked to risk taking behaviour but, contrary to expectation, individuals that took more time to exit from a refuge exhibited significantly greater dispersal rates than individuals that took less time to exit from a refuge. Overall, our findings suggest that individual differences in risk taking may provide a behavioural mechanism underlying heterogeneity in dispersal rates, while level of activity during prey search and propensity to disperse represent independent forms of movement.

Oral CCFFR (Quantitative tools)

EFFECTS OF DECELERATING AND ACCELERATING FLOWS ON JUVENILE SALMONID BEHAVIOR

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Fish have evolved intrinsic flight responses, allowing preemptive avoidance of potentially threatening situations. To direct downstream migrant fish away from deleterious conditions at dams and other barriers, mechanical devices such as travelling screens and fish bypass systems are often installed. However, field observations suggest that if these structures create areas of rapidly changing velocities, they do not effectively guide the fish. We studied the avoidance behaviour of actively migrating fall Chinook salmon *Oncorhynchus tshawytscha* smolts in controlled experiments of flow decelerations and accelerations. We measured the response velocity and the velocity gradient over body length. While the response velocity varied significantly with flow conditions and increased with increasing water temperature; the median velocity gradient at the instant at which smolts displayed an avoidance response was similar over the range of flows tested. Results from this study present the first quantitative information on the avoidance behaviour of fish to decelerating and accelerating flows and should provide data needed to help engineers and biologists develop effective systems to alleviate anthropogenically altered flow regimes. Furthermore, the devised experimental setup provides a valuable means to test the effects of velocity changes on any downstream migrant fish species.

Oral CCFFR (Habitat assessment)

GENETIC CORRELATES TO GROWTH AND SURVIVAL IN CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*)

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In 1997, a breeding program was established that selected for differential growth and survival in Chinook salmon. This program developed high and low performance strains of offspring which are now in their fourth generation. In 2008, a 7x7 full factorial breeding design was used to create offspring that were homozygous and heterozygous for high (H) and low (L) performance characteristics (HH, HL, LH, or LL). Individuals were measured for fork length and wet weight throughout development and survival was assessed at different stages for stage-specific differences between the strains. Fish were injected with PIT tags before the smolt stage to allow the identification of individuals at subsequent life stages. Results showed a significant effect of female, male, and female-male interactions on both fork length and wet weight, indicating additive, non-additive and maternal effects on these parameters. Offspring genotype (HH, HL, LH, or LL) also had a significant effect on length and weight. Early survival was not significantly influenced by genotype but there may be important maternal effects. Our results suggest that performance indicators of growth have a strong heritable component in Chinook and there is a differential contribution of additive, non-additive, and maternal effects.

Oral CCFR (Conservation genetics)

EFFECTS OF CONTAMINANTS ON FEMALE REPRODUCTIVE TRAITS IN THE BROWN BULLHEAD (*Ameiurus nebulosus*)

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Aquatic ecosystems are highly resilient to environmental stressors such as contamination. Fish communities are often able to thrive in environments exposed to contaminants well above concentrations known to elicit toxic effects in acute laboratory experiments. While the notion of aquatic resilience to contaminants has been widely acknowledged, the mechanisms driving this resilience and whether individuals show evidence of acclimation or adaptation remain to be understood. We used brown bullhead (*Ameiurus nebulosus*), a bottom-dwelling species tolerant to contaminant effects, to examine relationships between contaminant exposure and female reproductive traits. In 2009, we collected and compared ripe eggs from female bullhead from two contaminated and two clean habitats. We measured egg size, fecundity, total carotenoid concentration, and percent lipid concentration and quantified organic contaminants (e.g. PCBs, pesticides) for each individual. In order to assess whether responses to contamination are due to acclimation or adaptation, we compared reproductive traits between individuals caught in 2009 and those caught in 2008 that had been cleared in a clean and novel habitat for one year. This research will help to predict how individuals will respond to future contamination or habitat restoration.

Poster CCFR (General Session)

CHALLENGES IN ESTABLISHING REFERENCE POINTS FOR A PRECAUTIONARY APPROACH IN FISHES FROM THE GENUS *SALVELINUS*

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Canada has adopted a harvest strategy compliant with the Precautionary Approach (PA). The PA establishes caution proportionate to the degree of uncertainty, risk, and reversibility of impacts. Minimum requirements for a PA in Canada are establishing a limit reference point (LRP) and an upper stock reference point (USRP) in relation to a harvest rate. The LRP is intended to constrain harvesting within safe biological limits, while the USRP is intended to meet management objectives. Much of the research on establishing reference points have been done on marine species by modelling biomass and fishing mortality. Fishes of the genus *Salvelinus* are ecologically and economically valuable, and are sensitive to harvesting pressure. Establishing reference points for *Salvelinus* species in most instances will require an unconventional approach relative to most marine fisheries. Challenges in determining reference points include the variation in life-history, and protecting the morphological and ecological types within an aquatic system. An initial step would be to survey the research that have examined limits to harvest or minimum abundance for long-term sustainability which would help formulate potential LRP. Modelling would provide an important method for establishing reference points although robustness of the values may decrease in data-poor situation. The challenges are compounded by the large geographic distribution of *Salvelinus* and the latitudinal cline in biological parameters that influence population growth. Regardless of the challenges, *Salvelinus* species fit well to the PA as conservative reference points would be established for the majority of stocks until more appropriate and robust ones are established.

Oral CCFFR (Arctic resources)

ROLE OF CEPHALOPODS IN THE ARCTIC ECOSYSTEM

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Cephalopods are an important component of global marine ecosystems but have been overlooked in the western Arctic, particularly the Canadian Arctic. They have recently been reported to be an important component of the Arctic food web and *Gonatus fabricii* has been identified as a keystone species acting as both prey and predator for a variety of marine species including commercially and culturally important species like Greenland halibut and Arctic cod. Despite their importance, little is known of the other Arctic cephalopods concerning their biology, stock size and environmental requirements. A recent review (Gardiner & Dick, *in press*) of abundance and distribution data found that cephalopods are prevalent throughout the Arctic Ocean with concentrations in the Canadian Arctic. The most abundant in the Canadian Arctic are *G. fabricii*, *Rossia palpebrosa*, *R. moelleri*, *Bathypolypus arcticus*, *B. bairdii*, *B. pugniger* and *Cirroteuthis muelleri*. Abundance estimates were calculated to determine the cephalopod biomass throughout the Canadian Arctic. Morphometrics and DNA analysis are being used to identify local populations/stocks. Individuals representing four of the most common species were determined to be the largest on record and all were caught within the same small area of Davis Strait. Growth rates of “Canadian” cephalopods are being compared to other known rates from the warmer European Arctic to determine if temperature has any effect on size. Stable isotope and stomach content analyses are being used to determine the trophic position of cephalopods from Davis and Hudson Straits and to compare with data sets from other regions of the world.

Oral CCFFR (Arctic resources)

RESOURCE PARTITIONING, GROWTH AND DISPERSAL DIMORPHISMS

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Two major sources of larval diversity are maternal provisioning of resources (e.g., egg size) and changes in the timing that traits are expressed in development relative to an ancestral state (e.g., heterochrony). Species with a low per-offspring investment often have small, dispersive larvae with morphological traits associated with feeding and dispersal, while species with high per-offspring investment may produce young with accelerated growth, reduced dispersal and earlier metamorphosis. I focus on species that are developmentally variable, specifically those that bet-hedge and produce both dispersive and benthic morphs of young in each spawning event. These young are highly dimorphic in morphology, size, dispersal potential and trophic mode. We have found that the production of alternate phenotypes depends on both differential resource allocation by females and differential use of maternal resources by young. Our hypothesis is that phenotypic dimorphism in young is linked to changes in the timing of common developmental events, and specifically, is based on a de-coupling of differentiation from growth. In 'fast-track' offspring (hatching as dispersive larvae), differentiation occurs early (e.g., functional gut) followed by a prolonged growth period in the plankton. In their larger siblings, growth occurs early but tissue differentiation is delayed until shortly before metamorphosis. This suggests that in benthic offspring, resources are re-directed from tissue formation to growth, overall supporting a rapid onset of adult life. Both field collections and lab culture suggest this dimorphism is maternal in origin, and is not induced by different environmental conditions.

Oral CCFR (Divergent morphotypes)

PATHOLOGICAL ASSESSMENT OF EXPLOSIVE BASED INSTANTANEOUS PRESSURE CHANGE (IPC) ON FISH

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The oil and gas industry exploration in Northern Canada uses explosive-based seismic techniques to locate reserves beneath waterbodies that do not freeze to the bottom. Both industry and regulatory agencies acknowledge that the use of explosives in, or near, waterbodies has the potential to harm fishes, primarily through instantaneous pressure changes (IPC) arising from detonations. These IPCs can damage soft tissues through the rapid compression and expansion of the swimbladder as the pressure wave passes. In Canada, the *Guideline* stipulates that peak pressures not exceed 100 kPa. To simulate seismic exploration activities and examine the potential for trauma at IPCs near the current guideline, a field experiment was undertaken. In the Experimental Lakes Area, Ontario, swimbladder bearing adult lake trout (*Salvelinus namaycush*) and non-swimbladder bearing sculpin (*Cottus cognatus*) were held in cages and exposed to IPCs ranging from 0 to 127 kPa. Fish were later examined grossly and sampled for blood (lake trout) and tissues including liver, kidney and intestine, to determine the presence of any traumatic based pathological changes. Our results indicate the occurrence of altered pathologies in fish exposed to IPCs near the current guideline.

Poster CCFR (Arctic resources)

SPATIAL AND TEMPORAL VARIATION IN BURROWING MAYFLY NYMPHS (EPHEMEROPTERA: *HEXAGENIA LIMBATA* AND *H. RIGIDA*) AFTER RECOLONIZATION OF THE WESTERN BASIN OF LAKE ERIE

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In the early 1990's, burrowing mayfly species recolonized the western basin of Lake Erie after over 30 years of hypoxia at the sediment-water interface. Long-term monitoring of adult mayflies at shoreline areas showed that *Hexagenia rigida* was much more abundant than *H. limbata* during the initial recolonization period, but was gradually replaced by *H. limbata*. We hypothesized that the temporal shift in dominance from *H. rigida* to *H. limbata* would be confirmed by the distribution and abundance of nymphs (distinguished using unique pigmentation patterns confirmed by genetic analysis). We also hypothesized that the distribution of *H. rigida* (the original colonizer) in the basin would shrink and that *H. limbata* would expand. We identified nymphs collected using Petit Ponar grabs each spring throughout western Lake Erie from 1997 to 2004. The relative abundances of *H. rigida* and *H. limbata* nymphs exhibited the same temporal sequence as adults. In 1997 and 1998, *H. rigida* nymphs were most abundant and both species were equally numerous in 1999 and 2000. *H. limbata* then became increasingly dominant, representing 90% of all nymphs by 2004. *Hexagenia rigida* occurred alone at the mouth of the Detroit River and at the eastern edge of the western basin (facilitating distribution among islands), while *H. limbata* now dominates the central region of the basin. Phenotypic measurements revealed that mean body size differed between species (with *H. rigida* being significantly larger). The transition from the dominance of *H. rigida* to *H. limbata* may result from differential competition or growth between species.

Oral SCL (General Session)

DOES LAND USE DICTATE METHYLMERCURY CONCENTRATIONS IN SASKATCHEWAN WETLANDS?

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The production of methylmercury (MeHg), a vertebrate neurotoxin easily bioaccumulated by humans and wildlife, occurs in prairie wetlands across Saskatchewan. Pilot studies performed in 2006 suggest that land use can be a factor in predicting MeHg concentrations in water. In an initial survey examining MeHg concentrations in water in wetlands that tend to dry up by the end of the summer at the St. Denis National Wildlife Area near Saskatoon, we found that water MeHg concentrations were higher in ponds that had intact grassland riparian zones. In contrast, MeHg concentrations in water from temporary ponds that were cultivated to the shoreline using traditional farming methods were significantly lower. Dissolved organic carbon (DOC) and sulphate concentrations were also lower in cultivated wetlands, suggesting that rates of methylation were likely lower. In 2007 and 2008, we expanded our study to three treatments: 1. wetlands where modern pesticide-use agriculture farming occurred to within 1 m of the shoreline, 2. wetlands where organic pesticide-free agriculture farming occurred to within 1 m of the shoreline, and 3. wetlands that had been left in a natural grassland state for five years prior. Concentrations of MeHg in dissolved and particulate phases, DOC and sulphate concentrations, specific UV absorbance (a measure of the quality of the DOC), and basic limnological data (temperature, pH, etc.) were collected from each of three ponds per treatment group. This is the first part of a study that will also be examining MeHg concentrations in aquatic invertebrates and sediments from the treatment wetlands.

Oral SCL (Wetlands)

BACI ANALYSIS REVEALS MINIMAL EFFECTS OF STOCKED TROUT ON NATIVE FORAGE FISH IN BOREAL FOOTHILLS LAKES OF ALBERTA

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For over 100 years, salmonid species have been stocked into North American ecosystems where they are not native. These stockings, however, can have serious negative effects on native invertebrates, amphibians, and forage fishes of receiving waters. Although negative effects often occur in alpine lakes, recent research has suggested only mild effects of trout in productive, lower-elevation lakes.

The objectives of our research were to document effects of stocked trout on native fish communities in productive boreal foothills lakes of western Alberta. We used an asymmetrical Before-After-Control-Impact (BACI) design to determine if dace (*Phoxinus* spp.), brook stickleback (*Culaea inconstans*) and fathead minnow (*Pimephales promelas*) densities and average lengths changed in one lake after stocking relative to three control lakes. Mark-recapture analysis was used to determine dace density while catch-per-unit-effort (CPUE) was used as a response variable for stickleback and fathead minnow due to the low recapture rates for these species. Data were collected three years before and two years after stocking.

BACI analysis revealed no significant effects ($p > 0.05$) of trout introduction on dace density, fathead minnow and stickleback CPUE, and average lengths for all three species. Post-stocking effects of trout on forage fish appear to be minimal during the first two years after stocking in our study lakes, suggesting that the native fish fauna of productive lakes may be largely resistant to negative effects of trout stocking.

Poster CCFR (General Session)

THE COASTAL-ZONE SKATE (*LEUCORAJA* SP) OF THE SOUTHERN GULF OF ST LAWRENCE – AN UNDESCRIBED ENDEMIC?

Hanson* J.M.

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In Atlantic Canada, most marine research surveys do not sample water < 50 m deep. This means that the species of the coastal zone typically are not well studied. Nevertheless, studies by John D. MacEachran and colleagues in the 1970s suggested the population of coastal- zone skate of the southern Gulf of St. Lawrence (sGSL) differed substantially from Winter Skate (*Leucoraja ocellata*) in the rest of its range, and confirmed they were not Little Skate (*L. erinacea*). However, the possibility of an endemic skate in the sGSL was never assessed further by DFO scientists or academics. This study argues that the coastal-zone skate in the sGSL (COSEWIC status of this designated unit: endangered) differs from Winter Skate at the species level. The sGSL coastal-zone skates were sexually mature by 44 cm total length (TL), the smallest female carrying an egg case was 41 cm TL, and the maximum size observed was 62 cm total length (TL). This maximum size is less than length of 50% maturity (72-75 cm TL) for Winter Skate (maximum TL > 110 cm). Because skates practice internal fertilization by means of claspers, mating between the two forms would be all but physically impossible (= reproductive isolation) if the two groups co-occurred; however, the nearest known population of Winter Skate is > 400 km distant from the sGSL (= geographic isolation). In addition, 99% of coastal-zone skates occurred in water < 35 m deep (temperature of 50% occurrence 18.5 C) during summer while Winter Skate typically occurs in water > 110 m deep and at temperatures of 5-7 C (= physiological isolation). The maximum age of the coastal-zone skates was 10 or 11 years (98% were < age 9) compared to a maximum age of > 20 y for Winter Skate. Finally, published studies describe almost 100% separation on two of the 14 morphometric characters examined (vertebral number and tooth row number). The combined evidence strongly supports the thesis that the coastal-zone skate represents an undescribed endemic in the sGSL, and a full taxonomic and genetic evaluation is warranted. While molecular genetic analysis of the presumed Winter Skate populations is underway, the full morphometric analysis needed to describe this likely new species has not yet begun. Unfortunately, the most recent population analysis predicts the coastal-zone skate will be extinct within 10 years unless adult mortality is greatly reduced, and yet this COSEWIC designated unit currently is not protected under the Species at Risk Act.

Oral CCFFR (General Session)

TOTAL PHOSPHORUS AND HYPOLIMNETIC OXYGEN MODELLING IN NORTHERN COLDWATER BAYS OF THE LAKE OF THE WOODS, ONTARIO

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The Lake of the Woods (LoW) is a large (385,000ha), freshwater lake that is located within the boundaries of the provinces of Ontario and Manitoba and the state of Minnesota. The lake's largest tributary, the Rainy River enters the lake at its most southern point, establishing a south to north flow direction. This also results in great spatial and seasonal variability in nutrients and algal productivity in LoW, with a TP concentration gradient, beginning high in the south and decreasing through the main channel towards the north. Therefore, water quality of particular regions in LoW is largely determined by bay morphology and proximity to the main inflow from Rainy River. In the northern sector of LoW, there are several isolated bays that may be particularly sensitive to the impacts of anthropogenic nutrient loading. These areas of the lake have very clear waters and support cold water fish communities, including provincially-significant lake trout populations. Thus, it is important to understand how nutrient loading will change bay water chemistry and fish habitat quality.

Water quality modelling for total phosphorus (TP) and volume-weighted hypolimnetic oxygen (VWHO) of bays in the north end of LoW has been performed. The bays selected for TP and VWHO modelling span a gradient of development, including one site, Clearwater Bay, which has been under a provincial Restricted Area Order since 1991 limiting development on its shoreline. This study aims to develop, test, and perform management scenarios for these three bays using Ontario's Lakeshore Capacity Model, and the Molot et al. (1992) oxygen model, both developed for Precambrian Shield lakes. The models will be used to test the relative sensitivity of these waterbodies to shoreline development in general, and management recommendations will be presented for the continued protection of the water quality and lake trout habitat of these bays.

Oral SCL (Nutrients)

AN ASSESSMENT OF THE SUBSISTENCE MIXED-STOCK FISHERY FOR BROAD WHITEFISH, *COREGONUS NASUS PALLUS*, IN THE MACKENZIE RIVER SYSTEM USING MICROSATELLITE DNA: CONSERVATION IMPLICATIONS FOR SUBSISTENCE FISHERY MANAGEMENT

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Anadromous broad whitefish populations in the Mackenzie River system are extremely vulnerable to harvest, yet it is unknown what the relative contributions are of these populations to the subsistence fishery. We assayed variation at microsatellite DNA and employed mixed-stock fisheries analysis of anadromous broad whitefish in this system to address this gap in information. Our analysis revealed that all source populations contribute to the Mackenzie River subsistence fishery and that there is substantial variation in the contributions depending on harvest location. After combining all subsistence fishery samples, the Peel River was estimated to contribute the most ($52.1 \pm 4.2\%$ S.D.), followed by the Arctic Red River ($25.6 \pm 3.1\%$), and Mackenzie River populations at Fort Good Hope ($17.3 \pm 3.4\%$), and Point Separation ($4.7 \pm 2.1\%$). Additionally, the Peel River contributed an estimated 72% of fish harvested downstream of the Arctic Red River. Although this high Peel River contribution was unexpected for fish harvested at this location, these results, combined with previous otolith microchemistry analysis, suggest the presence of riverine life history in the Mackenzie River that uses the Peel River to spawn. Our results highlight the importance of the Peel River in contributing broad whitefish to subsistence fisheries in this system which will be important for future management and potential habitat protection strategies.

| Oral CCFFR (Conservation genetics)

THE INFLUENCE OF CIRCULATING BLOOD PHYSIOLOGY ON MIGRATORY BEHAVIOUR AND FATE OF AN IMPERILED STOCK OF CHINOOK SALMON

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To successfully navigate through a range of demanding environments on their way to natal spawning grounds, Pacific salmon must be in good physiological condition. In 2008 and 2009 we sampled summer-run Chinook salmon from the Puntledge River on Vancouver Island, British Columbia, a stock that has declined to less than 500 returning adults. The stock must migrate through a reach of river that is influenced by a hydropower installation and associated low water levels and there was an interest in determining the relationship between fish condition and their migration success. Fish were intercepted as they returned to the river to spawn at which time they were radio-tagged and biopsied to enable physiological analysis of the blood. Using a principal component analysis, we found that endogenous stores of energy influenced migratory success. The results are framed in the context of understanding the nexus between organismal condition and behaviour of an anadromous fish species in a hydropower impacted spawning river. Moreover, such data provide context regarding the condition of fish as the return to the river but prior to encountering hydropower infrastructure. This paper represents one of the first to use the “field physiology toolbox” to evaluate how individual fish respond to hydropower infrastructure and operations.

Oral CCFFR (General Session)

RECONSTRUCTING THE TROPHIC HISTORY OF LAKE SIMCOE, ONTARIO: A PALEOLIMNOLOGICAL STUDY OF A MULTIPLE STRESSOR SYSTEM

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Lake Simcoe, one of the largest inland lakes in Ontario, is a popular cottage destination and supports a thriving recreational fishery. Water quality has become a concern as phosphorus loading from the surrounding rural and urban sources has increased dramatically in the last century resulting in excessive algal growth. As a consequence, depletion of deep-water oxygen levels has led to fish recruitment failures. Although recent remediation efforts have resulted in reductions in the total phosphorus (TP) lake load beyond the target of 75 t/yr, the aforementioned problems persist. This suggests that other factors may be contributing to Lake Simcoe water quality problems, such as species invasions and climate change. Interactions among these multiple stressors may result in cumulative impacts creating challenges for lake and watershed management. To address these challenges, long-term data are necessary to understand the pre-disturbance conditions for Lake Simcoe and how conditions have changed over time. This paleolimnological study will examine changes primarily in sub-fossil diatom assemblage composition over the last ca. 150 years from a suite of ²¹⁰Pb-dated sediment cores retrieved from key locations in this large lake. These high-resolution data provide evidence that changes in lake water quality are consistent with recorded changes in land-use practices in the catchment, including turn of the century canal construction, agriculture, cottage and urban development and more recent phosphorus remediation efforts. Diatom-inferred trophic changes will be compared to trends in deep-water oxygen levels inferred from sub-fossil chironomid assemblages.

Oral SCL (Nutrients)

IF YOU BUILD IT, WILL THEY COME (OR STAY)? SUMMARY AND ASSESSMENT OF GREAT LAKES AQUATIC PROTECTED AREAS

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Fishes and their habitats receive various levels of protection at sites throughout the Laurentian Great Lakes. Ecosystem-level management strategies can use Aquatic Protected Areas to buffer against over-exploitation and uncertainty in population assessments and ecological understanding, and to protect aquatic habitats. Given current levels of decline in freshwater fish biodiversity and the relative importance of habitat loss in the imperilment of many fish species in and around the Great Lakes, the appeal of precautionary ecosystem-level management is increasing. To determine the types and amounts of protection afforded to fishes and their habitats, we created an inventory of Aquatic Protected Areas in the Great Lakes and connected waters used by Great Lakes fishes, including sites in both Canada and the U.S. Latitudinal trends in the size and number of Aquatic Protected Areas were apparent, with fewer, larger sites being established at higher latitudes. The relative effectiveness of different types of Aquatic Protected Areas for fish management and conservation was examined using time series data, and by comparing temporally coincident communities within and outside APAs. Fish biodiversity was typically higher within areas that permanently protect fish habitats, although a latitudinal trend in species richness was also apparent. Finally, a Gap Analysis was conducted to identify species and habitats that are currently under-represented within the current Aquatic Protected Areas network.

Oral CCFFR (Habitat assessment)

GENETIC COMPATIBILITY AND MATE CHOICE FOR JACK VERSUS HOOKNOSE MALE CHINOOK SALMON

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Mixed-milt fertilization is employed by several fish hatcheries, even though it can contribute to artificial selection of particular life history traits over many generations. This selection is the result of competition between the sperm of multiple males and/or female cryptic choice. We examined sperm competition in Chinook salmon, and ran *in vitro* fertilization experiments to investigate sperm competition between jack and hooknose males. The study utilized a 5 x 5 spawning design in which the eggs of each female were combined with a milt mixture consisting of equal proportions of jack and hooknose male sperm. Using microsatellites for parentage analysis we found that a higher proportion of eggs were fertilized by jacks than hooknose males, as well as evidence for maternal effects. Here we investigate whether the differential fertilization success is driven by variation in genetic compatibility between the ova and sperm. Several studies have suggested that the major histocompatibility (MH) genes influence fertilization success so sequences obtained from the major histocompatibility (MH) class I and class II genes were used to genotype the 25 half-sib families. If certain alleles/genotypes occur at a higher frequency in jack-sired offspring than hooknose-sired offspring, this could provide evidence of MH influence in fertilization success. Furthermore, this would support the claim that increased genetic oversight in hatcheries would be beneficial in order to minimize genetic change, especially in the MH genes which contribute to the overall survival of the organism.

| Oral CCFFR (Conservation genetics)

EFFECT OF VARYING FAMILY SURVIVORSHIP ON EFFECTIVE POPULATION SIZE (N_e) OF CAPTIVE SALMONID BROODSTOCKS

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Maintaining the genetic health and adaptive capacity of captive breeding populations is a key element of many conservation and restoration programs. In Ontario, hatchery broodstocks are used for the rehabilitation and supplemental stocking of economically important species. Maximizing N_e in captive populations is essential for the promotion of high levels of adaptability, future viability and persistence through a strong genetic base. Common broodstock management practices estimate N_e based exclusively on sex ratio and numbers of breeding adults. Data collected for this study provided a unique opportunity for calculating N_e by assessing variation in family representation (N_{ev}). Using three captive strains of lake trout (*Salvelinus namaycush*) and two strains of brook trout (*S. fontinalis*), comparisons were made between N_e and N_{ev} values based on demographic data. The results showed that N_{ev} values can be extremely low (0.19, 0.25, 0.26 and 0.37 in four strains of hatched fry) with highly variable N_e / N_{ev} ratios (0.88, 1.45, 1.29 and 0.65 in four strains of mature adults). As variance in family representation is not considered, estimates of N_e based on the numbers of breeders may be inflated in typical broodstock management procedures. As N_{ev} values are not typically calculated in broodstock management hatcheries, this variation is never detectable. This finding may warrant family tracking in broodstock hatcheries which have naturalized population goals.

Poster CCFFR (General Session)

INBREEDING AND OUTBREEDING DEPRESSION IN ENDANGERED POPULATIONS OF ATLANTIC SALMON

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The loss of within-population genetic diversity and occurrence of inbreeding depression can increase the risk of extinction of small populations. Introductions of individuals from neighbouring populations can sometimes increase the average fitness (e.g. through heterosis) or cause further fitness losses (e.g. as a consequence of outbreeding depression). The negative consequences associated with inbreeding depression and the loss of within-population genetic diversity may be similar in scope to those associated with outbreeding depression. A key question is whether the costs of outbreeding depression outweigh the potential benefits of introductions resulting in heterosis. Here, inbred and outbred crosses were generated, using three neighbouring endangered Atlantic salmon (*Salmo salar*) populations. The offspring were released into the wild environment in a reciprocal transplant designed to test for outbreeding depression and inbreeding depression. There was consistent evidence for outbreeding depression by the loss of local adaptation and inbreeding depression in one population (Economy River) and there was among-site variability in the responses documented within two other populations (Great Village and Stewiacke Rivers). There was also evidence of outbreeding depression by breakdown of co-adapted gene complexes for one second-generation hybrid cross in the wild environment. The findings reported here suggest that salmon populations can be locally adapted at small spatial scales and that the fitness consequences resulting from genetic interactions between population pairs cannot readily be predicted.

Oral CCFFR (Conservation genetics)

MODELLING THE UPTAKE OF NEWLY-DEPOSITED MERCURY BY YELLOW PERCH (*PERCA FLAVESCENS*)

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Linking the transformation and movement of newly-deposited inorganic mercury (HgII) to methylmercury (MeHg) levels in fish has proven challenging due to the large amounts of ambient mercury (Hg) present in aquatic ecosystems. Over a period of 7 years (2001-2007), isotopically-enriched Hg (²⁰²Hg) was added annually to a small boreal lake as part of a whole-ecosystem experiment (METAALICUS). Water, zooplankton, and yellow perch (*Perca flavescens*) were sampled monthly during the open water season and ambient and isotopic MeHg concentrations were determined. Stomach content analyses revealed that zooplankton constituted >80% of age-0 yellow perch diet. Two bioenergetics models (Wisconsin Fish Bioenergetics 3.0 and OneFish) were used to predict growth and MeHg levels in fish. The Wisconsin model assumes all fish Hg uptake is from diet, whereas the OneFish model includes uptake from both food and water. Model simulations were performed using empirical fish growth rates, water temperatures, fish diet composition, and prey Hg concentrations. Both models predicted fish growth patterns accurately, but muscle ²⁰²MeHg levels in the fish tended to be equal to or less than the observed levels. Additional uptake of mercury from water, incorrect assimilation efficiencies, or inaccurate zooplankton energy densities may account for these discrepancies. This study highlights the strengths of investigating Hg dynamics using ²⁰²Hg and provides support for evaluating Hg bioenergetics models in a natural setting.

Oral CCFR (Experimental Lakes Area)

RELATIVE UPTAKE OF DIETARY AND WATERBORNE MERCURY BY YELLOW PERCH

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Current bioenergetics models indicate that the majority of methylmercury (MeHg) in fish originates in their food; however, the quick exchange of mercury between water and zooplankton make it difficult to measure the relative contributions of these sources to fish MeHg levels. We conducted a controlled field experiment to quantify the uptake of mercury from ingested and aqueous sources by young-of-year yellow perch (*Perca flavescens*). Perch were collected from a lake with low mercury levels and housed in fiberglass tanks (160 L) containing one of four treatments: clean water + clean food; clean water + spike food; spike water + clean food; spike water + spike food. For the “spike” exposures, water and zooplankton were collected from a lake that had received ²⁰²Hg-enriched additions for seven years (2001-2007) during a whole-ecosystem experiment (METAALICUS). A nearby lake that had not received any ²⁰²Hg was sampled for the “clean” resources. Fish were sacrificed after four weeks of exposure and muscle tissue samples were analyzed for HgII and MeHg. Concentrations of ²⁰²Hg in fish from the treatments with only one source of ²⁰²Hg were additive and together approximated the concentrations of ²⁰²Hg in fish that received it from both sources. Total uptake of ²⁰²Hg from water accounted for 15% of the ²⁰²Hg in the fish. This study provides support for increasing the contribution of aqueous mercury to fish contamination in existing Hg models.

Poster CCFR (Experimental Lakes Area)

A COMPARISON OF PLANKTONIC PHOSPHORUS REGENERATION RATES IN MARINE & FRESHWATER ECOSYSTEMS

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Planktonic nutrient regeneration is a fundamental process that maintains most of the primary productivity in marine and freshwater environments. Although a predictive model that describes the pattern and efficiency of phosphorus cycling has been recently published for lakes, a similar empirical model does not exist for P-limited marine systems. Planktonic regeneration rates were obtained from marine studies that used a diversity of methods in different environments (e.g., Mediterranean Sea, North Atlantic Ocean, and South Pacific Ocean). The range in marine planktonic regeneration rate was 1-25 pM P/min. When regressed along a trophic gradient (measured as particulate P in each system), regeneration rates were well described by a linear model ($\log \text{regeneration rate (pM P/min)} = 0.87(\log \text{particulate P (pM)}) - 3.28$, $n = 25$, $R^2 = 0.77$). The empirical models of both marine and freshwater systems (freshwater, $\log \text{regeneration rate (pM/min)} = 1.17(\log \text{particulate P (pM)}) - 4.94$) revealed differences and similarities in rates along the trophic gradient. Temperature differences in the marine rates were considered in order to reconcile both models.

Oral SCL (Nutrients)

A LIMIT REFERENCE POINT FOR FISHERIES-INDUCED EVOLUTION

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I examined how the fitness (r) associated with early- and late-maturing genotypes varies with fishing mortality (F) and age-/size-specific probability of capture. Life-history data on Newfoundland's northern Atlantic cod (*Gadus morhua*) allowed for the estimation of r for individuals maturing at 4 and 7 yr in the absence of fishing. Catch selectivity data associated with four types of fishing gear (trap, gillnet, handline, otter trawl) were then incorporated to examine how r varied with gear type and with F . The resulting fitness functions were then used to estimate the F above which selection would favour early (4 yr) rather than delayed (7 yr) maturity. This evolutionarily-sensitive threshold, F_{evol} , identifies a limit reference point somewhat similar to those used to define overfishing (e.g., F_{MSY} , $F_{0.1}$). Over-exploitation of northern cod resulted in fishing mortalities considerably greater than those required to effect evolutionary change. Selection for early maturity is reduced by the dome-shaped selectivities characteristic of fixed gears such as handlines (the greater the leptokurtosis, the lower the probability of a selection response) and enhanced by the knife-edged selectivities of bottom trawls. Strategies to minimize genetic change are consistent with traditional management objectives (e.g., yield maximization, population increase). Compliance with harvest control rules guided by evolutionarily-sensitive limit reference points, which may be achieved by adherence to traditional reference points such as F_{MSY} and $F_{0.1}$, should be sufficient to minimize the probability of fisheries-induced evolution.

Oral CCFFR (Quantitative tools)

PALEOLIMNOLOGICAL INVESTIGATION OF TEMPORAL AND SPATIAL CHANGES IN WATER QUALITY IN LAKE OF THE WOODS, ONTARIO

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Lake of the Woods (LoW) is a large (~385,000 ha area), international waterbody shared between Ontario, Manitoba, and Minnesota. It is a hydrologically and morphologically complex lake consisting of hundreds of interconnected basins and thousands of islands. Activities within its very large catchment make the lake highly susceptible to anthropogenic impacts. Collectively, these characteristics present unique challenges for lake ecosystem managers when assessing the impacts of multiple stressors, such as climate change and eutrophication. In recent years, there have been reports that the northern regions of LoW have experienced increases in the frequency and intensity of late-summer cyanobacterial blooms. There is a common perception that these blooms are linked to increasing nutrient concentrations, particularly phosphorus. In order to effectively address these concerns, it is important to establish what the 'natural' or baseline conditions of LoW were prior to human impacts. In the absence of long-term monitoring data, paleolimnological techniques provide a useful tool for inferring pre-industrial lake-water conditions. Diatom assemblages will be analyzed in three high-resolution, ²¹⁰Pb-dated diatom profiles from sites along a gradient of shoreline development pressure. Comparisons in the timing and nature of species assemblage changes among these three distinct bays will offer insights into the impact of human disturbance on water quality. A diatom-based inference model will be applied to quantitatively estimate historical trends in lake-water phosphorus concentrations over the last ca. 200 years. Changes in diatom species assemblages will be examined in the context of substantial temperatures increases in this region and recent escalations in cottage development. Together these data will provide important insights into the impacts of multiple stressors in this complex aquatic ecosystem.

Oral SCL (Nutrients)

EFFECT OF DIET SHIFT ON THE ALLOMETRY OF ENZYMATIC ACTIVITY IN FISHES FROM A SHALLOW FLUVIAL LAKE

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Maximal activity of lactate dehydrogenase (LDH) in the axial musculature of fish has been suggested to be related to foraging behaviour and associated activity costs. LDH activity has mostly positive linear allometry during ontogeny; however, following a diet shift, LDH activity has been noted to decline, creating a breakpoint in the linear relationship. We sampled 1917 fish, representing 16 species, from shallow fluvial Lake St. Pierre in the St. Lawrence system and tested for the occurrence of a diet shift in the presence of a breakpoint in enzymatic allometry. Piecewise regressions showed that breakpoints were present for brown bullhead, emerald shiner, pumpkinseed sunfish, and yellow perch. Gut content analyses of fish at either side of the breakpoint showed that a diet shift occurred within the confidence interval of body size associated with the breakpoint. Our results suggest that bilinearity in the allometry of LDH activity can arise from a diet shift. The reduction in slope of LDH activity is likely related to changes in foraging tactics and energy use that accompany diet shifts.

Oral CCFFR (Quantitative tools)

PLASTICITY IN ENERGY ALLOCATION OF YELLOW PERCH (*PERCA FLAVESCENS*): COMPARISONS BETWEEN STUNTED AND NORMAL-GROWING POPULATIONS

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Seasonal changes in body composition (carcass, liver, gonads, gastrointestinal tract) and energy content of a stunted (mean length at age 5: 13.5 cm) and a normal-growing (21.8 cm) population of yellow perch were studied in two central Alberta lakes. Stunted perch started to allocate resources into reproduction at a younger age, at a smaller size, and at a lower body energy density (kJ/g) than normal perch. Energy densities of mature fish were approximately 10% and 15% lower in stunted females and males, respectively, while the seasonal density pattern was similar for each sex in both populations. Stunted perch that showed no gonadal development in late summer (immatures) had failed to significantly increase body energy density over the growing season. All differences in body energy density between the two populations could primarily be attributed to smaller intestinal fat deposits in stunted perch. Female (26.1%) and male (9.8%) gonads at the time of maximum development represented significantly more of the total body energy content in stunted perch than in their normal-growing conspecifics (17.9 % and 4.2%, respectively). Stunted perch allocated between 12.7% (males) and 35.2% (females) of all surplus energy into reproduction over their average life expectancy, compared to 7.6% and 24.1%, respectively, for normal-growing males and females.

Oral CCFFR (Divergent morphotypes)

DIFFERENCES IN CRUSTACEAN ZOOPLANKTON SEDIMENTARY ASSEMBLAGES FROM LAKES OF THE BOREAL SHIELD ACROSS A NARROW Ca GRADIENT

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There is growing interest in the direct and indirect impacts of declining lakewater calcium (Ca) concentrations on softwater regions such as the Canadian Boreal Shield, regarding both the impacts upon Ca-demanding flora and fauna with high Ca requirements, as well as the implications for recovery from acidification. The crustacean zooplankton may provide a particularly useful paleolimnological indicator for examining long-term changes in lakewater [Ca] due to their direct dependence on Ca as a structural element within their carapace. Differences in Ca content vary widely among crustacean zooplankton taxonomic groups, and these differences may be used to address the question of how ongoing Ca decline has transformed crustacean zooplankton communities in softwater lakes. However, relatively little is known regarding threshold Ca tolerances for all but a few species. To date, paleolimnological studies examining crustacean zooplankton microfossils on the Canadian Shield have used broad environmental gradients with, at most, a few data points from lakes near or below [Ca] fitness thresholds for large Ca-rich species such as *Daphnia pulex*. Here, we present zooplankton microfossil assemblages from a set of 36 headwater lakes in the Muskoka-Haliburton region of Ontario (Canada) across a narrow Ca gradient that encompasses thresholds of reproductive success for *D. pulex*. By examining differences among zooplankton communities, both within surface sediments and also from pre-industrial times, we add to our understanding of how these communities have responded to reduced Ca availability.

Oral SCL (General Session)

SEX-BASED DIFFERENCES IN ISOTOPIC RATIOS OF NORTHERN FISHES

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Stable isotopes are commonly used to characterize trophic relationships in freshwater food webs. Variability in isotope compositions among individuals within fish populations is often high, and this may obscure patterns at higher levels (e.g., among populations, among species). Some of this inter-individual variability is believed to reflect size-based differences in trophic ecologies but sex-based differences may also play a role. Males and females may vary in a number of ecological and physiological respects that could lead to divergence in their isotopic signatures. We compared isotopic compositions ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) between mature males and females from 20 populations representing seven species of northern freshwater fishes. Sex-based differences were assessed while accounting for covariation due to body size and tissue composition (lipid content, inferred from C:N). Body size and tissue composition generally accounted for greater amounts of variability among individuals than did sex, and body size effects were highly variable both among species and populations. Significant sex-based differences were evident in some populations though the nature of the effect was not consistent. Isotopic compositions differed between the soma and ova of mature females in some species, suggesting that fractionation associated with vitellogenesis may contribute to the observed sex-based differences.

Oral CCFR (Trophic linkages)

PATTERNS OF BYTHOTREPHEs LONGIMANUS DISTRIBUTION RELATIVE TO NATIVE MACROINVERTEBRATES

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As exotic species are introduced and spread across a heterogeneous landscape, the density and richness of potential competitors they encounter will vary. *Bythotrephes longimanus* is an exotic predatory zooplankton, which was inadvertently introduced into the Great Lakes in the 1980s and has since been spreading throughout inland lakes of the Canadian Shield. Little is known about its interactions with native predatory macroinvertebrates (e.g., *Mysis*, *Chaoborus*), which could be playing a role in limiting the establishment and spread of *Bythotrephes*. A first step in examining the potential interactions involves gaining an understanding of the spatial distribution and extent of co-occurrence and overlap both across and within lakes. An 80 lake survey was conducted in the summer of 2007 to obtain macroinvertebrate abundances across invaded and non-invaded lakes. A subset (15) of these lakes was surveyed more intensively to obtain stratified daytime and nighttime distributions of the organisms. Overall we found that co-occurrence of *Bythotrephes* with native macroinvertebrate predators is widespread across lakes. We also found changes in the relative abundance of *Bythotrephes* throughout the lake strata when native macroinvertebrate densities increased, suggesting that there may be important interactions between the species. The underlying mechanisms of these distributional shifts remain unclear; however, we are conducting experiments that may help us to understand some of the important factors.

Oral SCL (General Session)

THE RELATIONSHIP BETWEEN CLIMATIC VARIABLES AND PHYTOPLANKTON COMMUNITY STRUCTURE IN A SMALL BOREAL SHIELD LAKE

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The Experimental Lakes Area has accumulated a 40 year limnological record on a suite of long term reference lakes dating back to 1969. These lakes are in a pristine environment and are subjected to the same climate. Data from the ELA meteorological site indicate that the region has gone through several climatic regimes over the period of record. During the 1970's the climate was wet and cool, followed by a warm drought period through the 1980's that saw a 2 °C increase in lake surface temperatures coupled with increased light transmission. Through the 1990's the climate was wetter and cooler followed by a period of wet and warm through the 2000's.

Phytoplankton community structure was one of the biological variables studied over the 40 period. Changes observed in both phytoplankton biomass and composition were related to climatic variables such as temperature and precipitation. These climatic variables altered hydrological processes that in turn influenced inputs of major nutrients and affected the limnological structure of the lakes.

During the initial study years (1969-1979), a wet and cool period, phytoplankton biomass was low and dominated solely by chrysophytes. However, during the drought biomass increased by > 3 times, due to an increase in mixotrophic species (chrysophytes and dinoflagellates). Following the drought (1989-99), a period that was wet and cool, biomass decreased to values similar to the 1970's. Phytoplankton biomass was again elevated from 1999-2003 as lake surface temperature increased.

The data support using algal population responses as indicators of climatic variability.

Oral CCFR (Experimental Lakes Area)

EFFECT OF AGE TRUNCATION ON RECRUITMENT AND POPULATION SIZE ACROSS TAXA

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The attainment of sustainable fisheries remains a major challenge nationally and internationally. Numerous populations have been over-fished, leading to population collapses and, not uncommonly, minimal recovery despite reductions in fishing mortality. Traditionally, fisheries science has treated all spawning individuals as being equivalent, using stock assessment methods that assume no difference in the reproductive fitness of harvested and unharvested fish. Concerns have been raised that commonly employed harvest strategies selectively remove individuals with above average reproductive value, leading to detrimental changes in individual fitness (through changes in life history) and reductions in maximum per-capita population growth (r_{max}). The effects of selective harvesting on r_{max} almost certainly differ among species with different life histories, e.g. long-lived, bet-hedging species may be more sensitive to selective harvesting than species with shorter lifespans. Harvesting strategies commonly target the largest individuals in a population. In long-lived species, this can result in a significant age and size truncation and this has been hypothesized to cause changes in the timing of spawning, reductions in egg size, and increased variability or reductions in larval survival. A meta-analysis is used to determine how various indices of variation in age structure in a population are related to population size and recruitment. This analysis shows general patterns across taxa in which there is truncation in age structure as population size declines, and suggests that age truncation may be adversely influencing subsequent recruitment and per-capita growth rates in some species.

Poster CCFR (General Session)

EUTROPHICATION, ALGAL MICROFOSSILS AND CYANOBACTERIA IN CENTRAL CANADIAN LAKES

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Short sediment cores from Lake Winnipeg (LWPG) Manitoba, Lake of the Woods (LOW) and L227, Experimental Lakes Area are all located in central Canada. Cores from these lakes were analyzed for chemical composition and algal remains including both soft tissue non siliceous and siliceous microfossils. Cores were dated using ²¹⁰Pb and ¹³⁷Cs methods. This analysis focuses on the distribution of cyanobacteria remains (akinetes, sheaths and sometimes entire mucilage of colonies), chlorophyte remains and dominant planktonic diatom assemblages in the cores related to climate change, artificial and anthropogenic eutrophication. Changes in assemblage composition of microfossils in the cores examined indicate an increase in lakes trophic levels beginning in the mid 60's in LWPG, mid 70's and 80's in LOW (area dependent) and post 1969 in L227. Significant shifts in cyanobacterial akinetes (Anabaena vs. Aphanizomenon). The Lake 227 core history of both non siliceous and siliceous microfossils correlates very nicely with the plankton record post 1969 depicting the experimental changes in the additions of nitrogen and phosphorus. This study documents the sensitivity of both small and large water bodies to nutrient additions including natural (climate driven), cultural or experimental eutrophication.

Oral SCL (Nutrients)

ASSIMILATION OF FRESHWATER SALMONID AQUACULTURE WASTE BY NATIVE AQUATIC BIOTA

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An experimental finfish aquaculture farm was operated in a small lake at the Experimental Lakes Area in northwestern Ontario, Canada. In this study, we used the distinct and enriched carbon and nitrogen isotope ratios ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) of rainbow trout (*Oncorhynchus mykiss*) feed and waste to determine whether the operation provided a novel source of energy for native biota. For 1 year prior to and for 3 years during the cage culture, we collected littoral, pelagic, and profundal invertebrates and minnows from the experimental and reference lakes. In both the second and third years of aquaculture, there was an increase in $\delta^{15}\text{N}$ of all organisms sampled in the experimental lake; mean $\delta^{15}\text{N}$ values of littoral, pelagic, and profundal invertebrates and minnows shifted towards the signature of the fish feed by up to 4.2‰. Increases in $\delta^{13}\text{C}$ of up to 2.6‰ were observed in *Mysis*, profundal chironomids, and minnows but not in littoral invertebrates or zooplankton. Aquaculture waste became a progressively more important component of minnow diets over the course of this study. The dissolved and (or) particulate wastes of the cage operation became a novel source of energy for the native biota in this experimental lake.

Oral CCFFR (Experimental Lakes Area)

ADAPTATIONS TO SEASONALITY: ENERGY ALLOCATION STRATEGIES IN JUVENILE RAINBOW TROUT IN WHOLE-LAKE EXPERIMENTS

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Understanding energy allocation tradeoffs, particularly between soma and storage in juveniles, is essential for explaining growth and survival patterns of organisms experiencing size-dependent predation in a seasonally harsh, resource-limited environment. Juvenile rainbow trout (*Onchorhynchus mykiss*) exhibit a distinct shift from somatic growth, in order to escape gape-limited predation, to lipid accumulation for over-winter survival and thus show a quantifiable strategy in managing energy allocation tradeoffs. Whole-lake experiments in south-central British Columbia were used to determine how the interaction between genetics and the environment influences first year growth and survival mediated by energy allocation tradeoffs in juvenile rainbow trout. These small lake ecosystems exert contrasting selective pressures, varying in productivity, altitude and growing season length. The lakes were stocked with equal densities of two wild strains of hatchery-raised fry: one from an environment with long and severe winters and the other from shorter and milder winters. This common garden experiment examined the seasonal energy allocation strategies, growth and survival in both of these genotypes across an environmental gradient. The primary hypothesis is that each genetic strain has adapted to its long-term abiotic and biotic environment and therefore their energy allocation will vary due to a unique balance of physiological and ecological tradeoffs. The experimental results confirm that energy allocation strategies are modified by both genotype and environment. Sufficient lipid accumulation was the major determinant of over-winter survival, particularly in the lakes with longer ice-on periods and lower productivities.

Oral CCFRR (General Session)

PALEOLIMNOLOGICAL EVIDENCE OF THE TIMING, EXTENT, AND POTENTIAL CAUSES OF THE EUTROPHICATION OF LAKE WINNIPEG'S SOUTH BASIN

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Recently declared as "Canada's Sickest Lake" by Maclean's, Lake Winnipeg has experienced severe blooms of nitrogen (N) fixing cyanobacteria since the mid-1990s. However, despite ~20 years of water quality degradation, little is known about the timing, extent, and causes of algal proliferation. To address these issues, five sediment cores were recovered from the south basin of Lake Winnipeg and analyzed at sub-decadal resolution for changes in sediment geochemistry (carbon [C], N, phosphorus [P] content), stable isotope ratios ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$), radioisotope activity (^{210}Pb , ^{137}Cs), diatom species composition, algal pigments (chlorophylls, carotenoids), and morphological fossils of cyanobacteria. Nutrient influx (as $\delta^{15}\text{N}$, P content) varied little from ~1700 to 1930, but increased steadily to maximum in sediments deposited since 2005. Diatom production (as diatoxanthin) increased 400% and was highly correlated with nutrient influx, whereas abundance of total algae (as β -carotene) and colonial cyanobacteria (as canthaxanthin) both increased 300% from 1930 to a peak ~1995, then declined 50% as concentrations of akinetes from previously-rare *Aphanizomenon* and *Anabaena* spp. increased 10-fold. Interestingly, diatom species composition varied little during the past 200 years, suggesting physical rather than chemical mechanisms of regulation. In contrast, reciprocal changes in the abundance of total algae and N₂-fixing cyanobacteria coincide with an intensified livestock industry, changes in federal grain transport, and climatic variability. Together these findings suggest that remediation efforts must reduce algal abundance ~300% to achieve baseline conditions (1930s), but that less substantial changes may be sufficient to initiate a return to lower densities of N₂-fixing cyanobacteria.

Oral SCL (Nutrients)

APPLICATION OF TWO HYPOLIMNETIC OXYGEN PROFILE MODELS TO LAKES IN ONTARIO

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We tested two previously published models (inductive & deductive models) that predict end-of-summer oxygen concentrations in the hypolimnia of small lakes representing a broad range of the lake characteristics in the Boreal ecozone. The inputs of the inductive model include lake morphometry and total phosphorus concentration at spring-overturn. The inputs of the deductive model include lake morphometry and oxygen concentration at spring-overturn. Long-term data (approximately 30 years) from 6 lakes in central Ontario were used to evaluate the models' abilities to predict end-of-summer oxygen profiles. The predicted end-of-summer O₂ concentrations in each stratum of the hypolimnia were compared to the measured O₂ concentrations in the stratum for each lake. Statistical tests were used to evaluate coherence between these two values derived from the models. Results indicated that both of these two models were satisfactory for these lakes. The amount of nutrient is probably the key factor affecting the loss of O₂.

Oral SCL (Nutrients)

COMPARISONS OF TWO HYPOLIMNETIC OXYGEN DEPLETION MODELS

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Hypolimnetic oxygen depletion results in biological stress through habitat loss. In addition, changes in O₂ levels control oxidation/reduction reactions in aquatic habitats including sediments and bottom waters. We tested two previously published models that predict hypolimnetic oxygen depletion with data collected for 6 small lakes representing a broad range of the lake characteristics found in the Boreal ecozone. The first model is an empirical model that assumes volumetric hypolimnetic oxygen depletion (VHOD) rates depend mainly upon chlorophyll and the ratio of epilimnetic depth to lake depth. The second model is a semi-empirical model, which predicts both VHOD and oxygen profiles, that is, loss of oxygen with depth in the hypolimnion. The depth profiles are derived from the VHOD and the O₂ concentrations at spring turn-over plus the time length of stratification. Our results suggest that the first model has a reasonably good agreement between predicted and measured values while the second model may give a good estimate of VHOD but may not be appropriate for calculation of the O₂ concentrations in individual strata.

Poster SCL (Nutrients)

USE OF LASER ABLATION-ICP-MASS SPECTROMETRY OF OTOLITH STRONTIUM DISTRIBUTION TO DETERMINE INITIATION AND FREQUENCY OF ARCTIC CHAR, *Salvelinus alpinus*, SEAWARD MIGRATION IN HIGH ARCTIC LAKE SYSTEMS

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The extent of High Arctic Canadian Arctic char, *Salvelinus alpinus*, utilization of marine habitats has not been well documented. Previous unpublished/published studies of Arctic char from Lake C2 (Ellesmere Island) and Lake A (Ellesmere Island) suggest that a segment of these char populations is anadromous (migrates seaward in the summer months for feeding). The purpose of our study is to examine the frequency of the seaward migration and age of initiating migratory behavior. Sagittal otoliths will be chemically analyzed for strontium via laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS). Strontium (Sr) concentrations in otoliths are correlated with strontium concentrations in the ambient aqueous environment (generally, freshwater has reduced Sr whereas saltwater has increased Sr). Further examination of near-shore marine and estuarine habitat data as well as lake-water elemental composition will further aid in biological interpretation of Sr otolith profiles.

Oral CCFRR (Arctic resources)

THE USE OF REFUGE SITES BY SEA LAMPREY *PETROMYZON MARINUS*

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The sea lamprey (*Petromyzon marinus*) is a parasitic invader in the Laurentian Great Lakes, where it has had devastating effects on native fish populations. There is a need to increase understanding of the behaviour of adult sea lamprey in order to improve the effectiveness of the barrier and trapping control program. Sea lamprey are known to migrate at night and exhibit cryptic behaviour during the day. Little is known about their choice of daytime-refuge sites, or when and how sea lampreys use these sites. The aims of the study were to determine refuge locations and quantify the importance of habitat variables; and to determine activity patterns associated with these daytime-refuge sites. The study area consisted of three tributaries with instream barriers on the northern shore of Lake Ontario. The behaviour of sea lamprey during the spawning migration was monitored using passive integrated transponder (PIT) telemetry. Sea lamprey were found to be highly selective in their choice of refuge site, with flow, presence of boulders, distance to bank and barrier being important factors. Barriers were found to aggregate sea lamprey with 40-70% of the released individuals found in refuge sites within 6m of the barrier. Observations on the refuge-seeking behaviour showed that sites are primarily selected at night, confirming that tactile and rheotactic cues are more important than vision in locating suitable refuge. Knowledge of this behaviour could aide in the design of portable traps aiming at exploiting sea lampreys as they seek daytime refuge.

Oral CCFRR (General Session)

RESOURCE AVAILABILITY AND BEHAVIORAL INTERACTIONS: CHALLENGES IN FOOD WEB DYNAMICS AND BIOLOGICAL RECOVERY OF STRESSED LAKES

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Biological recovery in Sudbury lakes damaged by acidification and metal contamination is incomplete. Isolated communities are recovering but food web function is still impaired. With a low biomass of their benthic invertebrate food and re-establishment of piscivore predators, yellow perch face the challenge of resource limitation and avoiding predators at the same time.

We monitored fish diversity, density, and habitat use in six lakes with varying fish communities, as well as intensively surveying their main resources over four years. This includes estimating the biomass of benthic invertebrates in the littoral zone as well as zooplankton and *Chaoborus* biomass in the pelagic zone. Additionally, we manipulated three of the lakes by introducing smallmouth bass as a top predator. Trophic positions of populations and diets of fish were assessed by using stable nitrogen and carbon analysis (SIA). We found that piscivores caused behavioral as well as diet changes in perch. Perch mostly abandoned the pelagic zone once bass arrived. Perch remaining in the pelagic increased their consumption of zooplankton significantly, while littoral perch kept feeding on the same mix of littoral and pelagic sources. After piscivores were in the manipulated lakes for two years, perch moved back into the pelagic zone. Benthic invertebrate biomass declined over those years in the manipulated lakes. We hypothesize, that the initial response of perch is a predator avoidance strategy, wherein they do not cross between the littoral and pelagic zone where bass lurk. However, the perch populations can't be sustained by the low biomass of benthic invertebrates in Sudbury lakes, thus they seek zooplankton in the pelagic zone risking bass predation. The combined stresses of predator avoidance and limited food thus seem to hamper the biological recovery of whole these food webs.

Oral CCFR (Trophic linkages)

SPECIES ASSEMBLAGES, SPATIAL DISTRIBUTIONS, AND HABITAT ASSOCIATIONS OF MARINE FISH IN THE CANADIAN BEAUFORT SEA – THE CCGS *NAHIDIK* FISHING PROGRAM 2006-2009

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The proposed Mackenzie Valley Pipeline Project has sparked a renewal in intensive oil and gas exploration in the Beaufort Sea. Governmental regulators and resource managers are tasked with the assessment of potential impacts of anthropogenic activities on the region's natural environment, including fish and fish habitat. Despite considerable research focus on the biological and physical makeup of the Beaufort Sea during the last period of extensive oil and gas exploration in the late 1970s and early 1980s, the complex dynamics of the Beaufort Sea and its biota are still poorly understood. The data presented here were collected as part of the Northern Coastal Marine Studies Program (NCMSP), which is a multidisciplinary study aimed at characterizing the physical and biological nature of the Canadian Shelf. The central objective of the fishing component was to provide data regarding the presence of fish in support of an on-going multibeam mapping program of the Beaufort Sea floor, and to contribute to the general biological and ecological information on offshore fish populations. Benthic trawling was conducted from the Canadian Coast Guard Ship (CCGS) *Nahidik* in open water from 2006 - 2009 to study the composition and spatial distribution of fish relative to physical and chemical habitat parameters. Eight transects were sampled, spanning the nearshore waters to the offshore marine environment, between Herschel Island, YT, and Cape Bathurst, NT. Herein, we provide an overview of the fishing program, present a preliminary analysis of species assemblages, and explore links between spatial distribution of fishes to conductivity, temperature, and depth variables.

Poster CCFR (Arctic resources)

SEASONAL DISTRIBUTION AND ABUNDANCE OF SMALL FISHES IN THE OFFSHORE WATERS OF LAKE WINNIPEG

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Since at least the late 1800s, Lake Winnipeg has supported important subsistence, recreational and commercial fisheries. Despite its ecological, social and economic importance, dynamics of the fish community are not well understood. To describe seasonal distribution and abundance of small-bodied fishes in open waters of Lake Winnipeg, mid-water trawl tows were conducted near 65 lakewide, long-term monitoring stations from 2002 to 2008. Trawl samples collected during the spring, summer and fall were used to study effects of season and basin within the lake (south basin, channel and north basin) on species biomass estimates. Emerald Shiner (*Notropis atherinoides*), Rainbow Smelt (*Osmerus mordax*), and Cisco (*Coregonus artedi*) were the most abundant prey fish species caught in trawls. Biomass of Emerald Shiner was significantly greater in the south basin and the channel compared to the north basin, while biomass of Rainbow Smelt was significantly greater in the north basin of the lake compared to the channel and the south basin. Biomass of Cisco was also significantly greater in the south basin and the channel compared to the north basin. Biomass of Cisco and Walleye (*Sander vitreus*) were significantly greater in the summer and the fall compared to the spring. Walleye biomass estimates were significantly greater in the south basin compared to the channel, and in the channel compared to the north basin. Differences in distribution and abundance of small fishes in Lake Winnipeg may be due to species interactions as well as effects of environmental variables.

Oral CCFR (General Session)

DEVELOPMENTAL HISTORY OF A CUPRIFEROUS SWAMP IN NEW BRUNSWICK

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Cupriferous swamps are characterized by high concentrations of copper in the soil and water. We are studying one such example, the Aboujagane Swamp, situated about 8 km NW of Sackville, New Brunswick. It is a typical mixed coniferous-deciduous swamp with *Picea mariana*, *Larix laricina*, *Acer rubrum*, and *Abies balsamea*. Cu in the ground waters reached 1540 mg/l and surface peats (dry weight) have been found to contain up to 10%. A 210 cm core of peat, collected near the centre of the swamp, contains 10 cm of silty peat overlain by approximately 40 cm of limnic *Sphagnum* peat, with 160 cm of dense black and brown mixed peat. A radiocarbon age of 10 745 yrs BP was obtained at the base and an age of 8290 yrs BP was obtained at 111 cm at the transition between highly decomposed dense peat and a more fibrous less-decomposed peat unit. Cu content in the core ranged from trace values to a high of 4800 µg/g at 65 cm. Preliminary analysis of pollen and spores show marked changes which reflect a tree and shrub vegetation in and around the basin dominated by *Picea*, *Pinus*, *Betula*, *Abies* and *Alnus*.

An understanding of contemporary and past relationships between vegetation and Cu have implications for the rehabilitation of contaminated industrial landscapes with wetland technologies.

Oral SWS (Wetlands)

THE INFLUENCE OF TERRESTRIAL LINKAGES ON SMALL STREAM HABITAT AND BIOTA

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Habitat in small streams is influenced by both longitudinal (upstream) and lateral contributions of runoff and allochthonous inputs. Being controlled by topography, lateral of surface and subsurface inputs of water, organic and inorganic material are not uniform along the length of a stream. We refer to the contributing area laterally located to a stream reach as the "Reach Contributing Area" (RCA). The objectives of our research are to: 1) Evaluate associations between lateral contributions to a stream and characteristics of stream habitat and biota, 2) Examine changes in these terrestrial-aquatic linkages following forest harvesting and 3) Develop GIS based techniques to quantify levels of lateral contribution along streams. Reaches associated with larger RCAs had finer substrate and more wood debris, greater thermal variability, a distinct benthic invertebrate community structure, and higher fish abundance compared to reaches with smaller RCAs. Forest harvesting impacts on terrestrial-aquatic linkages were evaluated with an experiment monitoring water and nutrient inputs pre- and post- harvest. Following harvest, water yield from RCAs approximately doubled relative to pre-harvest and water flux increased significantly relative to a control. Concentrations of DOC and some nutrients (e.g. K, N, P) and metals (e.g. Mn, Fe) increased 2 to 3 times in the year after harvest, and the flux rate of mercury approximately double that of reference conditions. Finally, in areas with relatively thin soils, we analysed DEMs in a GIS to identify potentially significant RCAs where forest management activities may be modified to mitigate adverse impacts.

Poster CCFR (Habitat assessment)

EVALUATING THE EFFECTS OF AGRICULTURAL DRAIN MAINTENANCE ON GRASS PICKEREL, A SPECIES OF SPECIAL CONCERN

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The Grass Pickerel (*Esox americanus vermiculatus*) is listed as Special Concern under the *Species at Risk Act*. It prefers warm, slow moving streams and shallow bays of larger lakes dominated with dense emergent aquatic plants. The Grass Pickerel occurs within many stream systems in the Niagara Region, Ontario, most of which are part of expansive agricultural drainage networks. Stakeholders (federal agencies, provincial agencies, municipal governments and landowners) are involved in a three-year project to address the need to protect fish communities, including Grass Pickerel, and habitat while maintaining local agricultural drainage systems. To better understand the effects of agricultural drain maintenance on the fish community and Grass Pickerel, the objectives of this project are: 1) to develop a habitat supply model that can be used to determine changes in habitat supply, and consequently Grass Pickerel abundance; and, 2) to compare key life history characteristics of Grass Pickerel between control and reference sites before and after drain maintenance in Beaver Creek. In the first year of the study, we PIT-tagged over 600 individuals within Beaver Creek and have preliminary estimates of population size, density, individual movement within the creek and adult diet. The results of this study will provide scientifically defensible guidance on the potential impacts, and possible mitigations, of drain maintenance on fish communities, and Grass Pickerel in particular, in the study watersheds and similar-sized waterbodies elsewhere.

Oral CCFR (Habitat assessment)

NATURAL REPRODUCTION SITES OF CHINOOK SALMON IN LAKE HURON: THE USE OF OTOLITH MICROCHEMISTRY AS A FISHERIES MANAGEMENT TOOL

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Since the initial introduction of Chinook salmon to Lake Huron in 1968 it has become apparent that naturalized populations have become established. In 2005 wild reproduction of Chinook salmon was estimated to contribute 85-90% to the lake wide fishery. With such a large component of the Lake Huron Chinook salmon fishery originating from wild populations it is important to understand where these fish originate; however, logistical constraints have inhibited identifying these locations. Our study used the microchemical signature captured in the otolith to identify the juvenile environments (natal origin) of Lake Huron Chinook salmon. Unique archival properties of otoliths allow for the analysis of the environmental conditions throughout the life history of a fish. Fry were collected from 17 tributaries and 7 hatcheries around the Lake Huron region. These fry samples were used to create a discriminant function (DFA) model of the otolith elemental signatures of all known Chinook salmon spawning tributaries and hatcheries in the lake. The model correctly classified, with 86% accuracy, fry from known origin. Adult salmon collected from various locations around Lake Huron were applied to the DFA model to identify the natal origin. The results suggest that the majority of Chinook salmon (>50%) in the Lake Huron fishery originated from southern Georgian Bay populations. This supports current beliefs of local fisheries managers giving the first evidence of major contributing tributaries to the Lake Huron Chinook salmon fishery.

Oral CCFRR (Habitat assessment)

CLIMATE, FLOODING AND NUTRIENT LOADING TO LAKE WINNIPEG

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Nutrient enrichment leading to eutrophication of lakes is frequently ascribed to enhanced anthropogenic loading from the watershed. We use a water balance and phosphorous model for Lake Winnipeg to show that increased discharge and flood frequency in one tributary, the Red River, contributed more than increased anthropogenic loading to a recent surge in phosphorous concentration and a shift to a cyanobacteria-dominated plankton population in the lake. Since the mid-1990s the annual mean discharge of the Red River has been more than twice as great as in any previous decade. Widespread spring flooding has become common. The mean phosphorous concentration in the Red River doubles at flood discharges (compared to the concentration at discharges which do not exceed bankfull capacity) compounding the effect of increased flow on downstream phosphorous fluxes. We attribute this mainly to leaching of nutrients from flooded fields in the lower reaches of tributary streams. Downstream of extensively flooded reaches, phosphorous concentrations can range from 1000 to >2000 mg cm⁻³ (in one tributary river, the La Salle River) – i.e. up to several times the typical concentrations measured both upstream (in runoff from fields on the escarpment where flooding is less widespread and protracted) and downstream (in the mainstem of the Red River). In the mid-1990s, phosphorous concentration in Lake Winnipeg doubled compared to previous times. We use the phosphorous model to demonstrate that increased loading due to flooding would have caused a 33% increase, while direct increases in anthropogenic loading alone would have caused only a 12% increase.

Oral SCL (Nutrients)

GENETIC VARIATION IN AN ENDANGERED MINNOW THROUGHOUT ITS NATIVE RANGE

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The Pugnose Shiner, *Notropis anogenus*, is an endangered species in Canada and is of conservation concern in the U.S. We assessed genetic diversity based on microsatellite loci across its native range. This included samples from Lake Ontario, Lake Huron, and Lake Erie watersheds in Canada, and U.S. samples from New York, Wisconsin, and Minnesota. Our first objective was to assess population-level genetic variation and to determine if estimates of effective population size followed expectations based on conservation status. In addition, we evaluated how genetic variation in the Pugnose Shiner compared to that found in the congeneric Blackchin Shiner, *Notropis heterodon*, which is not of conservation concern. Second, we determined whether Canadian populations represented a distinct component of species-level diversity. Third, we evaluated dispersal patterns using both assignment tests and isolation by distance. Results from this study should help determine whether Canadian populations face risks associated with low genetic variation, such as inbreeding and reduced adaptive potential. Our results should help managers determine which populations are most at risk in Canada, and improve our understanding of what features represent barriers to dispersal in the species.

Oral CCFR (Conservation genetics)

COURSE SCALE MOVEMENT PATTERNS OF JUVENILE/SUBADULT LAKE STURGEON IN A SMALL WINNIPEG RIVER RESERVOIR

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Research conducted on the Winnipeg River has recently revealed that juvenile lake sturgeon, previously thought to be rare, are in fact abundant in many of the deep-water areas of the river. Through mark-recapture studies, in the Winnipeg River it has been observed that the vast majority of juvenile lake sturgeon recaptured are located in close proximity to where they were initially captured (Barth et al unpublished, North/South Consultants unpublished). We are currently using acoustic telemetry to further investigate the course-scale movement patterns of juvenile/subadult lake sturgeon in a 10 km long Winnipeg River reservoir bounded by the Pointe du Bois and Slave Falls generating stations. Forty-nine juvenile/subadult lake sturgeon were implanted with Vemco acoustic transmitters in spring 2009. Course-scale movements of these fish were monitored using Vemco VR2W receivers positioned throughout the reservoir. Three distinct zones of movement were identified: two smaller zones (~2 km of linear river distance) located at the upper and lower ends of the reservoir, and a larger zone (~6 km) located in the middle. Two narrow, fast-flowing sections of river separate the zones. Ninety-six percent of the fish tracked (n=49) were detected only within the zone they were initially captured. While these results are preliminary, it suggests that the narrows within this section of the Winnipeg River may function as partial barriers to movements. Implications to downstream movement and passage over a hydroelectric station will be discussed.

Poster CCFR (General Session)

DETECTION OF SELECTION FOR FEEDING TYPE IN PAIRED LAMPREY SPECIES

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Paired species of parasitic and non-parasitic lampreys are an interesting evolutionary problem; they are generally considered separate species due to differences in adult size that are thought to lead to immediate reproductive isolation. However, the larvae of a given pair are morphologically similar or indistinguishable and they often overlap habitat and geographic range. One example of a species pair are *Ichthyomyzon unicuspis* (silver lamprey) and *I. fessor* (northern brook lamprey), which are native to inland waters in eastern North America. Previous studies using mitochondrial and microsatellite DNA markers have shown that these two species are genetically indistinguishable when they occur sympatrically and suggest that nonparasitism has arisen independently at least twice. This suggests contemporary gene flow between them, but does not rule out the possibility that they are recently diverged or diverging species where genetic differences have not yet become fixed. Consequently this study will test whether silver and northern brook lampreys are under selection for feeding type, a possible mechanism of divergence. This will be done using amplified fragment length polymorphisms (AFLP) to generate a large number of marker loci across the genome, and determine whether the loci that differ between silver and northern brook lampreys have higher levels of divergence than would be expected with neutral loci. If these loci are found in multiple independently-derived populations, this would indicate that these loci are under selection or linked to genes under selection and could be candidates for genes that maintain such divergent feeding types. Preliminary data will be discussed.

Poster CCFR (Divergent morphotypes)

THE INFLUENCE TO STREAM THERMAL VARIABILITY ON FISH DISTRIBUTION AND COMMUNITY STRUCTURE IN NORTHWESTERN ONTARIO

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Thermal variability is an important component of habitat within streams providing optimal temperatures for foraging and thermal refugia for sensitive species such as brook trout. Riparian shading and lateral contributions of groundwater through the hyporheic zone are the main contributors to spatial variability in stream temperature. The objectives of this study were to 1) quantify thermal variability in stream systems through extensive mapping of streambed temperatures and to evaluate the influence of thermal variability on the stream fish distribution and community structure and 2) evaluate associations between thermal variability and reach, riparian and catchment scale features. Streambed thermal variability occurred on a sub-metre scale with temperature differing by up to 5.8 °C across a transect. The maximum variability found was 10.1 °C within a 50 m reach and 12.0 °C within a 300 m reach. Fish species diversity and brook trout abundance was positively correlated with the degree of thermal variability while rainbow trout abundance was negatively correlated. Furthermore, thermal variability was correlated with terrestrial variables associated with groundwater movement, including the amount of adjacent land contributing surface and subsurface runoff to the stream, also known as reach contributing area (RCA). In regions such as Northwestern Ontario where hydrologic pathways are related to topographic features, it may be possible to use environmental features such as RCA to locate and protect lateral groundwater inputs into streams.

Oral CCFR (Habitat assessment)

UNINTENDED CONSEQUENCES AND TRADE-OFFS OF UPSTREAM FISH PASSAGE

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This talk will review evidence for unintended consequences and trade-offs associated with upstream passage of fishes. Provisioning of upstream fish passageways at dams and dam removals are being carried out increasingly as resource managers seek ways to reduce fragmentation of migratory fish populations and restore biodiversity and nature-like ecosystem services in tributaries altered by dams. Potential benefits of provisioning upstream passage are highlighted widely. Possible unwanted consequences and trade-offs of upstream passage are coming to light, but remain poorly examined and under appreciated. Unintended consequences arise when passage of native fishes is unidirectional, highly selective taxonomically and numerically, and results in patterns of movement and habitat use that reduce rather than improve Darwinian fitness (e.g. ecological traps). Trade-offs arise when passage decisions intended to benefit native species interfere with management decisions intended to control the spread of non-native fishes, new diseases, and contaminants. The importance of these consequences and trade-offs can vary from system to system and can be costly economically and environmentally. More sophisticated frameworks are needed to help resource managers reach decisions that balance the benefits and unintended costs of upstream fish passage and that accommodate how benefits and costs vary among systems. More rigorous, comprehensive, and balanced assessments of the benefits and consequences of providing upstream fish passage are needed to determine the success of passage decisions.

Oral CCFFR (General Session)

USE OF SATELLITE IMAGERY AND AN AUTOMATED CLASSIFICATION METHOD TO ASSESS CHANGES TO FISH HABITAT IN COASTAL WETLANDS OF EASTERN GEORGIAN BAY

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Aquatic vegetation in the pristine coastal wetlands of eastern Georgian Bay provides critical habitat for fishes. The remote location and difficulty in accessing many of these marshes precludes the use of traditional field survey methods to identify habitat. Declining water level in Lake Huron (10 cm net change from 2002-2008) threatens to alter these marshes, therefore there is an urgent need to map and monitor Georgian Bay coastal wetlands. Our goal is to develop and implement an automated method to track changes in aquatic vegetation using satellite imagery. In two regions of eastern Georgian Bay we acquired IKONOS satellite images for 2002 and 2008. Our lab has developed an image-object based classification method called the process tree classification (PTC) to map coastal wetlands in eastern Georgian Bay using 2002 IKONOS satellite images. The PTC identified four distinct vegetation groups; meadow, emergent, high-density floating and low-density floating. Changes in the spectral properties of surface features in the 2008 images prevented us from applying the same PTC to the 2008 images. We created a new PTC that is specific to 2008 imagery and had the same level of accuracy as the 2002 PTC. Results indicate that for 15 wetlands, there was a significant decrease in low-density floating vegetation (mean -6191.2 m^2) while high-density floating vegetation saw a comparable increase (mean $+5272.5 \text{ m}^2$) between 2002 and 2008. While not significant, there was also a trend towards increasing meadow vegetation and decreasing emergent vegetation (mean change of $+1515.0 \text{ m}^2$ and -2070.9 m^2 respectively).

Oral CCFFR (Wetlands)

CHANGES IN FISH COMMUNITY COMPOSITION AND HABITAT STRUCTURE IN RESPONSE TO DECLINING WATER LEVELS IN EASTERN GEORGIAN BAY COASTAL MARSHES

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Over the past 10 years, water levels in eastern Georgian Bay, Lake Huron have been near the record low, which occurred in the 1930s. Low water levels can alter both the structure and distribution of aquatic macrophytes, which will change the type and amount of fish habitat available. In a companion study that evaluated water level trends in Georgian Bay from 2002 to 2008, there was a significant decrease in available fish habitat following a net decline in water level of 10 cm. There was also a change in the complexity of the remaining habitat from one dominated by many small patches of dense vegetation with intermittent sections of less dense areas, to wetlands dominated by uniform high density vegetation. In this study we assess fish-community responses to changing vegetation habitat using 38 wetland-years of data, collected between May and August (from 2002 to 2009). In general, there was a significant decline over time in species richness (paired t-test; $\text{prob} > 0.0001$; mean 5.6 ± 1.0 per wetland). At the species level, there were significant increases in the proportion of the catch bowfin (*Amia calva*) and pumpkinseed (*Lepomis gibbosus*) (paired t-test; $\text{prob} > t = 0.0004$ and 0.0007 , respectively). There was also a trend towards, increased proportions of rock bass (*Ambloplites rupestris*) and brown bullhead (*Ameiurus nebulosus*) and decreasing proportions of largemouth bass (*Micropterus salmoides*). Our results suggest that sustained low water levels can reduce the complexity of coastal marsh habitat and lead to a less diverse fish community.

Oral CCFR (Wetlands)

LAKE TROUT ENHANCEMENT: A BY-PRODUCT OF RAINBOW TROUT CAGE AQUACULTURE

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One of the major research projects at the Experimental Lakes Area (ELA), northwestern Ontario, in recent years is a whole-lake experiment to assess the impacts of rainbow trout cage aquaculture in Lake 375, a small oligotrophic lake. Fingerling rainbow trout were added to a commercial culture cage located in this lake each spring for five years, 2003 – 2007. They were feed commercial pellets twice daily until they were harvested each fall. We will summarize changes that occurred in the native fish populations of Lake 375 during the years of cage culture, but concentrate on changes that occurred in the lake trout population. We monitored changes in abundance, annual survival, recruitment, growth, and condition of lake trout in Lake 375 and in two other nearby control lakes. Growth, condition, an annual survival of Lake 375 lake trout increased starting the second year of cage culture, and abundance increased starting the third year of cage culture. Lake trout abundance more than doubled by the end of the final year of cage culture. Other changes that occurred were decreased first age of maturity and increased frequency of females in the population that spawned annually. None of these changes occurred in the lake trout populations of other nearby control lakes. The changes in the lake trout population in Lake 375 appeared linked to increased abundance of other fish species in this lake during the years of cage culture.

Oral SCL (Experimental Lakes Area)

MODELLING DOLLY VARDEN (*SALVELINUS MALMA*) HABITAT IN THE WESTERN ARCTIC, CANADA IN SUPPORT OF ECOSYSTEM BASED MANAGEMENT

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Dolly Varden (*Salvelinus malma*) is a char native to western North America that is harvested by northern communities for subsistence purposes. Populations occur in eight river systems found across the Canadian Western Arctic and several of these have experienced significant declines. As a result, local communities, co-management boards, and government agencies agreed to implement conservative harvest quotas, which included fishing closures in some areas. Several stakeholders believe that changes to habitat, specifically low water levels over successive years, are partially responsible for declining stocks. Winter habitat, which is critical for survival of this species in northern environments, is limiting as it is restricted to several small areas in headwater sections of freshwater streams. Spawning and winter habitats typically overlap and both are associated with perennial groundwater sources. We surveyed two spawning and overwintering reaches from Fish Hole Creek, a tributary to the Babbage River, and Little Fish Creek, a tributary to the Big Fish River. Depth, velocity, substrate, and cover were measured at positions in the stream where fish were observed and also at spawning redds. A two-dimensional hydrodynamic fish habitat model (River2D: www.river2d.ca) was developed and used to estimate minimum discharge thresholds for spawning and winter habitats. These discharges can be used as a guideline to help stakeholders manage Dolly Varden stocks more effectively by monitoring water levels in these rivers annually. Developing a metric which can be used to monitor limiting habitat for this culturally important fish, is an integral component of ecosystem based management.

Oral CCFRR (Habitat assessment)

DECLINING SULFATE, PHOSPHORUS AND IRON CONCENTRATIONS IN DORSET LAKES BETWEEN 1981 AND 2005

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Long-term declines in mean annual concentrations of sulfate, total phosphorus (TP) and total iron of about 25-35% have occurred in seven intensively studied lakes near Dorset, Ontario 1981-2005. The sulfate declines began in the early 1990s but the TP declines began 10 years earlier. The long-term trends in TP, Fe and sulfate closely correspond to each other after 1990. Mass balances will be used to examine the extent to which changes in external factors like soil acidity and wetland redox and internal removal processes are responsible for Fe and TP trends. We hypothesize that internal processes play a major role: sulfate declines in lakes associated with acid deposition controls may have resulted in decreased sulfide production with concomitant increased iron mobilization from lake sediments and an increase in iron phosphate sedimentation.

Oral SCL (Nutrients)

SHAPE SHIFTING YELLOW PERCH – IS IT BETTER TO FLEE OR FEED?

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Lakes in the Sudbury area that have recovered sufficiently from acidification and metal contamination are rapidly colonized by an ontogenetic omnivore, the yellow perch (*Perca flavescens*). This species reaches high population densities and dominates the fish community. In these lakes perch exhibit two morphs based on shape and habitat use. In the pelagic zone there is a shallow bodied form with a thin, elongated caudal peduncle region while a thicker bodied form with a thick, short caudal peduncle occupies the littoral zone. As lakes continue to recover piscivores are beginning to re-colonize and perch respond by adopting the littoral morph. However, is the habitat shift caused by selective predation on the pelagic morph or by an increase in littoral resource availability as the density of perch is reduced by predation? We manipulated a perch-only lake in 2006 by introducing a gape-limited piscivore, the smallmouth bass (*Micropterus dolomieu*). The proportion of pelagic morph yellow perch declined significantly within two years, from 20% of the population to less than 1%. However by the end of 2008, the remaining perch population appeared to have depleted an already impoverished littoral benthic community. In 2009 one-third of the population was again occupying the pelagic zone but with a shape intermediate between the historical pelagic and littoral morphs. These fish also have different feeding morphology (gape size and gut length), trophic position, and diet (determined from stable isotope analysis). This “new” morph appears adapted to the reduced littoral resources and increased predation risk.

Oral CCFFR (Divergent morphotypes)

MERGING ABORIGINAL TRADITIONAL KNOWLEDGE AND WESTERN SCIENCE TO ASSESS DIVERSITY IN CISCOES (*COREGONUS* SPP.)

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The species at risk act (SARA) states: “*the traditional knowledge of the aboriginal peoples of Canada should be considered in the assessment of which species may be at risk and in developing and implementing recovery measures*”. An effective mechanism for accomplishing this requirement is currently lacking. We undertook a study with the Yellowknives Dene First Nation to identify traditional knowledge (TK) and historical use of cisco (*Coregonus* spp.) fisheries with a particular emphasis on the shortjaw cisco (*Coregonus zenithicus*; presently under re-assessment by COSEWIC). The objectives of our study were: 1) to engage aboriginal elders in on-the-water sampling associated with a SARA-related research program; 2) to collect traditional knowledge on cisco diversity, habitat, and historical use; and 3) to develop an approach for gathering and incorporating TK into SARA-related activities. We found that engaging elders on their land and conducting sampling activities as partners was a successful mechanism for building trust. Engaging the elders in sampling activities was an excellent forum for the reciprocal exchange of western scientific and traditional knowledge. Further, a semi-directive approach to group interviews (either on the water or around a campfire) was an effective means of stimulating discussion on key uncertainties. We conclude that traditional knowledge can be gathered effectively and is one step toward better environmental monitoring and management decision-making. A more holistic approach that incorporates TK is vital to the conservation of northern ecosystems where long-term data sets may not exist.

Oral CCFFR (Including fishers in fisheries science)

ONTOGENETIC SHIFTS IN GILLRAKER MORPHOLOGY AMONG LAKE CISCO *C. ARTEDI* FROM GREAT SLAVE LAKE, NT: ARE INDIVIDUALS CHAMELEONS?

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Gillraker number and length are important characters in the discrimination of cisco species (Salmonidae: Coregoninae). Gillraker morphology has a heritable component, but it is also subject to environmentally induced phenotypic variation. We used a data set collected from Great Slave Lake, Northwest Territories to test predictions generated by the hypothesis that *C. artedi* gillraker morphology (i.e., length, spacing, and number) varies throughout ontogeny. In particular, we tested the predictions that: 1) gillraker length and number were positively correlated with age, body length, and head length; 2) gillraker spacing was negatively correlated with age, body length, and head length and positively correlated with gillraker number; and 3) gillraker morphology is linked to ontogenetic shifts in food habits. We found that gillraker number and length was positively correlated with age, body length, and head length. Gillraker spacing was negatively related to age, body length, and head length, and gillraker morphology was related to trophic morphology and mean length of prey ingested. These data support the hypothesis that not only is gillraker number subject to phenotypically induced variation from environmental influences, but that it is also plastic at the individual level and varies throughout ontogeny in response to shifts in trophic resource use. As gill rakers are used as key diagnostic features of cisco species, these findings have implications for taxonomic studies – the latter should be based upon adult specimens in which gill raker number and morphology are fixed,

Oral CCFRR (Arctic resources)

USING LANDSCAPE APPROACH TO EVALUATE THE IMPACT OF THE LAKE CATCHMENT DEFORESTATION ON BENTHIC INVERTEBRATES' COMMUNITY OF THE LAKES IN NORTH AND CENTRAL ONTARIO, CANADA

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We assessed the benthic macroinvertebrates assemblage of 51 lakes located at north and central Ontario in order to understand how impact on lakes' watershed changes structural composition of benthos. Environmental variables were divided into 6 categories; (1) Spatial variables (SV) (2) Regional Factors (RF) (3) Landscape Variables (LSV) (4) Geological variables (GV) (5) Local Chemical (LC), and (6) Local Physical (LP) and were correlated with benthos relative abundance–environmental using redundancy analysis (RDA). Both local chemical and physical explained more species variations than other environmental categories; however, there was a significant correlation between local variables and those of higher scale. This further suggests that both chemical and physical variables are determined by geographical location of the lakes, bedrock geology, and whether catchment is developed or forested. Generally lakes clustered in three major groups 1) those with no deforestation in their catchments (e.g. Bear, Heney and Timberwolf) 2) those with larger portion of the lakes' catchment deforested as the consequence of acid rains, agriculture, and urban development (e.g. Hannah, Middle and Scogog) 3) those lakes with minimum impact in their catchments with larger portion of their catchments being forested (e.g. Glen, Balsam, Red Chalk East and Main). Lakes with highest impact in their catchment had significantly higher % Chironomidae, % Dominance and lowest Taxa Richness, % EPT and EPT/Chironomidae compared to lakes with no impact or low impact. This further indicates that lakes' catchment deforestation could impact the occurrence of many sensitive taxa such as EPT and dominance of more tolerant taxa such as Chironomidae.

Oral SCL (General Session)

THE CASE FOR PHOSPHORUS LIMITATION IN LAKE SIMCOE

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In Lake Simcoe, the largest inland lake in southern Ontario, we found that phosphorus (P) is the limiting nutrient to algal growth. Currently, there is a lot of effort going into controlling the P inputs to the lake, and although total P loads and in-lake concentrations are known, the bioavailability of this P is still unknown. Seasonal and spatial surveys were conducted in 2008 and 2009 to determine the limiting nutrient to phytoplankton communities. P bioavailability was examined using the different forms of P, as well as physiological indicators of nutrient status. P limitation was determined using alkaline phosphatase activity (APA), P-debt, stoichiometric ratios of particulate nutrients (N:P, C:P) and P addition photosynthetic efficiency experiments. Nitrogen (N) limitation was also assessed and related to long term trends in N concentrations. Indicators of N limitation included: C:N ratios, N-debt and N addition photosynthetic efficiency experiments. Heterocyst counts were also used as a proxy for N fixation. We determined that the majority of lake stations were P deficient, and the deepest stations exhibited the most P limitation. Indications of P and N co-limitation were found in an urban-influenced deep bay. There appears to be a lack of correlation between P concentrations and indicators of P limitation which may be related to the relationship between different forms of P.

Oral SCL (Nutrients)

CYANOBACTERIA BLOOMS IN BRIGHT LAKE, IRONBRIDGE, ON: HOW A LAKE ASSOCIATION TRIES TO CLEAN UP ITS LAKE

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Cyanobacteria (commonly called 'blue-green algae') blooms have been reported more frequently in recent years, even in remote lakes. Often the only observations are made by residents or visitors at these lakes. Bright Lake (16 km², 11 m max. depth), a polymictic lake on the Canadian shield in Northern Ontario, is such a lake. In 2009, half of the 107 residents formed the Bright Lake Association, Inc., to address increasing concerns about these blooms and ask scientific partners to develop a sustainable approach to remediation. Preliminary investigation identified two main phosphorus (P) sources, agricultural input from streams and internal load released from sediments to facilitate these blooms. A study is being developed to quantify these loads as the first step towards potential remediation. Members of the Lake Association are presently collecting sediment samples so that P release rates can be predicted from sediment total phosphorus and reductant-soluble fractions. They have measured oxygen and temperature profiles and found that Bright Lake becomes hypoxic and anoxic for up to 5 m above its relatively warm (above 18° C) bottom sediment during late summer and fall. They are also collecting water samples so that basic chemistry and seasonal nutrient concentrations will be known.

The remediation of remote lakes such as Bright Lake may be more important in the context of its location within the general watershed. Its outlet drains into the Mississagi River which is a large tributary to Lake Huron, where a deteriorating water quality and cyanobacteria blooms in the Northern Channel have become a notorious issue.

Poster SCL (Nutrients)

INTERNAL LOAD AND SEDIMENTATION IN PHOSPHORUS MASS BALANCE MODELS

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Internal phosphorus (P) load is one of the most challenging subjects in lake and reservoir eutrophication and restoration. The main reason for quantifying internal load is to determine its effect on the trophic state and water quality of a lake. To accomplish this, mass balance models have typically been used. However, so many such attempts were unsuccessful that the mass balance approach has become discredited. There are several reasons for such failure:

1. Mixing net, partially-net, and gross estimates of internal load
2. Combining upward with downward P fluxes in retention models

The development of most models (even those published in recent years) include lakes with sediment release, so that they incorporate both upward and downward fluxes to a various degree. To circumvent this problem, a retention model is necessary that specifically predicts downward fluxes (sedimentation). Such a model has been developed previously on oxic stratified lakes that do not experience sediment P release (Nürnberg 1984), but other models may be more useful in different lakes (polymictic, hardwater) and will be discussed here. In most cases, a strict mass balance cannot be expected to predict epilimnetic summer P averages, the variable that is most thought after. (E.g., this is the case when the outflow is from the bottom water, which exhibits elevated concentration due to internal load); here, a calibration for the specific lake or reservoir is necessary. A successful application of this approach is demonstrated for Cherry Creek Reservoir, Denver, CO.

Oral SCL (Nutrients)

SPATIAL VARIATION IN SUMMER DIET OF INVASIVE RAINBOW SMELT (*OSMERUS MORDAX*) IN LAKE WINNIPEG

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The dietary selectivity of zooplanktivorous rainbow smelt (*Osmerus mordax*), which were first observed in Lake Winnipeg in late 1990, was studied along a transect of 10 stations in the North Basin during the July 2008 cruise of the M.V. *Namao*. Densities, proportions and body lengths of available zooplankton were quantified for four prey groups: copepods, *Daphnia* spp., *Eubosmina* spp. and *Bosmina* spp. Gut contents of rainbow smelt in two size classes (<120 mm and >120 mm total length) were analyzed to determine proportions of zooplankton prey in their diets. Smaller smelt (<120 mm TL) displayed variable electivity values among stations; however, electivity for *Daphnia* spp. and against copepods and *Bosmina* spp. was unchanging. Larger smelt (>120 mm TL) showed consistently positive electivity for *Daphnia* spp. and negative electivity for the other prey groups. Rainbow smelt and zooplankton densities increased northwards along the sampling transect, paralleled by decreasing overlap between proportions of prey groups available and present in gut contents. Energetic quality of prey groups was assessed on the basis of mean body size, escape ability and caloric content. The results of this study suggest that a gradient of smelt foraging strategy may be present in the North Basin of Lake Winnipeg, with a selective strategy in the higher water clarity of the northern section shifting towards a generalist strategy in the more turbid south.

Oral CCFRR (Trophic linkages)

ENVIRONMENTAL DETERMINANTS OF THREESPINE STICKLEBACK (*GASTEROSTEUS ACULEATUS*) EVOLUTION AND CONTINUED PERSISTENCE.

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Southwestern British Columbia is unique in that it is apparently the only place on Earth with sympatric pairs of threespine stickleback (*Gasterosteus aculeatus*). Within specific lakes these fish are found in two forms: benthic and limnetic. Speciation is thought to have occurred through a double-invasion process followed by character displacement. While this hypothesis is supported by geology, morphology, and genetics it does not take into account the environmental factors needed to support threespine stickleback in two separate microhabitats. It is conceivable that the divergence and persistence of the threespine stickleback species pairs may be due to unique environmental characteristics of the lakes they inhabit, including physical lake characteristics, water chemistry, or biological productivity that have facilitated speciation. Alternatively, speciation could have been due to specific attributes of fish community structure or random colonization events unrelated to lake attributes. To establish this, I measured a number of abiotic (water chemistry, physical lake parameters) and biotic (food resources, macrophyte abundance) variables from both species pair and non-species pair threespine stickleback lakes in order to identify any factors that may discriminate species pair lakes from non-species pair lakes, thereby leading to a clearer understanding of their habitat needs.

Oral CCFFR (Divergent morphotypes)

FATE OF DECABROMODIPHENYL ETHER ADDED TO IN SITU MESOCOSMS AT THE EXPERIMENTAL LAKES AREA

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Decabromodiphenyl ether (DecaBDE) has been used as a brominated flame retardant in a wide variety of consumer products. The use of DecaBDE is controversial because of its potential to break down into lower-brominated diphenyl ethers, which are generally more readily absorbed and more toxic. Laboratory studies have shown that DecaBDE can be degraded by light, by anaerobic microbes, and in fish. Whereas debromination has been clearly demonstrated under laboratory conditions, the extent to which this process occurs in the natural environment is largely unknown. We are investigating: i) the extent to which DecaBDE is debrominated in natural aquatic ecosystems; ii) the bioavailability of DecaBDE and its degradation products to aquatic biota; and iii) the toxicity of DecaBDE and its degradation products to fish. From 2007-2009, four large mesocosms were installed in a remote, oligotrophic lake located at the Experimental Lakes Area in Ontario, Canada. The mesocosms (10-m diameter, 2.5m deep) were open to the atmosphere and sediments and contained a natural littoral food web, as well as stocked age 1+ yellow perch (*Perca flavescens*). We added different doses of DecaBDE (BDE-209) to three mesocosms, and a fourth mesocosm served as a control. We monitored PBDE concentrations in water, sediments, periphyton, zooplankton, benthos and fish over the 3 years of the study. Our study is the first to demonstrate, under realistic field conditions, that DecaBDE is debrominated in the natural aquatic environment and that DecaBDE and its breakdown products are subsequently bioaccumulated by aquatic biota.

Oral CCFFR (Experimental Lakes Area)

MODELING ELA RESERVOIR STUDIES AND THE RELEVANCE TO MANITOBA RESERVOIRS

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Over the last several decades, large amounts of data have been collected on reservoirs in Manitoba. These data sets include extensive information on water flows, temperature, water quality, and biology. Most of the data were collected to address specific questions and lacked an ecosystem context. With increasing recognition of the importance of an ecosystem approach to environmental management, there is now a desire to re-examine these data and to assess their relative usefulness for predicting the ecosystem impacts of reservoir creation and management. We employ an ecosystem approach to develop a dynamic ecosystem model used to predict impacts of reservoir creation and operation on fish productivity. Data collected from ELARP and FLUDEX reservoir experiments at the Experimental Lakes Area provide critical parameter values utilized in the model. By using an ecosystem modeling approach, we are able to run various simulations to explore what are the dominant ecosystem pathways affecting changes in fish productivity in reservoirs of different ages as well as what are the best ways to measure impacts to these pathways. We use the reservoir ecosystem model to demonstrate the ability to use data from small experimental reservoirs and apply them to other larger reservoirs. We also use the model to show that upstream sources have a large influence on the productivity of the system, primary production may not be very different between reaches of the riverine sections, and that strong CO₂ diurnals need to be considered when estimating the productive capacity of a system.

Oral SCL (Experimental Lakes Area)

EFFECTS OF WHOLE LAKE ADDITIONS OF A POTENT ESTROGEN ON FISHES

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A whole-lake study was conducted over ten years at the Experimental Lakes Area to determine whether the potent synthetic estrogen 17 β -ethynylestradiol (EE2) used in the birth control pill and discharged in municipal wastewaters affects fish populations. Surface waters of the experimental Lake 260 were maintained at EE2 concentrations of ~5-6 ng/L through weekly additions during the summers of 2001 to 2003. Lake trout, white sucker, pearl dace and fathead minnow were sampled two years before, 3 years during, and for up to 5 years after EE2 additions and compared to reference lake data. Endpoints examined included plasma or whole body concentrations of the egg protein precursor vitellogenin (VTG) and gonadal histology for both males and females, and size frequency and/or abundance data for the four species. The relative induction of VTG in EE2-exposed fishes was always greater for males than females and highest for fathead minnow and lowest for white sucker. Delayed gonadal development and intersex were found in both male and female pearl dace and fathead minnow but not in the trout or sucker. The population of the shortest-lived fish species, the fathead minnow, collapsed after 2 summers of EE2 additions and did not recover until 2006. Some impacts of EE2 on size-frequency distributions and/or abundances of pearl dace and lake trout were also observed after the third year of additions. Results suggest that life history strategies play an important role in determining the risks that estrogens and their mimics pose to fish species in systems receiving municipal wastewaters.

Oral CCFFR (Experimental Lakes Area)

NUTRIENT SEQUESTRATION IN LAKES AND RESERVOIRS IN THE LAKE WINNIPEG WATERSHED

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In structurally complex watersheds, upstream lakes and man-made reservoirs may act as nutrient sinks and thereby reduce the transport of nutrients to and the eutrophication of downstream waterbodies. Using a network of 62 water quality sampling sites we estimated nutrient sequestration in the major lakes and reservoirs of the Lake Winnipeg watershed between September 2008 and September 2009. Preliminary analysis suggests that large prairie lakes and reservoirs are effective in sequestering nutrients, with Lake Winnipegosis, Lake Manitoba and Lake Diefenbaker retaining up to 30% of the phosphorus entering via surface inflows. In contrast, small or shallow prairie lakes and the smaller mainstem reservoirs of the Saskatchewan River system do not sequester a high proportion of incoming phosphorus. Differences in water residence time likely account for much of the difference in nutrient sequestration among the monitored waterbodies, with long water residence times being positively correlated with nutrient sequestration rates.

Oral SCL (Nutrients)

CONSTRUCTED PONDS AS BREEDING HABITAT FOR THE HORNED GREBE IN THE PEACE PARKLAND, CANADA

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The destruction and degradation of wetlands have resulted in significant declines in populations of aquatic birds throughout North America. The Horned Grebe (*Podiceps auritus*) is a migratory diving bird considered “of special concern” by COSEWIC (2009). Current conservation strategies for aquatic birds in western Canada include not only preserving, but also restoring and constructing wetland habitat. We examined use by breeding Horned Grebes of borrow-pits (ponds created during highway construction) in the Peace Parkland, northwest Alberta, Canada. Our goals were to document patterns of occurrence and breeding success of grebes on borrow-pit ponds and to determine if occupied and unoccupied ponds differed in local habitat features or landscape characteristics. In May 2003 and 2007 we surveyed 330 constructed ponds for grebes. In 2007 we chose 100 occupied and 100 unoccupied ponds for additional surveys in June, July and August 2007, and again in June and August 2008. We collected habitat and landscape data for these 200 ponds. Generalized linear mixed model regression analysis, coupled with Akaike’s Information Criterion, was used to determine which environmental variables were most effective in explaining occurrence of Horned Grebes. The best model included all habitat features. Grebes occupied larger ponds with more emergent and riparian vegetation and avoided ponds surrounded by greater proportions of forest within 1 km that supported beavers and contained human structures. We conclude that the construction of small wetlands offers a viable means of increasing breeding habitat for the Horned Grebe.

Poster SCL (Habitat assessment)

SPATIAL AND TEMPORAL TRENDS IN WATER QUALITY AND TOTAL PHOSPHORUS CONCENTRATIONS IN THE LAKE OF THE WOODS

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The Lake of the Woods (LOW) is an international waterbody spanning the Canadian provinces of Ontario and Manitoba, and the U.S. state of Minnesota. Although algal blooms have been reported in southern regions of the LOW since the early 1800's, there is a perception that water quality in northern regions of the lake is deteriorating, leading to an increase in algal bloom severity in recent years. New evidence suggests that recent climatic warming may also play a role. In the absence of long-term historical data, however, these trends are difficult to verify. Furthermore, due to its size and hydrological complexity, the water quality of the LOW is highly variable and difficult to assess. We present monitoring and paleolimnological data to assess spatial and temporal trends in water quality in the LOW. In this presentation, we focus on total phosphorus concentrations (TP), showing that concentrations are highly variable, both spatially and seasonally throughout the lake. Using models developed from diatom assemblages in lake sediment cores, we reconstruct total phosphorus concentrations through time at multiple sites. We report that current diatom inferred-TP concentrations are lower than or similar to concentrations inferred for pre-industrial times. Finally, we synthesize existing data into a nutrient budget quantifying the relative sources of total phosphorus to the LOW.

Oral SCL (Nutrients)

REGIONAL TRENDS IN TOTAL PHOSPHORUS AND CALCIUM CONCENTRATIONS IN RECREATIONAL LAKES ACROSS ONTARIO

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In south-central Ontario, there is evidence that multiple environmental stressors are leading to changes in inland lake water chemistry that include declines in total phosphorus (TP) and calcium (Ca) concentrations in recent decades. Ontario's Lake Partner Program has collected low-level, precise TP data since 2002 and Ca data since 2008 from hundreds of inland lakes using volunteer samplers. Here, we provide an evaluation of the geographic distribution of TP and Ca concentrations in recreational inland lakes across Ontario using data collected by Lake Partner volunteers. This study will provide an assessment of the total number of lakes in various TP and Ca categories for different regions of the province and will examine which regions contain lakes that are at, above, or below previously-determined biological thresholds. These data have the potential to provide early detection of these emerging environmental stressors in Ontario's recreational inland lakes.

Poster SCL (Nutrients)

HOW WILL CHANGES IN ATMOSPHERIC MERCURY EMISSIONS AFFECT BIOACCUMULATION OF METHYL MERCURY IN AQUATIC FOOD WEBS? RESULTS FROM THE METAALICUS PROJECT

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The objective of the METAALICUS project is to determine how much and how quickly changes in mercury (Hg) deposition will affect methyl mercury (MeHg) bioaccumulation in the aquatic food web. We added enriched stable Hg isotopes to a lake and its catchment at the Experimental Lakes Area between 2001 and 2007. In 2008, we stopped isotope additions and are now following ecosystem recovery. By adding different isotopes to the lake, upland, and wetland areas of the catchment we examined the relative contribution of different potential sources to MeHg bioaccumulation. Mercury applied directly to the lake now represents approximately 35-50% of MeHg in all biota. Relative accumulation of this MeHg was more rapid among short-lived members of the food web (e.g. zooplankton, small fish), but increases in all components appeared to be nearing a new steady state by 2007. We did not see strong recovery in 2008. Isotopes applied to the surrounding catchment have remained near or below detection levels in aquatic biota throughout the study. This is partly a result of dilution of isotopic Hg in the large pool of ambient Hg in catchment vegetation and sediments. Our results imply that the overall response of biota to changes in Hg emissions will depend on the relative contribution of the catchment to overall lake Hg budgets. Lakes receiving most of their Hg from direct deposition to the lake surface will see more rapid responses than lakes primarily receiving Hg from catchment runoff.

Oral SCL (Experimental Lakes Area)

DISPERSAL AND SURVIVAL OF AQUACULTURE ESCAPEES: NEW INSIGHTS FROM ANGLER RETURNS IN LAKE HURON

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Dispersal and survival of escaped fish from commercial aquaculture operations are important factors in determining their potential effects on the local system. This aspect has been passed over in many impact assessments, yet is important to understanding the magnitude of potential ecological concerns that may arise with an escape event. In May 2009, we tagged (Floy tag), measured (mean = 712 g) and released 1000 harvestable rainbow trout into the North Channel of Lake Huron from two fish farms; Lake Wolsey (semi-contained) and the Wabuno Channel (open). Eighty telemetry tagged fish were released at the same time from both farms. A creel survey was run two days each week for the summer months, and angler reporting was relied on to obtain dispersal, survival, and growth information. In total, 6.3% of floy-tagged rainbow trout released to the wild were reported by anglers, 30% of which were caught within 2 weeks after release. A majority (97%) of the fish released at the Lake Wolsey farm were angled within 5 km of release site, with a maximum capture distance of 12 km away. In contrast, 42% of fish released at the Wabuno Channel farm were angled 20-280 km away. This information compliments and broadens the telemetry data we have simultaneously collected.

Habitat selection and susceptibility to angling by these domestic escapees will aid in understanding the extent of potential impacts of their presence in the wild, which would be impossible in a system of this size without the cooperation of the anglers.

Oral CCFRR (Including fishers in fisheries science)

SITE FIDELITY PATTERNS OF FARMED RAINBOW TROUT ESCAPED FROM AQUACULTURE OPERATIONS IN LAKE HURON

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The behaviour of farmed fish after escape is poorly understood, yet the extent to which these fish might impact freshwater ecosystems is in part dependent upon their dispersal in the wild. We examined site fidelity of farmed rainbow trout released from a commercial open pen farming operation in a lake connecting to the North Channel of Lake Huron, Ontario, where a majority of Canada's freshwater aquaculture production occurs. In May 2009, 40 farmed rainbow trout were implanted with telemetry transmitters and released at a commercial farm to imitate a small scale escape event. We used four stationary receivers placed at the farm and throughout the lake to monitor the movements of tagged fish. Overall fidelity to the cage site and a number of varying individual patterns over time will be displayed. Focus will be placed on the initial response of escaped domestic fish into open waters and the individually adopted patterns established over a three month monitoring period.

Poster CCFR (General Session)

IDENTIFYING THE MIGRATION TIMING AND TYPE OF A CANADIAN ARCTIC FISH – BROAD WHITEFISH (*COREGONUS NASUS*, PALLAS)

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Habitat use in Arctic aquatic systems by important species such as broad whitefish (*Coregonus nasus*) is poorly known. Spawning movements of fishes are costly, and are also under considerable selective pressure. We sampled within the Mackenzie River system to determine aspects of critical habitat use by broad whitefish during their spawning period. Broad whitefish are observed moving extensively into tributaries of the Mackenzie River, such as the Arctic Red River in the fall. These movements are hypothesized to occur for the purposes of spawning. To determine if this is the case, we measured the gonado-somatic index (GSI) of broad whitefish entering the Arctic Red River and kept a record of catch abundance from June to the end of November in two successive years. The GSI increased gradually during this time and started to peak in the third week of October. Movements of broad whitefish into the system, implied by gillnet catches, showed corresponding increases of abundance. In addition we were able to statistically describe the slopes and changes in slopes of the GSI and abundance indices supporting our conclusion of a spawning migration. We conclude that mature and ready-to-spawn broad whitefish start migrating in early October, with peak migration occurring between late October and early November. This work further supports the knowledge that the Arctic Red River is an important spawning river for broad whitefish.

Oral CCFR (Arctic resources)

COMMON GARDEN EXPERIMENT SHOWS DIFFERENCES IN EARLY LIFE-HISTORY TRAITS IN BEACH AND DEMERSAL SPAWNING POPULATIONS OF CAPELIN

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Capelin (*Mallotus villosus*), a key forage fish in the north Atlantic, spawn eggs that adhere to sediments on beaches and in demersal (deep water) habitats throughout their geographic range, resulting in divergent thermal regimes for the incubating eggs. Recent field experiments have revealed divergent developmental strategies between beach and demersal spawning capelin in coastal Newfoundland. A Common Garden Experiment design was used to examine if population differences in early life history traits exist among two beach (BB and LB) and one demersal (BD) population of capelin in coastal Newfoundland. Eggs and larvae were incubated at three temperatures (cold, 4°C; medium, 7°C; warm, 12°C) that are representative of summertime incubation temperatures in coastal Newfoundland. Hatching success was highest for BB at all temperatures and was highest for all populations at medium temperature. With the exception of LB hatching earliest at cold temperatures, eggs of all populations hatched earlier at higher temperatures. Preliminary results suggest different temperature reaction norms for early life history traits, indicating differences between the populations investigated. The divergent biology of beach and demersally spawned eggs suggest that each will respond differently to environmental change and, thus, require different approaches for successful management.

Oral CCFFR (Divergent morphotypes)

ONTOGENETIC DIFFERENCES IN ISOTOPIC SIGNATURES AND CROP CONTENTS OF *CHAOBORUS*

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Trophic relationships play an integral role in structuring aquatic ecosystems and lead to complexity in their food webs. While inter-specific interactions are often the basis for the complexity of aquatic food webs, intra-specific changes in trophic interactions linked to ontogenetic changes can add to this complexity. We therefore (a) examined isotopic signatures and crop contents of different *Chaoborus* species and life stages, and (2) determined whether ontogenetic changes in diet are reflected in their isotopic signatures. Different *Chaoborus* species and life stages were collected from fifteen Precambrian Shield lakes for stable isotope and crop contents analyses. Early instar *Chaoborus* $\delta^{13}\text{C}$ and lipid-corrected $\delta^{13}\text{C}$ signatures were enriched in ^{13}C , while their *Daphnia*-corrected $\delta^{15}\text{N}$ signatures were lower compared to those of late instars and pupae. Larval *Chaoborus* size was significantly related to their $\delta^{13}\text{C}$, lipid- and *Daphnia*-corrected $\delta^{13}\text{C}$, and *Daphnia*-corrected $\delta^{15}\text{N}$ isotopic signatures. *Chaoborus* crop contents varied among species and larval instars. Overall, early instars consumed more rotifers and phytoplankton and had lower *Daphnia*-corrected $\delta^{15}\text{N}$, whereas late instars consumed comparatively larger quantities of copepods, nauplii, cladocerans and early instars, and had higher *Daphnia*-corrected $\delta^{15}\text{N}$. Together our results show that there are differences among larval *Chaoborus* life stages. Hence, different instars of these important aquatic predators cannot be grouped together, but should be separated by species and life stage when examining trophic interactions in freshwater food webs.

Oral SCL (Trophic linkages)

ENVIRONMENTAL DRIVERS OF CARBON TRANSFER AND TROPHIC DYNAMICS WITHIN BENTHIC COMMUNITIES OF TEMPERATE LAKES

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Benthic invertebrates are an integral component of the biological communities within temperate lakes. These organisms are vital in the natural flow of energy because they generally feed on algae, detritus and bacteria, and in turn are consumed by important predators such as fish. As a consequence of their role in freshwater food webs they can potentially be affected by a number of environmental drivers. For example, dissolved organic carbon (DOC) may directly and indirectly influence benthic feeding via its control of bacterial and algal abundance. Therefore we aim to investigate the importance of key environmental drivers, including DOC and nutrient concentrations, on carbon transfer and trophic dynamics within benthic communities. Benthic invertebrate carbon and nitrogen stable isotope data are used to assess differences in carbon transfer routes and determine trophic status. Results and conclusions are based on sixteen different benthic taxa collected from fifteen Central Ontario lakes in 2008 and 2009 with a wide range of environmental conditions.

Poster SCL (Trophic linkages)

DAM-RELATED THERMAL POLLUTION IN THE SOUTH SASKATCHEWAN RIVER AND IMPLICATIONS FOR THE BENTHIC ECOSYSTEM

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The South Saskatchewan River is one of the most important waterbodies in western Canada, transporting drinking water to much of Saskatchewan's residents, supporting industrial consumption and irrigation, while providing hydroelectric power in southern Saskatchewan. Because of the dam electricity production in this great river though, major habitat fragmentation, and abiotic changes occur downstream of the Diefenbaker Lake reservoir. In particular, the hypolimnetic release of water significantly depresses the temperature of the river, precluding the establishment of many invertebrate species for tens of kilometers downstream to the city of Saskatoon. This reduction in benthic macroinvertebrate abundance constitutes a substantial reduction in forage resources for fish such as the Lake Sturgeon present in the Saskatchewan Rivers System. As a compounding biological problem, the unique conditions provide a toe-hold for invasive species in the province, where competition for resources is essentially absent. We already identify one group of stenothermic midge taxa (Chironomidae: *Paracladius*) that have moved into this environment, and other invasive species to watch for in the coming years unless conditions in the River are improved to more natural temperature regimes. Here we present the results of ongoing temperature monitoring in the South, North and Mainstem Saskatchewan Rivers, showing the degree of distance required before temperature and characteristics of the benthic macroinvertebrate fauna return to reflect upstream conditions. In particular, we show that the temperature does not recover until after the City of Saskatoon, and impacts of this thermal stress are apparent for nearly 100km.

Poster SCL (Habitat Assessment)

USING A DYNAMIC STATE VARIABLE MODEL TO PREDICT THE EFFECT OF TEMPERATURE ON SURVIVAL PROBABILITIES OF FATHEAD MINNOWS OVER AN ICE-FREE SEASON

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In shallow water ecosystems, small fish experience a range of temperatures over the course of the ice-free season. In some systems, peak summer temperatures reach 30°C. Previous research suggests that on the Canadian prairies, fathead minnows, *Pimephales promelas*, will have an almost 60% chance of surviving the ice-free season (which typically extends from March to November). To predict the role that temperature plays in the survival of fathead minnows, I wrote a state-dependent model to predict survival probabilities of fathead minnows when temperatures increase 2°C (a conservative increase) and 4°C (a more extreme increase). Within the model, individuals can die due to starvation or predation, both of which vary with temperature. The probability of survival for a minnow, regardless of their energetic state at the beginning of spring, declines as the temperature of the water increases. Whether more individuals die as a result of starvation versus predation depends on whether the probability of consuming food increases (here predation is responsible for the greatest proportion of death) or decreases (risk of starvation is greater than the risk of predation) with prey density. More fish die due to predation than starvation under all scenarios. The model output suggests that temperature increases will have a detrimental outcome to the survival probabilities of adult fathead minnows, at least in the short term, regardless of the relationship between probability of receiving food and temperature. Climate change predictions suggest rising temperatures across the prairies; this study suggests that populations of minnows may experience a reduction in numbers.

Oral CCFFR (Quantitative Tools)

SPERM COMPETITION AND SECONDARY SEXUAL CHARACTERS IN COHO SALMON

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Sperm competition occurs when sperm from more than one male compete for fertilizations. This form of post-copulatory sexual selection is recognized as a significant force in the evolution of male reproductive traits. We examined secondary sexual characters (spawning colouration and overall body size) in relation to sperm quality in one alternative reproductive tactic of coho salmon (*Oncorhynchus kisutch*): large hooknose males that spawn in dominance-based hierarchies. Males with less intense red spawning colouration had higher sperm velocities than males with darker red spawning colouration. There was no relationship between male body size and sperm quality metrics. We also used in-vitro fertilization trials to examine how the relative influences of sperm velocity and sperm longevity determine sperm competition success. Microsatellite paternity analyses revealed that a male's relative sperm velocity was significantly correlated with sperm competition success. In contrast, a male's relative sperm longevity was not related to sperm competition success. These results suggest that (1) within an alternative reproductive tactic, variation in sperm competition intensity may select for a tradeoff between investment in sexual colouration and sperm quality and (2) sperm compete for access to eggs in a race in which the fastest sperm have the highest probability of success.

Oral CCFFR (General Session)

EFFECT OF NET PEN AQUACULTURE ON A LAKE ECOSYSTEM: RESULTS FROM THE ELA AQUACULTURE PROJECT

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The net pen aquaculture industry poses a risk to the aquatic environment due to the release of fish manure and the potential release of escaped fish; as a result this industry is receiving increasing scrutiny from regulatory agencies and ENGOs. In Canada, the freshwater net pen industry is relatively small, but future growth is anticipated and regulation of this industry requires an understanding of the effects of these releases to the freshwater environment. From 2003-2007, researchers operated a 10 tonne/yr all-female rainbow trout (*Oncorhynchus mykiss*) cage in Lake 375, a 23 ha lake at the Experimental Lakes Area. Impacts from the cage operation on water quality, phytoplankton production, zooplankton, and changes in sediment characteristics and benthic invertebrate communities were monitored. The farm released an average of 86.7 kg of P and 517.9 kg of N to L375 each year. There was a resulting increase in TP, but we estimate that only approximately 15% of the P added to the lake was retained in the water column. Total production of phytoplankton increased but this increase largely occurred directly after turnover and was a smaller response than has been observed to similar P loading to small boreal lakes. There was relatively little change in the zooplankton community, while the benthic community and sediment chemistry near the farm responded rapidly to settling waste. Stable isotopic signatures of zooplankton, benthos and fish indicated that the native foodweb was incorporating waste material from the farm. The abundance and condition of forage fish and the population size, condition, and recruitment of lake trout (*Salvelinus namaycush*) and white suckers (*Catostomus commersoni*) have been monitored and show evidence of this subsidy. Escapees from the farm were monitored through the use of acoustic telemetry to determine survival and spatial distribution after escape. The presentation will provide the audience with an overview of environmental impacts observed during the five years of farm operation and the first year of recovery.

Oral SCL (Experimental Lakes Area)

INITIAL FINDINGS OF A LARGE-SCALE, AMERICAN EEL STOCKING EXPERIMENT IN LAKE ONTARIO

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Precipitous declines in the recruitment of American eel to formerly productive habitats in the Upper St. Lawrence River and Lake Ontario resulted in the implementation of an experimental American eel conservation stocking program. Nearly 3.8 million American eels were stocked in 2006 through 2009 in the St. Lawrence River near Mallorytown Landing, and in the Bay of Quinte near Deseronto. The first quantitative boat electrofishing assessment in the spring of 2009 found densities between 25 - 30 eels/ha at the two locations. Fall assessments documented 55 eels/ha in the Thousand Islands, and 200 eels/ha in the Bay of Quinte. Rapid growth was observed in both locations. Stocked eels appear to be dispersing widely, as they have been captured up to 300 km away from the stocking locations. Stocked American eels appear to be surviving, dispersing and growing well, but it will take a decade to determine if the stocking experiment results in silvering eels that appear to be outmigrating normally.

Oral CCFFR (General Session)

REACTION NORMS OF COD SPERM PERFORMANCE AS A FUNCTION OF TEMPERATURE

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Phenotypic plasticity occurs when a genotype produces variable phenotypes under different environments; the shapes of such responses are known as norms of reaction. The genetic scale that reaction norms can be determined is restricted by the experimental unit that can be exposed to variable environments. This has limited their description beyond the family level in higher organisms, thus hindering our understanding of differences in plasticity at the scale of the individual. Using a three year common-garden experiment we quantify reaction norms in sperm performance of individual genotypes within different families of Atlantic cod (*Gadus morhua*). Cod sperm showed phenotypic plasticity in swimming performance across temperatures (3, 6, 11, 21°C) but the pattern of the response depended upon how long sperm had been swimming (30, 60, 120, 180 s). Sperm generally swam fastest at intermediate temperatures when first assessed at 30 s post-activation. However, a significant genotype×environment interaction was present, indicating inter-individual differences in phenotypic plasticity. To our knowledge this is the first study to describe variable sperm performance across environmental conditions as a reaction norm. The results have potential theoretical, conservation and aquaculture implications.

Oral CCFRR (General Session)

CHANGES IN THE DISTRIBUTION OF LAKE TROUT AND THEIR PREY *MYSIS RELICTA* IN RESPONSE TO AN EXPERIMENTAL FRESHWATER AQUACULTURE OPERATION

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Lake trout (*Salvelinus namaycush*) and their prey, the opossum shrimp (*Mysis relicta*), are glacial relicts that require cold, well-oxygenated waters. The effects of freshwater aquaculture on lake trout and *Mysis* were studied in Lake 375 of the Experimental Lakes Area (ELA). The distributions of lake trout and *Mysis* were examined in Lake 375 and reference Lake 373 in 2002 (prior to aquaculture) and 2005 (after three years of production). In 2005, nutrient rich waste from the aquaculture operation caused oxygen depletion in the deepest areas of Lake 375. This resulted in a migration of *Mysis relicta* from deep to intermediate depth zones and an increase in *Mysis* densities in those zones. Despite suitable habitat being available over deeper areas of the lake, lake trout were most frequently detected over intermediate zones. A high correlation between *Mysis* and lake trout in 2005 (0.81) compared to 2002 (0.43) suggests that lake trout altered their distribution in 2005 in response to higher *Mysis* densities. Similar spatial shifts in *Mysis* and lake trout were not observed in the reference lake. The results of this study provide evidence that a change in lake trout distribution in Lake 375 may have been caused by changes in *Mysis* distribution, and indirectly caused by altered lake parameters due to freshwater aquaculture. We hypothesize that the rapid decline in *Mysis* in subsequent years of aquaculture production was not solely the result of habitat limitation caused by low dissolved oxygen concentrations, but also due to increased predation from lake trout.

Poster CCFRR (Experimental Lakes Area)

SUBFOSSIL CHAOBORIDAE AND CHIRONOMIDAE ASSEMBLAGES TO RECONSTRUCT PAST CHANGES IN LAKE THERMAL REGIMES IN THE EXPERIMENTAL LAKES AREA

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Predicted future changes to aquatic ecosystems include declines in maximum depth and shifts in thermal regimes due to altered hydrological and biogeochemical processes in a warmer climate. These shifts may have particularly pronounced ecological consequences on shallow lakes. Multivariate ordination (Redundancy Analysis) of subfossil Dipteran (Chaoboridae and Chironomidae) assemblages in 35 boreal shield lakes in the Experimental Lakes Area (NW Ontario, Canada) indicated that maximum depth (Z_{\max}) was the major environmental gradient structuring the composition of subfossil Dipteran communities in these lakes. A Z_{\max} inference model ($r^2_{(\text{jack})} = 0.68$) using subfossil assemblages was developed; however, application of this model to a subfossil biostratigraphy from Lake 240 suggested that assemblages were not accurately tracking changes in Z_{\max} . Further examination of assemblage composition using Principal Components Analysis (PCA) indicated assemblage clustering associated with mixing regime (stratified versus polymictic). A logistic regression model to predict mixing regime using subfossil assemblages was developed by expressing assemblage composition as PCA sample scores and coding mixing regime as a binary variable. A subfossil Dipteran-based inference model to reconstruct past changes in thermal regimes may represent a new paleoenvironmental tool to track the effects of climate change on shallow lakes.

Oral SCL (General Session)

BIOECONOMIC EVALUATION OF HARVEST CONTROL RULES FOR LAKE ERIE WALLEYE FISHERY

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This study presents a multi-disciplinary approach to evaluating harvest policies. Using the Lake Erie walleye (*Sander vitreus*) commercial fishery as a case study, we developed a bioeconomic simulation framework to examine the effects of alternative harvest control rules on both biological and economic performance indicators in the presence of uncertainty about the stock size. The simulation framework contains constant fishing mortality and abundance-based harvest control rules, including the ones currently used to set Lake Erie walleye harvest, and which range from conservative to liberal exploitation rates. The biological model describes stochastic age-structured population dynamics of walleye population and the economic model generates short-run gross and net revenues for the walleye commercial harvesting operations. We generated the joint probability distribution of Ricker parameters and initial conditions by using a Bayesian method. We estimated cost equation by a pooled regression method using the financial data collected from the Lake Erie harvesters. We applied the Monte-Carlo approach in order to project the fishery forward in time. We ranked harvest control rules in terms of expected abundance, catch, landings and value of landings, and present value of net revenues, as well as in terms of probability of either economic or biological indicators falling below some undesirable threshold. Our results emphasize the need for examining the trade-offs between biological and economic objectives, as well as the trade-offs between the expected magnitude of and variation in catch and profits.

Oral CCFRR (Including fishers in fisheries science)

PERFORMANCE COMPARISON OF TRADITIONAL SAMPLING DESIGNS AND ADAPTIVE SAMPLING DESIGNS FOR FISHERY-INDEPENDENT SURVEYS

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Fishery-independent surveys play an important role in fish stock assessment. An efficient sampling design is one of the keys to a successful fishery-independent survey. In this study, we compared the performance of the traditional sampling designs with adaptive sampling designs, using Lake Erie fishery-independent survey data for yellow perch as an example. Based on the existing survey data (1989 – 2003), yellow perch was observed to be heterogeneously distributed and this heterogeneity varies over time. Traditionally, the Lake Erie fishery-independent survey has been conducted with a stratified random sampling design based on depth strata; however, adaptive sampling designs are thought to be more suitable for surveying heterogeneous populations. Initially, we used bias, mean absolute error (MAE) and variance of the mean of the estimator to compare simple random sampling, stratified random sampling and adaptive two-phase sampling (ATS). ATS was the best design under most situations. We then compared ATS, adaptive cluster sampling (ACS), adaptive two-stage sequential sampling (ATSS), and the currently used sampling design. ATS performed better than the other two approaches and the current sampling design. A simulation study was conducted to compare these designs by examining the accuracy and precision of the estimator. We concluded that for yellow perch, ATS is preferable to the current sampling design of the fishery-independent Lake Erie partnership index fishing survey.

Oral CCFRR (Quantitative tools)

LONG-TERM CHANGES IN THE BENTHIC INVERTEBRATE COMMUNITY OF LAKE SIMCOE, ONTARIO

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Lake Simcoe has experienced the effects of multiple stressors during the past century, including significant changes in nutrient loading, species invasions and climate change. Due to their varying sensitivity to water chemistry (e.g., dissolved oxygen), benthic invertebrate community assemblages have frequently been used as indicators of water quality. Historic data from initial studies on the lake dating back to the late 1920's provide a unique opportunity to evaluate long-term changes in the spatial distribution of benthic taxa, and evaluate how changes in the benthic community correspond with ecosystem-level change associated with temporal variation in deep water summer dissolved oxygen (O₂) levels. Here, we report comparisons of the benthic community sampled during 1926-28 (uncertain deep water summer O₂) with samples obtained prior to the invasion of Dreissenid mussels in 1994 (very low deep water summer O₂), and with contemporary samples collected 2008-09 (improved deep water summer O₂). Temporal and spatial patterns in benthic invertebrate community change were compared among three transects represented to varying degrees during this time period. The spatial component set out to determine whether the deep and heavily urbanized Kempenfelt Bay demonstrated a unique bottom fauna compared with sites from our two main basin transects. Preliminary results suggest increases in total invertebrate abundance from the late 1920's compared with densities during the last three decades. Invertebrate densities appear to have peaked prior to the establishment of Dreissenids, and declined somewhat since that time.

Oral SCL (General Session)

ALTERNATIVE LIFE HISTORIES IN POPULATIONS OF LAKE SUPERIOR BROOK TROUT PROVIDE STRONG SUPPORT FOR PARTIAL MIGRATION

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Age and growth analyses were used to test for alternative life histories in Lake Superior brook trout. Anecdotal observations suggest two forms of brook trout (*Salvelinus fontinalis*) inhabit Lake Superior and some tributary streams: large fish hypothesized to originate in streams and reside in Lake Superior for significant parts of the year and small fish hypothesized to be stream resident. Declines in the distribution and abundance of the lake form have created conservation concern and improved understanding of the migratory system is needed to assist conservation efforts. Analyses of vertebrae and otoliths demonstrated that lake caught fish live longer and grow faster than stream-caught fish. Mean back-calculated lengths at age differed between forms by year 1 of life and there was no evidence of individuals switching from one growth trajectory to another. Growth trajectories of lake and stream caught brook trout were similar respectively to those of migrant and resident brook trout reported for populations from elsewhere, but Lake Superior fish grow more slowly and allocate less energy to reproduction. Our findings suggest the variation in Lake Superior brook trout represents a migrant/resident dichotomy (partial migration), and not adult and juvenile stages from a migratory population, or individuals differing in the age at which they first migrate to the lake.

Oral CCFR (Divergent morphotypes)

CURRENT STATUS AND TEMPORAL TRENDS IN THE NEARSHORE FISH COMMUNITY OF LAKE SIMCOE IN LATE SUMMER

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In this study, we assess changes in the nearshore fish community of Lake Simcoe, a large lake in central Ontario, since 1992. The diverse fish community inhabiting Lake Simcoe is of considerable ecological and economic significance. In recent decades many biological and anthropogenic stressors have altered the Lake Simcoe aquatic ecosystem, including the introduction and establishment of several exotic species, changes in nutrient inputs, land use patterns, recreational fishing, management initiatives and climate change. We examine patterns in the current status and temporal trends in the catch rate, species composition and biological attributes of warmwater species inhabiting the nearshore habitat in late summer, including black crappie, bluegill, bowfin, brown bullhead, largemouth and smallmouth bass, northern pike, pumpkinseed, rockbass and yellow perch. Data were collected annually using an Ontario provincial standard trap netting protocol that is based on random site selection within a specific time period. Despite the multitude of changes that have occurred in the aquatic ecosystem temporal analysis provided no indication that there has been an overall change in the catch rate of warmwater species during the study period. Although the catch rate of most species, especially black crappie and yellow perch was highly variable among years no directional change was observed in the catch rate of six of the eight species examined. Our analyses highlight the value of long-term lake monitoring programs, which are especially valuable in light of the dramatic ecosystem level changes that will continue to occur in Lake Simcoe, in general and aquatic ecosystems, more broadly.

Poster CCFR (General Session)

MULTILEVEL ZERO-INFLATED REGRESSION FOR MODELLING SPECIES ABUNDANCE IN RELATION TO HABITAT: A BAYESIAN APPROACH

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Ecological data often have clustered or nested structure, in which observations are made on units grouped at different hierarchical levels. We examined the variation in counts of the slimy sculpin, a fish species commonly found in North American streams, in relation to habitat descriptors from sites nested hierarchically within a river basin in eastern Canada. The sampling scheme comprised three levels: 600 sites distributed among 120 reaches and 22 streams of the Cascapedia River, Québec. The distribution of counts was highly over-dispersed and had excess zeros, with nearly 10% of the sampled sites having zero counts. Zero-inflated Poisson (ZIP) regressions, as well as multilevel extensions of this model incorporating random effects, were used to account for overdispersion and potential intra-group correlations arising from the nested sampling scheme. Eight environmental variables were considered as predictors. Parameter estimates were obtained by MCMC; comparisons between models of differing complexity were based on DIC and posterior predictive checks. The inclusion of random effects allowed for improved assessment of the environmental influences and the spatial structure of unexplained variation. The zero-inflated regressions were useful in distinguishing structural from sampling zeros and identifying the main environmental determinants of incidence (presence/absence) separately from those of abundance (number of individuals), two key objectives in studies of habitat quality. Heterogeneity in count data is common in ecological studies and is probably best viewed as a potentially rich source of information rather than as a nuisance.

Oral CCFRR (Quantitative tools)

INTEGRATING ECOLOGICAL GENOMICS WITH FIELD STUDIES OF NATURAL SELECTION IN POSTGLACIAL FISHES

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Understanding how natural selection results in the remarkable fits we see between organisms and their environment is an important task for evolutionary biologists. Natural selection is a force that acts on traits, but the evolution of these traits is determined by the genes. When an organism colonizes a new environment, or that environment changes, understanding the genetics of adaptation is necessary to predict how organisms may evolve in response to environmental change. There are two significant challenges to understand the genetics of adaptation in nature. The first is identifying the targets of selection and the genes underlying adaptive traits. The second is an understanding of the genetic steps taken by adaptation upon a change in the environment. What sequence of events and what genetic changes driven by natural selection have led to phenotypic divergence during a bout of adaptation? Ecological genomics is emerging as a powerful framework within which we can begin to understand the causal links involved from genotype to phenotype to fitness during the process of adaptive divergence. In this talk I will discuss recent efforts to integrate ecological genomics with field studies of natural selection, focusing on recent bouts of adaptive evolution in postglacial populations of lake whitefish (*Coregonus clupeaformis*) and threespine stickleback (*Gasterosteus aculeatus*) to demonstrate the utility and limits of these methods.

Oral CCFRR (Divergent morphotypes)

DIFFERENTIAL GROWTH RATES IN EARLY AND LATE-SPAWNED YOY PUMPKINSEED SUNFISH (*LEPOMIS GIBBOSUS*) IN LAKE ONTARIO EMBAYMENTS.

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While using otolith daily rings to determine age of young-of-the-year (YOY) pumpkinseed (*Lepomis gibbosus*) from populations in embayments of Lake Ontario, we noticed that early-spawned fish grew more slowly than late-spawned fish. Early-late growth incongruence was found in three embayments over two successive years. Since embayment temperatures were much cooler early in the season, we thought that a growing-degree-day (GDD) transformation of time (14C base temperature) might account for the apparent growth difference between early and late cohorts. However, we found that late-spawned fish were able to achieve lengths equivalent to those of early-spawned fish in half the GDD. We considered that our choice of 14C as a GDD base temperature might be too low for pumpkinseed growth; therefore growth in early summer may not occur despite calculations indicating substantial GDD accumulations. However, trial calculations with higher base temperatures failed to eliminate the observed inconsistency in growth. Finally, we examined the possibility that slow growing early-spawned fish were remnants of a “normally” growing population that suffered severe predation on the larger individuals. However, this hypothesis failed because early-spawned fish were smaller than the lower limits in size expected in a “normally” growing cohort. We are currently considering two remaining explanations. First; the prey spectrum in early summer may train early-spawned fish to forage in ways that result in slow growth under the prey regime characterizing late summer. Second; exposure to low temperatures early in life may set growth physiology to a “slow” setting that persists throughout the first growing season.

Oral CCFRR (General Session)

HABITAT EFFECTS ON ENERGY EQUIVALENCE AND SELF-THINNING IN JUVENILE SALMONIDS

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The energy equivalence hypothesis infers constant available energy to a cohort as it ages, i.e. that increases in average body size are balanced by a reduction in density (self-thinning) that can be predicted from body size-metabolism relationships. This theory has been applied extensively to understand patterns of self-thinning among juvenile salmonids, with variable success. I use a simplified stream habitat and bioenergetic model to assess 1) the validity of the assumption of equivalent available energy for cohorts of different individual size, 2) the effects of differences in channel structure (e.g. proportion of pools vs. riffles) on slopes of self-thinning curves, and 3) the implications of varying channel structure for limitation of productive capacity in a size-structured population.

Oral CCFRR (General Session)

A PRODUCTIVITY-SUSCEPTIBILITY RISK ANALYSIS FOR THE EFFECTS OF FISHING ON ARCTIC CHARR (*SALVELINUS ALPINUS*) STOCKS FROM THE NUNAVUT TERRITORY

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We present the results of a productivity-susceptibility risk analysis (PSA) for the effects of fishing on Arctic charr stocks from Nunavut. PSA is based on the assumption that risk to a fish population depends on (1) the rate at which the population can recover from potential depletion or damage (productivity \approx resilience) and (2) on the extent of the impact due to fishing activities (susceptibility \approx exposure). Arctic charr populations were ranked for risk on a two-dimensional plot of productivity-susceptibility, with risk corresponding to the Euclidean distance from the origin. Productivity was averaged from population estimates of age at maturity, growth rate and mortality. A range of values was determined for each of these attributes using (a) available data on Arctic charr stocks (1960s to present), (b) approximations derived from maximum size equations, and/or (c) available estimates from the literature. Each range was subdivided into thirds corresponding to low, intermediate and high productivity categories, and given a risk score between 0 (low risk = high productivity) and 1 (high risk = low productivity). Susceptibility was estimated as the product of encounterability (measured as distance from human settlement), availability (overlap of fishing effort with stock distribution), gear selectivity and post-capture mortality. Susceptibility attributes were scored for individual fishing methods using a similar risk scale of 0 to 1. Our results demonstrate the utility of a single-species PSA analysis for evaluating the relative sustainability of a fishery over a broad geographical scale and under time-limited and data-poor circumstances.

Poster CCFR (General Session)

LONG TERM EMISSIONS OF GREENHOUSE GASES FROM PEATLAND RESERVOIRS HAS LIKELY BEEN UNDERESTIMATED

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Previous studies of greenhouse gas emissions from man-made reservoirs have demonstrated two situations where emissions could be similar to those released from fossil fuel-based methods of electricity production. These are tropical reservoir sites and northern sites where peatlands containing large stores of carbon are flooded. We have studied emission rates from a peatland reservoir at the Experimental Lakes Area, Ontario for the last 17 years. Following flooding, there was an initial increase in greenhouse gas emissions, which did not decrease. Our earlier studies of the peatland reservoir emphasized measurement of emissions of greenhouse gases from the air-water interface. One limitation of these early measurements is that they could not be made year round, and could miss emissions that occurred during the annual drawdown period. To overcome this limitation, we also followed the loss of carbon content in the flooded peat. We did this by following the increase in the Hg:C ratio of the peat following flooding. Because the mass balance budget of mercury in the reservoir had been studied simultaneously, and it was well constrained, we were able to use the increase in the Hg:C ratio in the whole peatland to estimate the loss of carbon from the peat on a year round basis, over the 17 year time period. Our most recent data indicate that previous studies underestimated the total loss of greenhouse gas by several fold. Therefore, the importance of greenhouse gas emissions from peatland reservoirs, already thought to be high, appears to have been underestimated.

Oral SCL (Experimental Lakes Area)

LONG-TERM DECLINES IN CRAYFISH DIVERSITY AND ABUNDANCE: THE RELATIVE INFLUENCE OF CLIMATIC, BIOLOGICAL, AND PHYSICAL-CHEMICAL PROCESSES.

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Spatial surveys conducted across 100 lakes in south-central Ontario during 1994 and 2004 have shown that crayfish diversity, relative abundances, and distributions are declining on a broad geographic scale. Annual temporal surveys in a subset of these lakes have documented similar trends. We focus on this latter temporal dataset to examine the patterns and correlates of declining diversity and abundance using multiple regression and time series approaches. While the findings are consistent with declines in calcium concentrations and increases in water temperatures in Shield lakes, there are multiple stressors, including climate variability, altered habitat structure, oligotrophication, and introduced fish species that may also play a role in determining crayfish abundances. Teasing apart the relative influences of these and other stressors responsible for the decline in crayfish across this region remains an important goal for a better understanding of both the ecology and management of this important link in aquatic food webs.

Oral SCL (General Session)

HOMELESS AND HUNTED: IS THIS THE FATE OF MACQUARIE PERCH IN COTTER RESERVOIR, AUSTRALIAN CAPITAL TERRITORY?

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The expansion of Cotter Reservoir from 4GL to 78GL is a major part of the plan to secure water supply in the Australian Capital Territory (ACT). Subsequently the availability of fish habitat will change, potentially having detrimental impacts on the only population of endangered Macquarie Perch, *Macquaria australasica*, in the ACT. This study aims to determine information about the ecology of Macquarie Perch and their predators, cormorants, which will guide effective management of this fish population in the expanded reservoir. Diurnal radio-tracking of 52 adult Macquarie Perch and cormorant observations were conducted at fortnightly intervals for one year. Results show that Macquarie Perch prefer complex structures around the perimeter of the reservoir as daytime refuge. During spring and summer there is a shift in the spatial distribution of Macquarie Perch towards the upstream shallow end of the reservoir. This shift coincides with a significant increase in the abundance of Great Cormorants which also show a preference for the upstream section of the reservoir for foraging. These results suggest that predation risk upon Macquarie Perch is highest in spring and summer when predator numbers are high and there is overlap in spatial distribution. It is recommended that complex structure be maintained around the perimeter of the enlarged Cotter Reservoir, particularly in the top section during spring and summer, in order to conserve this population of endangered fish.

Oral CCFR (General Session)

INVESTIGATING FLUCTUATING ASYMMETRY IN CHAR: A POTENTIAL INDICATOR FOR MONITORING PROGRAMS

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Fluctuating asymmetry (FA) in paired structures has been noted as a potential, but somewhat controversial, indicator of environmental and genetic stress in fish populations. FA may occur when development is disrupted as a result of either environmental change, genetic stress, or a combination of both. We investigate the frequency of this event occurring in northern Canadian populations of Arctic char (*Salvelinus alpinus*), Dolly Varden (*S. malma*) and bull trout (*S. confluentus*). The following suite of meristic characters were analysed to identify FA in these chars: pectoral fin rays, pelvic fin rays, upper gillrakers on the first gill arch and lower gillrakers on the first gill arch. Fluctuating asymmetry may prove to be a cost-effective, non-lethal method of detecting change in chars and could become an integral component of monitoring programs.

Poster CCFR (Arctic resources)

AN ISOLATED POPULATION OF THREE-SPINED STICKLEBACK (*GASTEROSTEUS ACULEATUS*) IDENTIFIED IN NUEL TIN LAKE, MANITOBA AND NUNAVUT: POST-GLACIAL DISPERSAL AND POPULATION RELATEDNESS

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Gasterosteus aculeatus, the three-spined stickleback, is a small anadromous fish species complex that is a well known model for behavioural and evolutionary studies. In particular, rapid evolutionary radiations in post-glacial timeframes have resulted in distinct local populations with remarkable variation in morphological, physiological, and behavioral characteristics. This study compares coastal populations of *G. aculeatus* from Hudson Bay with a putatively non-migratory population from Nuel tin Lake, Manitoba. The objective of this study is to use morphological and molecular analyses to describe post-glacial dispersal and colonization events of *G. aculeatus*, to assess population relatedness and to identify evolutionary divergence. Current results reveal significant population level differences between *G. aculeatus* found in Nuel tin Lake and those found within the Thlewiaza watershed; as well as those from adjacent watersheds. Genetic and morphological differences will be discussed with respect to post-glacial isolation as a result of isostatic rebound inhibiting gene flow between Nuel tin Lake and Hudson Bay populations. The identification of an isolated and genetically distinct population in Nuel tin Lake, Manitoba may also present an opportunity to investigate similar evolutionary events and post-glacial colonization patterns in other northern aquatic organisms. Through further research opportunities, localized physiological and behavioural strategies may be recognized and consideration of special conservation status of the Nuel tin Lake population could be required, as has been granted for isolated populations of *G. aculeatus* elsewhere in the world.

Oral CCFR (Arctic resources)

CONTROLS OF PRODUCTIVITY AND RESPIRATION DYNAMICS IN SALINE PRAIRIE LAKES

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Prairie lakes are often characterized by high salinities in combination with elevated nutrient levels. Yet, primary production estimates in these systems are commonly below those of freshwater lakes with comparable nutrient concentrations. Potential reasons are thought to be related to osmotic stress, limited bioavailability of nutrients, enhanced grazing, or competition by benthic algae. Additionally, increased respiration rates may also limit primary production in these systems. To address these questions we applied dual-budget approaches, concentrations and stable isotope values, to dissolved oxygen and dissolved inorganic carbon across 20 prairie lakes. Additionally, we measured Chl a concentrations throughout the water column to obtain biomass-specific estimates for productivity and respiration. Our study lakes had very large ranges for salinity, nutrients, water depth and food-web structure, which allowed us to estimate the relative importance of these parameters in controlling productivity in these systems.

Oral SCL (General session)

PHOTO-INHIBITION OF PHOSPHATE UPTAKE IN UVR EXPOSED PLANKTON ASSEMBLAGES: RATE OF RECOVERY AND INFLUENCE OF CELL SIZE

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We examined the effect of ultraviolet radiation (UVR) and plankton cell size (0.2-0.8, 0.8-2.0 and >2.0µm) on the level of photo-inhibition and rate of recovery for natural plankton assemblages from 9 freshwater lakes located in Central Saskatchewan, Canada. Plankton assemblages were incubated for 4h under artificial sunlight (SUNTEST Solar Simulator, 250Wm⁻²). Radio-phosphate (³³PO₄) uptake assays were conducted at 0, 1, 2 and 4 hours post incubation. Photo-inhibition was inferred from a decline in the rate of ³³PO₄ uptake relative to controls; whereas, recovery was inferred by a gradual increase in the rate of ³³PO₄ uptake over time. A significant reduction in the rate of ³³PO₄ uptake was observed in 7 of the 9 lakes. Rate of recovery was rapid with full recovery detected 1-4 hours post incubation. ³³PO₄ uptake in control vessels was typically dominated by cells <0.8 µm in size. However, ³³PO₄ uptake in cells <0.8 µm declined 3-90% in UVR exposed samples, with complete inhibition of PO₄ uptake occurring in 2 lakes. Photo-inhibition of the 0.8-2.0 µm size fraction was minimal; whereas, >2.0 µm plankton were generally unaffected by UVR exposure. The percentage of total ³³PO₄ acquired by larger cells (>0.8 µm) increased concomitantly with a decline in ³³PO₄ acquired by cells <0.8 µm. However, recovery of cells <0.8 µm over time reversed this trend (i.e., the percentage of ³³PO₄ in cells <0.8 µm increased, with a concomitant decrease in the percentage of ³³PO₄ in cells >0.8 µm). In summary, our study demonstrates that UVR may reduce rates of P uptake in natural plankton assemblages, although recovery may be rapid (1-4h). UVR primarily affects cells <0.8 µm in size, and larger plankton may have a competitive (albeit temporary) advantage in P acquisition in the surface water of lakes exposed to UVR.

Oral SCL (Nutrients)

TROPHIC LINKAGES AMONG ZOOPLANKTON, THE INVASIVE RAINBOW SMELT (*OSMERUS MORDAX*) AND WALLEYE (*SANDER VITREUS*) IN LAKE WINNIPEG

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Invasive species can have both negative and positive impacts on the trophic structure of aquatic systems. Rainbow smelt were first observed in Lake Winnipeg during late 1990 and their impact on upper and lower trophic levels is unclear. Walleye is a commercially important species in the lake and is a potential predator of rainbow smelt. Since smelt were observed, walleye populations appear to be thriving and catches have increased. To determine impacts of this invasive species, basic information on the dietary composition of these species first must be elucidated. During mid-Summer 2009, we simultaneously sampled the stomachs of walleye and smelt and characterized the zooplankton community in the North Basin of Lake Winnipeg. Zooplankton samples and rainbow smelt (total length: 70 - 130 mm) were collected from 7 stations on M.V. *Namao*. The relative abundance of four zooplankton prey groups (copepods, *Daphnia* spp., *Eubosmina* spp. and *Bosmina* spp.) was analyzed from the zooplankton samples and the smelt stomach contents. Walleye (total length: 180 - 580 mm) were collected from 3 locations via gillnetting and their stomach contents were examined for presence of rainbow smelt, including both intact fish and otoliths. Proportions of walleye stomachs containing rainbow smelt and size distributions were determined to assess the contribution of rainbow smelt to the diet of walleye. With detailed knowledge of the trophic linkage among walleye, rainbow smelt, and the zooplankton community we can begin to quantify the effects of invasive rainbow smelt on the foodweb structure of the lake.

Poster CCFR (Trophic linkages)

ENVIRONMENTAL STABILITY AND LAKE PLANKTON DIVERSITY- CONTRASTING EFFECTS OF CHEMICAL AND THERMAL VARIABILITY

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Environmental variability in space and time is a primary mechanism allowing species that share resources to coexist. Fluctuating conditions are a double edged sword for diversity, either promoting coexistence through temporal niche partitioning or excluding species by stochastic extinction. The net effect of environmental variation on diversity is largely unknown. We examined the association between zooplankton species richness in lakes and environmental variability on interannual, seasonal and shorter time scales, as well as long-term average conditions. We analyzed data on physical, chemical and biological limnology in 53 temperate zone lakes in North America and Europe sampled over a combined 1,042 years. Large fluctuations in pH, phosphorus and dissolved organic carbon concentration on different time scales reduced zooplankton species richness. More species were found in lakes that showed greater temperature variation on all time scales. Richness was more closely associated with interannual and unpredictable environmental variability than long-term mean conditions or the degree of seasonality. Overall, temporal fluctuations in the chemical environment tended to exclude zooplankton species while temperature variability promoted greater richness. The results indicate that anthropogenic increases in temporal variability of future climates may have more profound effects on biodiversity than changes in the long-term average conditions.

Oral SCL (Experimental Lakes Area)

A DECISION ANALYSIS EVALUATING MANAGEMENT OPTIONS FOR THE DAM ON THE BLACK STURGEON RIVER

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This study is using decision analysis to quantify ecological and social trade-offs, and to evaluate management options, for the dam on the Black Sturgeon River, a tributary of Black Bay, Lake Superior ON. Human alteration of the Great Lakes allowed the invasion of the parasitic sea lamprey, which contributed to declines of large native fishes. The invasion of the sea lamprey has led to the implementation of a binational control program relying on in-stream applications of chemicals, trapping, and barriers to reduce abundances of sea lamprey. Barriers prevent maturing sea lamprey from accessing upstream spawning habitat and the Black Sturgeon River dam serves an important control function in Lake Superior. In-stream barriers can also impede the migrations of native fishes and there is concern that the Black Sturgeon dam is impeding recovery of walleye and lake sturgeon in the Black Bay area. Management options for the Black Sturgeon dam include complete dam removal, reconstruction of the aging dam, dam reconstruction with provisioning of selective fish passage, and dam relocation above habitat suitable for walleye and lake sturgeon spawning and rearing. Literature syntheses and stage-structured models of population dynamics have been combined to characterize key uncertainties associated with each management option and the trade-offs between sea lamprey control and recovery of walleye and lake sturgeon. Explicitly quantifying and communicating the trade-offs and projected outcomes for the management options is expected to help stakeholders reach a decision for the Black Sturgeon dam that is balanced, sound, and scientifically defensible.

Oral CCFR (Quantitative tools)

POPULATION STRUCTURE OF PACIFIC LAMPREYS (*ENTOSPHEMUS TRIDENTATUS*) ALONG THE WEST COAST OF NORTH AMERICA

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The strategies used by anadromous fish to select spawning sites affect the degree of population structure present in the species. Salmonids, which use olfactory cues to return to their natal streams, exhibit a high degree of genetic differentiation among populations. In contrast, sea lampreys do not home to their natal streams and instead select spawning sites using pheromones released by larval lampreys, resulting in a panmictic population. The migratory strategy used by Pacific lampreys is unknown, and previous studies have provided conflicting results regarding population structure. Pacific lampreys, like sea lampreys, respond to larval pheromones, suggesting a similar lack of natal homing. Furthermore, 99% of mitochondrial DNA variation in Pacific lamprey from north-central British Columbia to northern California was found to occur within drainages rather than among drainages. However, differences in morphology and life history traits among lampreys spawning in different river systems, as well as significant differences in amplified fragment length polymorphism variation among groups of lampreys in the Pacific Northwest, support the hypothesis of local adaptation and genetic differentiation among populations. In this study, we use 11 microsatellite markers (which provide greater resolution than genetic techniques previously used in this species) to determine the degree of population structure present in Pacific lamprey along the west coast of North America. Pacific lamprey numbers are declining in parts of their range, and conservation efforts (including attempts to restore spawning runs using lampreys from different locations) must consider whether Pacific lampreys are a single panmictic population or many genetically differentiated populations.

Poster CCFR (Conservation Genetics)

CLIMATE CHANGE EFFECTS ON AQUATIC ECOSYSTEM HEALTH

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While substantial attention has been given to the effects of climate change on human health, it remains unclear how climate change will affect the health of inland aquatic organisms. Current projections for inland and marine systems forecast increases in parasite prevalence and disease at multiple trophic levels due to climatic forcings. Because organismal health is highly sensitive to changes in habitat quality and food web stability, it could serve as an early indicator of the effects of climate change on aquatic ecosystem structure and function. Additionally, aquatic organism health is an important consideration for conservation programs and commercial fisheries. I analyzed samples of fish, zooplankton, invertebrates and phytoplankton from ten representative lakes in the Saskatchewan prairie to determine how parasitism, niche shifts and fish body condition may reveal changes in the health of ecosystems destabilized by climate change. The ten lakes span a broad range of water qualities and species compositions in order to identify potential environmental controls on parasite and disease prevalence. Preliminary results show considerable spatial and temporal variation in fish health and condition. While many of the effects of climate change on aquatic ecosystems are unclear, health and condition effects are clearly pivotal factors in climate change biology.

Oral CCFFR (Trophic linkages)

DO FOOD WEB DISRUPTIONS ALTER PREDATOR-PREY INTERACTIONS IN FISH COMMUNITIES?

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Understanding predator-prey interactions is a central goal in ecology and evolution, as the outcome of these interactions influences the dynamics of populations, communities, and ultimately, the functioning of ecosystems. Classical optimal foraging theory posits that predators should distribute themselves on the distribution of their prey ('prey tracking'), whereas more recent theoretical work suggests that predator distribution may match that of their prey's resource (which they do not consume: 'resource tracking'). We conducted a study in which we simultaneously quantified predators, prey, and qualities of habitat patches of fish communities in Lake Huron over two years (2001 and 2004). Substantial changes in the food web of Lake Huron occurred during this time period, leading to speculation that this may alter the interactions between predators and prey in pelagic fish communities. We used hydroacoustic techniques to survey fish communities and bottom habitat qualities. Spatial statistical approaches were used to identify hotspots of fish biomass in different trophic levels. In 2001, predator and prey hotspots were observed at similar habitats, indicating resource tracking may have been occurring. This pattern switched in 2004, when predator and prey hotspots were observed at different habitats. However, predator hotspots coincided with locations of high prey biomass in 2004 (but not 2001), suggesting that predators may have switched to a prey tracking strategy. Thus, predators may have flexible foraging strategies that allow relatively rapid responses to substantial changes in food web structure.

Oral CCFFR (Trophic linkages)

A NEW APPROACH TO INVESTIGATE THE LINK BETWEEN FOOD QUALITY AND SECONDARY PRODUCTION IN MARINE ECOSYSTEMS

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Copepods, the most abundant group of zooplankton, are the main primary consumers in most marine ecosystems, forming a critical link in the food web between primary-producing phytoplankton and planktivorous fish. Examining this link is crucial to effectively estimate the transfer of energy within a food web. Historically, phytoplankton abundance has been represented in terms of total (or size-fractionated) chlorophyll concentration, which does not provide information on the nutritional value of the diet available to zooplankton. Similarly, total zooplankton biomass has typically been used to represent food available to larval fish, which becomes problematic in oceanic systems wherein advection, patchiness, and vertical migration come into play. More recently, “bioindicators” (e.g. fatty acids, stable isotopes) have been used to highlight the importance of food quality rather than food quantity. Lab studies examining the fatty acid content of copepods have clearly demonstrated the potential for variations in food quality to affect growth, however, these results have yet to be observed in the field where consumers are exposed to a much wider range of foods of differing nutritional quality. This research will examine the fatty acid content of copepods in order to assess the quality of the phytoplankton diet consumed. In addition, a new technique involving the crustacean moulting enzyme, chitinase, will be used to obtain *in situ* measurements of secondary production. Ultimately, this study will represent the first time quantitative measurements will be used to link community-level secondary production to changes in primary production across temporal and spatial scales in marine ecosystems.

Oral CCFRR (Trophic linkages)

NO RECOVERY OF COD IN ATLANTIC CANADA AFTER FIFTEEN YEARS WITH LITTLE FISHING: ARE COD TRAPPED IN A PREDATOR PIT?

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Cod stocks in the southern Gulf of St. Lawrence (SGSL) and on the eastern Scotian Shelf (ESS) collapsed in the late 1980s and early 1990s and have not yet recovered. A fishing moratorium was imposed in these areas in 1993, though small fisheries were re-opened in the SGSL in 1998. Despite severely limited fishing, the biomass of large cod (ages 5+ yr) has declined further, by 90% on the ESS and 70% in the SGSL. The main reason for the lack of recovery of these stocks is elevated natural mortality (M) of adult cod. In both stocks, estimated M increased in the 1980s, reaching levels above 0.6 in the 1990s and 2000s. These levels are well above values considered normal for adult cod (about 0.2). We examine hypotheses for the elevated M in these stocks, in particular the hypothesis that cod in these areas are trapped in a predator pit, resulting from the collapse in cod biomass due to overfishing coincident with a dramatic and continuing increase in the abundance of grey seals (*Halichoerus grypus*).

Oral CCFRR (Trophic linkages)

HOW DO ANADROMOUS ARCTIC CHARR (*SALVELINUS ALPINUS*) AFFECT THE ECOLOGY OF COASTAL ARCTIC LAKES?

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Although Arctic charr (*Salvelinus alpinus*) are iteroparous and do not contribute “on mass” carcass additions to freshwater lakes, anadromous Arctic charr may facilitate the transfer of marine-derived nutrients to freshwater lakes through egg deposition and overwintering mortality. From 2006-2008, we investigated nutrient budgets, trophic ecology, fish growth, and food web structure in six lakes located in Nunavut, Canada; three lakes contained partially anadromous Arctic charr whereas three lakes did not. Forage fishes and lake trout (*Salvelinus namaycush*; top predator) were present in all lakes. Using water chemistry data, we found that anadromous Arctic charr do not likely have an effect on primary productivity in Arctic lakes. Consistent with this, stable carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope ratios of fishes and invertebrates did not indicate a marine subsidy in lakes where anadromous Arctic charr were present. Lake trout C:N and condition were significantly higher in lakes with Arctic charr, however, and ninespine stickleback (*Pungitius pungitius*) condition was significantly lower. Isotope data indicated that pre-smolt and resident Arctic charr may function as prey for lake trout and a competitor for ninespine stickleback. Linear distance metrics applied to isotope data showed that food webs were more compact and had more isotopic redundancy in lakes where Arctic charr were present. Despite this, lake trout populations in these lakes occupied a larger isotope space and showed greater diet specialization. Anadromous Arctic charr appear to affect ecology and feeding of sympatric freshwater species, but effects are more subtle than those seen for anadromous Pacific salmon species.

Oral CCFFR (Trophic linkages)

OLD, COLD, SALTY LAKE TROUT (*SALVELINUS NAMAYCUSH*): ANADROMOUS LAKE TROUT IN THE CANADIAN ARCTIC

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In the family Salmonidae, lake trout (*Salvelinus namaycush*) are considered the least tolerant of saltwater. There are, however, sporadic reports of lake trout in coastal, brackish habitats in the Canadian Arctic. Recent physiological work has shown that lake trout gills retain some osmoregulatory functions common to anadromous salmonids. Otolith microchemistry analyses conducted on lake trout and Arctic charr (*Salvelinus alpinus*) from 4 Canadian Arctic lakes revealed that 37 of 140 lake trout made annual marine migrations. Anadromous lake trout were in significantly better condition, had significantly higher C:N ratios, and had significantly higher $\delta^{15}\text{N}$, $\delta^{13}\text{C}$, and $\delta^{34}\text{S}$ isotope ratios than resident lake trout; results were similar for Arctic charr and agree with previous findings. Mean age of first migration for lake trout was 13 years, which is significantly older than that for Arctic charr (5 years). This could be a reflection of size-dependent salinity tolerance in lake trout, but further research is required. These are the first detailed scientific data documenting anadromy in lake trout. Results are interpreted in the contexts of partial migration and conditional life history strategies.

Oral CCFFR (Arctic resources)

ASSESSING ENVIRONMENTAL CHANGE IN FRESHWATER ECOSYSTEMS IN ARCTIC AND SUBARCTIC NATIONAL PARKS

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Over the next few decades, environmental stressors such as climate change, contaminant loading, invasive species introductions, and resource development are expected to continue to increase in Arctic and Subarctic regions, and the impacts of these stressors on freshwater habitats within northern regions will also increase substantially. Protected areas, such as national parks, will not be immune to these environmental changes, and assessing how freshwater ecosystems will be affected by changes will be essential for effective management and conservation of these unique areas. There is a critical role for fisheries scientists, limnologists and wetland scientists to play in detecting impacts and understanding the consequences to the ecological integrity of northern parks. In this talk, I will present recent initiatives towards monitoring ecological changes in freshwater ecosystems in northern parks, and some of the partnerships that have been developed as part of freshwater research during the International Polar Year, as well as discuss additional opportunities for freshwater research in northern national parks.

Oral SCL (Arctic resources)

THE NUTRITIONAL STATUS OF SUBARCTIC LAKES IN WAPUSK NATIONAL PARK

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Understanding how ecosystems will respond to environmental change is particularly important in northern regions, as climate change is predicted to have profound effects in this area. In the subarctic, melting permafrost is expected to affect lake chemistry through changes in the cycling of nutrients and organic matter. In an effort to understand how aquatic ecosystems in subarctic regions will respond to future climate change, we assessed the nutritional status of 21 lakes in Wapusk National Park. Each lake was sampled for water chemistry and chlorophyll a. Nitrogen:phosphorus ratios suggested that all of the study lakes are limited by phosphorus. To test this, we conducted 6-day nutrient enhancement experiments. Water from each lake was distributed among 16 4-L cubitainers. We created four treatments: phosphorus, nitrogen, phosphorus and nitrogen, and a control where no nutrients were added. Nutrients were added at a concentration 10x the average ambient density across our study lakes. Results from our nutrient enrichment bioassays showed that 24% of the study lakes were phosphorus limited, 14% were nitrogen limited, 24% were co-limited by phosphorus and nitrogen and 38% were not limited by either nitrogen or phosphorus. This suggests that the controls on phytoplankton growth in these subarctic communities are complex and involve many factors. This has implications in the face of future climate change, which will likely have large impacts on plankton communities in the subarctic.

Oral SCL (Nutrients)

FOREST AND WETLAND ORGANIC MATTER AS A SUBSIDY FOR RECOVERING INVERTEBRATE COMMUNITIES IN A SUDBURY LAKE

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Watersheds with healthy forests, productive wetlands, and organic soils provide clean water and a steady flow of organic materials and nutrients to receiving lakes. Many of the historically acid and metal-stressed watersheds of the Sudbury area are devoid of these important organic matter and nutrient subsidies. Their lakes are characteristically clear and unproductive, and the nearshore benthic macroinvertebrate communities are less diverse than would be expected when compared to reference conditions. Recent studies in the Daisy Lake watershed show positive relationships between forest and wetland cover, the export of particulate organic matter, and diversity of nearshore benthic macroinvertebrates. This work indicates that these terrestrial systems are providing subsidies to these recovering aquatic communities, and that without this important subsidy aquatic diversity is severely impaired. Differences in organic matter quantity and quality were related to wetland cover and other measures of watershed composition. This research will help to understand how terrestrial systems subsidize aquatic food webs, as well as promoting land reclamation practices that assist biological recovery of damaged aquatic systems.

Oral CCFFR (Wetlands)

VARIATION, MIGRATION AND POPULATION ASSESSMENT IN ARCTIC FISHES

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Canadian Arctic communities in the Nunavut and the Northwest Territories depend upon a limited selection of anadromous species for subsistence needs and sport and commercial enterprises. These taxa are targeted because their unusual life cycles give them the characteristics most desirable to primitive harvesters. Their migrations are predictably seasonal with their numbers highly concentrated in time in space. Harvesters are able to use gillnets or weirs to capture large numbers of these fishes with little effort. At the same time there are alternative forms of many species that do not leave freshwater lakes and thus provide a stable source of food throughout the entire year. While sensitive to harvest stocks are very difficult to assess due their complex life cycles. For example, broad whitefish and inconnu growth curves to determine production are difficult to estimate for individual stocks because the offspring rear in locations geographically remote from the spawning grounds. Like Arctic charr, adults may spend several seasons resting after spawning and therefore catch-per-unit-effort indices are suspect. Arctic charr present an even greater difficulty for stock assessment because a large and variable portion of the adult population may be resting and migrating into other systems. Thus, most abundance estimates suffer from a lack of a closed population. Fishery analyses rely on observations of age structure and comparisons with other situations. Precise levels of exploitation rates are not known. These problems have not been solved as yet and there is no management model that is satisfactory.

Oral CCFFR (Arctic resources)

SEASONAL HABITAT SELECTION BY LAKE TROUT IN A BOREAL LAKE

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The need for cold, well-oxygenated waters significantly reduces the habitat available to lake trout (*Salvelinus namaycush*) during stratification of small temperate lakes. We examined their spatial and pelagic distribution over two consecutive summers and winters to test whether winter increased habitat availability and access to prey in littoral regions. Telemetry methods involved the implantation of pressure-sensing acoustic transmitters, which were monitored by passive receivers and an automated positioning system. In winter, lake trout had a narrowly-defined pelagic distribution (<3 m) spatially situated in the central region of the lake. Individual core areas of use were much reduced (75 %) and spatially non-overlapping compared to summer areas, but activity levels were similar between seasons. Winter habitat selection is in contrast to observations from the stratified season, when lake trout were consistently located in much deeper waters (>6 m) and widely distributed throughout the lake. Trout winter distribution appeared to be strongly influenced by ambient light levels; snow depth and day length accounted for up to 69 % of the variation in daily median fish depth. More restricted habitat use during winter than summer refutes our original prediction and illustrates that a different suite of environmental factors influence seasonal lake trout distribution.

Poster CCFR (Experimental Lakes Area)

TOTAL PHOSPHORUS AND P SEDIMENTATION; IMPLICATIONS FOR LAKE HOMEOSTASIS AND LAKE MANAGEMENT

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A survey of published information on total phosphorus concentration (TP) in lakes reveals an approximately lognormal distribution with a strong mode in the oligotrophic range for deep lakes ($z_m > 10$ m) and in the oligo-mesotrophic range for shallower lakes ($z_m \leq 10$ m). Although different geographic regions have different modes, probably related to land use and geology, the strong central tendency and relatively low values of the modes relative to other surface waters suggest that they reflect internal processes in the lakes. We tested this hypothesis by examining both the relationship between spring TP and summer TP, and the relationship between P sedimentation rate ($\text{mg P m}^{-2} \text{d}^{-1}$) and TP. Both relationships are consistent with the hypothesis that P sedimentation varies non-linearly with TP and that sedimentation velocity of P (m d^{-1}) increases with TP. Lakes with very low TP appear to conserve P during stratification while lakes with higher TP export relatively more P to the sediments, and the net result is the strong mode at the TP concentrations over which sedimentation accelerates. The data also suggest that P sedimentation declines again in the eutrophic range, possibly because colonial, buoyant phytoplankton increase. The management implication is that TP responds weakly to increases in loading in lakes near the mode and may be a poor indicator of nutrient stress. We hypothesize that significant deterioration in littoral and hypolimnetic habitats may occur before epilimnetic TP responds to loading.

Oral SCL (Nutrients)

SEASONAL MOVEMENT AND HABITAT USE OF A LACUSTRINE POPULATION OF BROOK CHARR (*Salvelinus fontinalis*) USING ULTRASONIC TELEMTRY

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Brook charr (*Salvelinus fontinalis*) behaviour was investigated to determine the suitability of existing near shore sampling techniques and gear for estimating population size and community structure in lakes. Seasonal habitat use and fish movement was monitored in a small pond in the Indian Bay watershed east of Gander, Newfoundland from September 2008 to November 2009. Twenty brook charr were internally tagged with pressure and temperature sensing Vemco ultrasonic telemetry tags. Fish positions were monitored using Vemco VR2W acoustic receivers arranged in an equilateral triangle grid throughout the lake. The results of these position data were compared with pond limnology, light transmittance, and pond morphometry data to identify seasonal and diel patterns in lacustrine brook charr behavior.

Oral CCFR (Habitat assessment)

TESTING A HABITAT SUITABILITY INDEX MODEL FOR LAKE STURGEON (*ACIPENSER FULVESCENS*) IN THE RAINY LAKE SYSTEM OF NORTHWESTERN ONTARIO

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Until recently there has been very little known of the life history of Lake Sturgeon in the Rainy Lake system on the Ontario/Minnesota border. Studies began in 2002 with a focus on critical habitat identification for adult spawning. Work has continued through to present with indexing of genetic diversity, estimation of adult seasonal movement patterns, estimation of adult population size, and identification of pre-spawn sexual hormone indicators of maturity. As an effort to capitalize on the current momentum of interest and resources we will be attempting to further develop the knowledge base of Lake Sturgeon within our study area. Our approach involves aspects of Habitat Suitability Index Models (HSIM) in assessing the environments presented through this large, complex mesotrophic system. The first step will be testing an HSIM using fetch, depth, and substrate as variables in predicting invertebrate prey abundance, a key component in habitat selection. We will then utilize density estimates from previous lake sturgeon sampling efforts to create an isodar to show optimal habitat at low density. This will then be compared to the optimal habitat as shown by an HSIM for foraging adults, assuming that a habitat with a rank of 1.0 in the HSIM model is optimal. With the typical invertebrate biomass being greatest within the near shore areas of this system, a supervised classification of the near shore sub-surface substrate through high resolution GIS imagery will attempt to identify these predicted habitats.

Poster CCFR (Habitat assessment)

CO₂ AND CH₄ FLUXES AT EASTMAIN 1 RESERVOIR (QUEBEC, CANADA) USING THREE DIFFERENT METHODS

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The growing concern regarding the long-term contribution of freshwater reservoirs to atmospheric greenhouse gases (GHG) led Hydro-Québec to study net GHG emissions from Eastmain 1 reservoir. The net emissions are those related to the creation of a reservoir minus those that would have been emitted or absorbed by the natural systems over a 100-year period in the absence of the reservoir. This large study is realized in collaboration with the University of Quebec in Montreal, McGill University and Environnement Illimité Inc. The measurement of GHG fluxes were conducted by 1) measuring gas partial pressures with gas chromatography and infrared instruments during field campaigns (punctual monitoring) and with automated systems (continuous monitoring), 2) measuring direct fluxes with floating chambers, and 3) measuring CO₂ concentration in the air originating from a large upwind area using the eddy covariance technique. Follow up of the CO₂ and CH₄ fluxes at the Eastmain 1 reservoir showed a rapid increase in both CO₂ and CH₄ emissions the first year after flooding and a rapid return to natural aquatic ecosystem values within two and three years for CH₄ and CO₂, respectively. All three measurement techniques showed comparable results during the summer season indicating that the net GHG evaluation that will be done in 2010-2011 will be based on highly representative results of the Eastmain 1 reservoir emissions. Overall GHG emissions from Eastmain 1 reservoir are very low in comparison to thermal power plants of the same capacity.

Oral SCL (General Session)

GENETIC BASIS OF FLESH COLOUR IN CHINOOK SALMON

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There is high variation among Chinook salmon populations in the amount of carotenoid deposition in the flesh, leading to populations of white- or red-fleshed Chinook salmon. Current research suggests that the genetic variation underlying this phenotypic variation may be relatively simple, with as few as one or two alleles causing reduced pigment deposition in white-fleshed populations. To begin examination of the genetic basis of flesh colour, white and red Chinook were reared on pigmented and unpigmented food, and gene expression within the muscle was compared using microarrays. Analysis of transcriptomic data, particularly if combined with proteomics data, may have the potential to indicate possible physiological mechanisms such as reduced pigment transport in the blood or reduced pigment uptake that may cause muscle to have low pigment levels. More in-depth genetic analysis will make use of backcross lines between the two strains that have been generated to begin searching for quantitative trait loci associated with carotenoid deposition. This research has applications for the development of genetic mapping resources in Chinook salmon, as well as understanding the ecological and evolutionary basis of flesh colour variation in salmonid populations.

Oral CCFFR (Divergent morphotypes)

PHOSPHORUS DEFICIENCY INDICATORS IN LAKES

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Phosphorus is often the primary nutrient limiting productivity in freshwater systems. Assessing the degree to which plankton are P limited is therefore of considerable interest. Several techniques have been used to measure P deficiency. However, studies often report conflicting results when multiple indicators are used simultaneously. We examined the common P deficiency indicators soluble reactive phosphorus (SRP), total phosphorus (TP), specific alkaline phosphatase activity (SAPA) and dissolved phosphate turnover time (TT), in addition to the more recent steady state phosphate (ssPO₄) technique. Measurements were performed for 39 Saskatchewan lakes ranging in TP concentrations from 7 to 298 µg L⁻¹ during the summers of 2008 and 2009. SRP was correlated with TP and TT was correlated with ssPO₄. SRP and TP were correlated with TT but the relationships were strongly influenced by four high TP lakes; these variables were not correlated in lakes with TP < 75 µg L⁻¹. SAPA was inversely related to ssPO₄ and had similar but successively weaker relationships with TT, TP and SRP. These relationships suggest that low SAPA can indicate a very broad range of P limitation, whereas high SAPA only occurs at very low PO₄ concentrations. Overall, results support the use of ssPO₄ and TT as P deficiency indicators, but not SRP and TP. SAPA can be useful for detecting extreme P deficiency but becomes uninformative when P deficiency is moderate or low.

Oral SCL (Nutrients)

"FISHING THE LINE" AROUND REGULATORY CLOSURES

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Recent studies have examined the distribution of fishing activities around marine protected areas (MPAs) and seasonal closures. Fishing effort becomes concentrated at the boundaries of these closures, termed "fishing the line", in an attempt to exploit "spill over" from the protected areas. However, contrary to the expected benefits of fishing at the boundary, often the catch rates closest to the boundary are lower than those found farther away. In this study we examine the relationship between profitability and distance from the boundary of the Brown's Bank spawning closure that protects Scotian Shelf haddock (*Melanogrammus aeglefinus*). We employ statistical analyses of hypotheses developed from the game theoretic perspective of the ideal free distribution. Our analysis incorporates data from vessels logs and price reports from the otter trawl fishery. Preliminary analysis indicates that there is indeed a strong "fishing the line" component to this fishery during the closure months with effort concentrated along the north-west, east, and south-east boundaries of the closure. On at least one of the boundaries, the eastern boundary, the pattern of lower catch rates closer to the boundary relative to farther away appears to be present in 2005 and 2006 but this does not seem to be reflected in the effort distribution. Future work will incorporate fuel cost estimates and vessel movements to investigate this pattern as well as broader scale vessel movement among neighbouring banks.

Poster CCFR (Including fishers in fisheries science)

BEHAVIOURAL RESPONSES OF JUVENILE ATLANTIC SALMON (*SALMO SALAR*) WHEN EXPOSED TO JUVENILE EXOTIC SALMONIDS

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Over-exploitation and habitat alteration has led to the extirpation of the Lake Ontario Atlantic salmon (*Salmo salar*), a once abundant top predator. Reintroduction of Atlantic salmon has been actively pursued in recent years to restore waning biodiversity of the lake and provide economic benefits through recreational fishing. However, reintroduction efforts have been unsuccessful perhaps because of the presence of non-native and ecologically similar salmonids stocked in Lake Ontario. Here we use semi-natural stream experiments to examine aggressive and feeding behaviours exhibited by three stocks of juvenile Atlantic salmon (La Have, Lac St. Jean, and Sebago Lake) when exposed to juvenile brown trout (*Salmo trutta*), an aggressive non-native salmonid, and juvenile rainbow trout (*Oncorhynchus mykiss*), a non-native species exhibiting considerable niche overlap with Atlantic salmon. We propose that interactions between Atlantic salmon and these non-native species are adversely affecting growth and survivorship of the Atlantic salmon during the critical freshwater juvenile stage of life. We will discuss our data in light of the feasibility of reintroducing juvenile Atlantic salmon into streams with or without stocked or established populations of non-native juvenile brown trout and rainbow trout in Lake Ontario. We will also discuss the efficacy of each of the La Have, Lac St. Jean and Sebago Lake stocks of Atlantic salmon proposed for reintroduction into the Great Lakes.

Oral CCFR (General Session)

TAXONOMIC DIVERSITY OF CISCOES IN GREAT SLAVE LAKE

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Coregonine diversity in Great Slave Lake, NT has not been adequately described and the taxonomic associations of forms in this lake are poorly resolved. We collected ciscoes from three lacustrine and one riverine site in Yellowknife Bay and two lacustrine and one riverine site in the east arm between September and October 2008. We employed a traditional taxonomic approach to identify the number of unique forms (i.e., morphs), described and compared those morphs, and developed a preliminary taxonomic key based on qualitative and quantitative traits. We identified five cisco morphs: A) riverine; B) lacustrine; C) shortjaw; D) googly-eye; and E) big-eye. These morphs can be distinguished based on habitat of capture, eye size and position, mouth orientation, head profile, dorsal fin height versus width of the base, caudal fin shape, paired fin length, dorsal body coloration, comparative osteology and gillraker number. These analyses indicate that the species complex in Great Slave Lake is composed of several morphs and that the pattern of phenotypic differentiation may parallel that observed in systems such as the Laurentian Great Lakes. Great Slave Lake is relatively unperturbed and, therefore, provides a rare opportunity to study ecological divergence in a more 'natural' setting in comparison to the Laurentian Great Lakes where much of the native diversity has been lost.

Poster CCFR (Arctic resources)

INTERSPECIFIC AND INTRASPECIFIC OSTEOLOGICAL VARIATION IN SYMPATRIC CISCOES, YELLOWKNIFE BAY, GREAT SLAVE LAKE

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In North America, 11 species of Coregonine ciscoes are recognized. These species exhibit considerable interspecific and often, intraspecific morphological variation. Currently, *Coregonus artedi* is the sole taxon recognized in Great Slave Lake, Northwest Territories; however, ongoing research supports the hypothesis that an array of forms and/or species may be present. In this study, comparative osteology was used to evaluate variation in bones related to food acquisition (i.e., trophic morphologies) as one method for distinguishing among ciscoes. A total of 15 ciscoes were examined, which included 3 putative morphs and/or species: lake cisco, *C. artedi* (n=5), shortjaw cisco, *C. zenithicus* (n=5), and a new form the “googly-eye” cisco (n=5). Although intraspecific variation was observed, it was most prominent in the first pterygiophore, supramaxilla, suspensorium elements and some opercular elements. Despite this variation, there were considerable interspecific differences in the shape of certain dermal elements, particularly in the maxilla, dentary, parasphenoid, and frontal and to a lesser degree, interopercle, preopercle and the supraorbital elements. These differences were prominent enough to serve as ‘hard’ character traits for the identification of taxa. The presence of teeth on the ectopterygoid was unique to the googly-eye cisco and may be considered an autapomorphy, that is, an apomorphy (derived or specialised character) restricted to a single morph/species. This research demonstrates that cisco forms can be distinguished using comparative osteology and the analysis supports the hypothesis that three distinct forms are present in Great Slave Lake.

Poster CCFRR (Arctic resources)

BAKER CREEK ARCTIC GRAYLING: ASSESSING FISH HABITAT USE IN A RECONSTRUCTED STREAM

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Baker Creek originates from a network of small lakes northwest of the city of Yellowknife and flows south through Giant Mine, into Yellowknife Bay on Great Slave Lake. In 2006, a 600 m portion of Baker Creek known as ‘Reach 4’, was realigned to the west side of Highway 6. The primary objectives of the Reach 4 realignment were to isolate the contaminated Mill Pond from Baker Creek, thereby eliminating a source of ongoing contamination, and prevent seepage from Baker Creek into areas of the mine itself (the C1 Pit). A Fisheries Act Authorization required the provision of suitable spawning, rearing, and overwintering habitat for Arctic grayling (*Thymallus arcticus*) as compensation for habitat losses incurred from the realignment. As part of the Authorization, DFO mandated a monitoring program to assess habitat compensation effects on life history stages associated with the realignment. During three years of monitoring, egg site conditions, embeddedness, substrate, flow rates, food availability and overall habitat were studied. In all years since the construction of Reach 4, the measured parameters were within ranges suitable for grayling and longnose sucker spawning. The spawning adult population was characterized by individuals ranging from 4 to 11 years of age with near absence of certain age classes. Successful hatching occurred in Reach 4 and YOY continued to benefit from the available habitat, absence of predators, and appropriate water temperature and flow characteristics of Baker Creek. Young-of-year successfully outmigrated 24 to 38 days after emergence and ranged in size from 36 to 65 mm. Based on our analyses, Reach 4 provides suitable habitat for all grayling life stages.

Oral CCFRR (Habitat assessment)

SUCCESSFUL USE OF FISH TELEMETRY FOR AN ENVIRONMENTAL IMPACT ASSESSMENT: KUTCHO PROJECT BULL TROUT TELEMETRY STUDY 2007-2008

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In Canada, the Environmental Assessment (EA) process involves the collection of baseline information in the area of any planned mining development. A two-year telemetry study on bull trout was undertaken for a planned copper-gold mine in northern British Columbia because of the presence of bull trout (*Salvelinus confluentus*) in the upper watershed where mine infrastructure was planned. Bull trout are listed as a threatened species under the U.S. Endangered Species Act and listed as a species of special concern in British Columbia. A total of 20 small adult bull trout from the upper watershed and 12 large adults from the lower watershed were implanted with radio telemetry transmitters and tracked over two summers. The purpose was to discover critical spawning areas and determine if the bull trout populations in the upper and lower watersheds were isolated by a 1.6 m waterfall barrier. Important results included identification of several bull trout spawning areas and limited migration over the 1.6 m waterfall barrier. Determining the detailed habitat use of bull trout was critical for estimating the potential project effects on this species. This telemetry study had a significant impact on the project because of its important role in developing the detailed Environmental Assessment and helping to change the overall mine plan to reduce environmental disturbance. This type of information is now being required by regulatory agencies such as the federal Fisheries and Oceans Canada (DFO) and the provincial British Columbia Ministry of Environment (BC MOE).

Oral CCFRR (Habitat assessment)

SHIFTS IN FORAGE BASE ALTER LAKE TROUT HABITAT USE

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Lake trout (*Salvelinus namaycush*) are a top predator fish species that are sensitive to change and can be impacted by the introduction of invasive species. Yellow perch (*Perca flavescens*), a common littoral-pelagic forage fish, invaded Lake 626 at the Experimental Lakes Area (ELA) and have become the dominant forage fish, displacing the previous littoral minnow community. We examined whether the invasion by perch influenced the pelagic and spatial distribution of lake trout using acoustic telemetry methods. A Before-After Control-Impact (BACI) design was used to compare lake trout habitat use before (2001) and after (2008) invasion by yellow perch in Lake 626, and in an unimpacted reference lake (Lake 373) that contains a littoral minnow community during the period of peak stratification. Lake trout occupied significantly deeper depths (1.4 m deeper) following the introduction of yellow perch ($t_{17} = 4.5$, $P < 0.001$), after accounting for differences in temperature between years. Similarly, lake trout significantly reduced their presence in littoral regions following the introduction of perch ($t_{14} = 2.5$, $P = 0.025$). Lake trout shifts to deeper, offshore habitat following the introduction of perch is consistent with the change in prey community distribution from shallow littoral regions to littoral-pelagic. This study suggests that the invasion of yellow perch has changed habitat selection by lake trout, which can now access forage fish while remaining in optimal environmental conditions.

Poster CCFRR (Experimental Lakes Area)

AN ASSESSMENT OF PROGRESS OF RECOVERY OF THE WETLANDS IN SOUTHERN IRAQ

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The wetlands on the Mesopotamian Plain in southern Iraq were extensively drained in the 1990s. Re-flooding of drained areas commenced in 2003. This paper focuses on macrophyte vegetation, phytoplankton, and zooplankton (ie. rotifers and cladocerans) studied from 2005 to 2008 in re-flooded areas and parts of the wetlands not drained during the 1990s because these groups have proven to provide good indication of the current state of wetland ecosystem processes and longer term potential to re-establish wetlands in the region. The aquatic macrophyte communities are less diverse and reflect a much more subdued seasonal fluctuation in the quantity of water flowing into and out of the wetlands, and changes in the chemistry of water sources when comparing pre- and post-flooding vegetation communities. The phyto- and zooplankton communities show similar seasonal community shifts towards greater diversity. Preservation of flood pulsing and maintenance of interconnection between the Tigris and Euphrates Rivers with their floodplains will be essential in the longer term restoration of this important riverine wetland ecosystem, and might be accomplished through intricate engineering and management plans of upstream water flowing into the wetlands.

Oral SCL (Wetlands)

IDENTIFYING BULL TROUT POPULATIONS AND THE ORIGIN OF MIGRANT INDIVIDUALS USING GENETIC CLUSTERING METHODS AND TRADITIONAL ASSIGNMENT TESTS IN TANDEM

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Identification of genetic population structure and spatial scale of migration are central considerations in salmonid fish management. Genetic clustering methods based on Bayesian models were used to reveal population structure in the core of the bull trout range of southwestern Alberta. This method of population identification is a more parsimonious alternative to traditional techniques that define populations *a priori* by spawning stream. Populations identified by both genetic clustering and traditional methods were then used as reference populations for genetic assignment of 85 mainstem-caught adult bull trout. Assignment confidence was higher when using reference populations defined by genetic clustering rather than individual spawning streams. In addition, stream distance of migration was calculated for each individual fish to derive the spatial scale over which each population operates. These methods used in tandem are powerful tools and are becoming increasingly accessible for use in practical fisheries management.

Oral CCFR (Conservation genetics)

VARIATION IN MIGRATION RATES OF MATURING FEMALE KOKANEE SALMON IN MEADOW CREEK, BRITISH COLUMBIA

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A population of land-locked kokanee salmon in southeastern British Columbia migrate to their natal spawning grounds at various states of maturity. The fitness consequences of this variation are not yet understood but could be important. Two morphotypes of female kokanee, silver and red (with delayed and advanced maturity, respectively), were monitored during their migration to determine if maturity affected migration rate. We hypothesized that the silver females, being in a less advanced state of senescence, will be able to swim faster and therefore shorten their duration of migration. We used Passive Integrated Transponder (PIT) tags to measure their migration rate over a 5 km stretch as well as over a shorter distance of 25 m. Migration rate was highly variable among females, but the silver females were not significantly faster than the other morphotype. We suggest that alternative factors such as reproductive motivation may play a larger role in determining migration rates in this population.

Oral CCFRR (Divergent morphotypes)

NEW TECHNOLOGY DEVELOPMENTS FOR UNDERSTANDING SPATIAL AND TEMPORAL ACTIVITY PATTERNS OF FISH IN NATURE

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Measurements of fish activity and energetics in nature has always been technologically challenging. We describe the development and implementation of a new accelerometer acoustic transmitter along with a new multi-array positioning system to study the spawning behavior of the banded morwong, *Cheilodactylus spectabilis*.

In Tasmania, Australia, detailed movement and activity information is urgently required for *Cheilodactylus spectabilis* (Hutton 1872), given its vulnerability to fishing. Large-scale array of VR2Ws (VPS) and a small-scale (VRAP) acoustic monitoring systems were used to examine the temporal/spatial movement and activity patterns of *C. spectabilis* implanted with accelerometer acoustic transmitters on rocky reefs on the Tasman Peninsula, Tasmania. *Cheilodactylus spectabilis* exhibited diurnal activity patterns and were highly site attached residents, with $\geq 83\%$ of VR2 detections on one or two adjacent receivers at the tagging site for ≥ 100 days. Those individuals tracked with VRAP and VPS occupied small core areas of reef between 175-868m². *Cheilodactylus spectabilis* fitted with accelerometer/depth tags showed a repeatable pattern of fish moving to >20 m and up to 45m at sunrise to spawn and then returning to <20 m at sunset during the spawning period. Acceleration was calibrated with swimming speed in the laboratory, allowing for swimming activity of individual fish during spawning to be examined. This study has provided important information on the temporal and spatial movement and activity patterns of *C. spectabilis*, including providing crucial information for implementing appropriate management strategies for this vulnerable species.

Oral CCFRR (General session)

THE INFLUENCE OF AN ALTERNATIVE MALE MATING STRATEGY ON EGG FERTILIZATION AND GENETIC DIVERSITY IN ATLANTIC SALMON

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Atlantic salmon (*Salmo salar*) males express markedly different alternative mating strategies. Large anadromous males fight for access to females, whereas small mature male parr sneak fertilizations. In some Atlantic salmon populations, anadromous male returns are declining due to take fisheries, such that mature male parr may be an increasingly important factor for population persistence. Parr may influence effective population size, as well as increase genetic diversity of offspring. We conducted an experiment at the Margaree Fish Hatchery in Margaree, Nova Scotia to investigate the degree to which mature male parr influenced the genetic diversity of offspring, as well as egg fertilization success when small numbers of parr were present. Females spawned with parr in the presence or absence of an anadromous male. Sections were excavated and a subsample of eyed eggs was used to conduct paternity analyses. We sequenced part of the MHC class II β gene, which functions in immune response, to examine whether females were more likely to increase diversity of offspring by spawning with MHC dissimilar males, as whether diversity among offspring was influenced by the presence of an anadromous male. We found no differences in egg survival in the presence or absence of anadromous males. Females mated with more genetically dissimilar mature male parr than would be expected if mating were random with respect to MHC genotype. These findings suggest that mature male parr can play a large role in egg fertilization, and also increase the genetic diversity of offspring at functionally important loci.

Oral CCFRR (Conservation genetics)

EXPERIMENTAL CONSERVATION GENETICS OF ATLANTIC SALMON RESTORATION IN LAKE ONTARIO

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The collaborative effort to re-establish Atlantic salmon to Lake Ontario following its extirpation in the 19th century faces many uncertainties, which necessitate an experimental approach for achieving self-sustaining populations in historical habitats. Challenges range from the establishment and maintenance of captive broodstocks to determining optimal life stages to stock for juvenile survival and adult returns, to assessing the effectiveness of different experimental approaches and management strategies. To address these challenges, genetic markers are being used to track Atlantic salmon at population, family, and individual levels, and evaluate the relative fitness of different strains and life stages. Three allopatric populations with contrasting ecological characteristics have been used to establish broodstocks for experimental stocking. Genetic monitoring of these broodstocks is helping to ensure their genetic diversity and integrity, as well as providing baseline data for identifying proportional contributions to fish in Lake Ontario and its tributaries. Genetic tracking of single-pair matings and family-specific stocking at several juvenile life stages is being used to assess their relative survival and growth in tributaries, as well as their timing of emigration to Lake Ontario with respect to environmental cues. Combined individual assignment tests and parentage analyses are being used to identify the source strain(s), families and stocked life stages of adult Atlantic salmon captured during summer creels on Lake Ontario, as well as adults that were captured in tributary rivers in 2008 and 2009. These results are helping to inform restoration efforts, and will provide ongoing assessment and feedback to help ensure their success.

| Oral CCFRR (Conservation genetics)

VARIABLE SALINITY CONTROLS ON FOOD-WEB COMPONENTS IN PRAIRIE LAKES

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Prairie lakes commonly encompass large gradients for many environmental parameters, including salinity, nutrients, and morphometry. A previous study has shown that significant changes in zooplankton composition were dependent on changes in salinity, Ca, and nutrient concentrations. Here, we extended this survey 1) to evaluate which parameters affect the communities of littoral macroinvertebrates and fishes in prairie lakes, and 2) to assess the consequences for trophic interactions. Similar to zooplankton, salinity and nutrient concentrations were most strongly associated with changes in diversity and taxonomic composition of littoral macroinvertebrates and fishes. Nevertheless, salinity tolerance varied greatly among these three groups. Zooplankton showed the most dynamic response as while freshwater species disappeared, new species were encountered at higher salinities. Additionally, several taxa that are commonly associated with littoral habitats invaded the pelagic areas. In contrast, for littoral macroinvertebrates and fishes, we observed a continuous loss in diversity and almost no taxa invaded the lakes at higher salinities. Furthermore, with the exception of stickleback, fishes were limited to freshwater lakes, while littoral macroinvertebrates flourished even in lakes with fairly high salinities. Beyond strictly physiological effects of increasing osmotic stress, the different responses of zooplankton, macroinvertebrates, and fishes resulted in interesting food-web interactions. In freshwater lakes, zooplankton composition was mostly affected by the presence of planktivorous fish, whereas at higher salinities competition and physiological constraints seemed more important. In contrast, littoral macroinvertebrates were unaffected by fish predation across the whole salinity gradient and were even able to colonize the pelagic areas once fish were absent.

Oral SCL (Trophic Linkages)

GENETIC AND BEHAVIOURAL ASSESSMENTS OF THE CULTUS PYGMY SCULPIN (*COTTUS* SP.) AS A DESIGNATABLE UNIT UNDER SARA

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The Cultus pygmy sculpin (*Cottus* sp.) is endemic to Cultus Lake, southwestern BC, and is listed as threatened under the federal Species at Risk Act (SARA). The Cultus pygmy sculpin was first discovered by Ricker in the 1930's (Ricker 1960) and was described as a dwarf coastrange sculpin (*Cottus aleuticus*). It matures at a smaller size than *C. aleuticus*; has a lacustrine rather than a fluvial life history; and also appears to undertake diurnal feeding migrations into the water column to feed on the abundance of *Daphnia*. Little else, however, is known of the biology of this fish. We used both mtDNA and microsatellite analyses to determine whether there is any taxonomic distinction between the pygmy sculpin and the coastrange sculpin. Potential behavioural differences between the two forms were also examined by comparing vertical depth selection in the laboratory, with and without *C. asper*, a benthic predator found in Cultus Lake. Results from combined microsatellite and mtDNA analyses indicate that the pygmy sculpin is genetically distinct at the population level, but there is no clear phylogeographic separation between pygmy and coastrange sculpin. Initial results from the behavioural study show a significant difference in behaviour between the Cultus pygmy sculpin and stream forms, but only if *C. asper* is present. We conclude that the presence of abundant planktonic prey within the water column of Cultus Lake combined with the presence of predators on the bottom, have promoted the expression of pelagic behaviour by the pygmy sculpin.

Oral CCFFR (Conservation genetics)

DOES MACKENZIE RIVER PLUME INFLUENCE DISTRIBUTION OF ARCTIC LARVAL FISH?

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The coastal area of the Canadian Beaufort Sea shelf is characterized by an infusion of warm, turbid and nutrient-rich waters such that it is often referred to as an estuarine region. This freshwater input is mainly the result of the plume dispersion from the Mackenzie River during spring and summer periods. The extent of the plume covering the Canadian Beaufort Sea shelf is approximately 60,000 km² with an average depth of 6 m. In the present study, we examined the importance of the Mackenzie River plume on larval fish distribution and abundance in the shelf region. Sampling was conducted in July and August of 2007 during the open water season across three distinctive water masses that included: intense plume, diffuse plume and oceanic water. The total larval catch of larval fish was considered high with 922 larval fishes collected in total. They represented six families: Clupeidae, Gadidae, Cottidae, Agonidae, Liparidae and Stichaeidae. Gadidae and Stichaeidae were the most abundant families of larval fish. Analysis performed on the data revealed significant abundance and distribution differences across the different water masses. This study suggests that the plume waters could play an important role in the ecology and distribution of marine larval fish on the Canadian Beaufort shelf.

Poster CCFR (Arctic resources)

GENETIC STRUCTURE AND DIVERSITY AMONG POPULATIONS OF MUSKELLUNGE (*ESOX MASQUINONGY*) IN LAKE HURON AND GEORGIAN BAY

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Conservation and management issues related to genetic diversity and stock structure have been largely unexplored in Great Lakes muskellunge (*Esox masquinongy*). In eastern Georgian Bay and the North Channel of Lake Huron, populations of muskellunge have been impacted by recreational fisheries and marked ecological changes, including loss of spawning habitat and deterioration of water quality. Spawning adults were sampled from nine tributaries in the North Channel and eastern Georgian Bay and screened with 21 highly polymorphic microsatellite DNA markers to assess their spatial structure and diversity, as well as to determine the number of genetic groups present and their ranges and relationships. The microsatellite data showed substantial genetic diversity among wild muskellunge, with good congruence between sampling sites and genetic populations. Individual- and population-based analyses revealed hierarchical population structuring with strong patterns of spawning site fidelity and isolation by distance. The extremely limited evidence of straying between spawning sites based on individual assignment tests and significant pairwise divergences among sites indicate very low levels of gene flow over historical and contemporary timescales. The results of this study will help inform management options for muskellunge in the Great Lakes, and will also be useful for assessing the effectiveness of restoration and rehabilitation efforts for extirpated populations of muskellunge in Spanish River (Georgian Bay) and Lake Simcoe.

Oral CCFR (Conservation genetics)

RESTORATION OF DELTA MARSH, MANITOBA: EXCLUSION OF COMMON CARP (*CYPRINUS CARPIO*)

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Delta Marsh is a large freshwater coastal wetland on the south shore of Lake Manitoba. Similar to other freshwater habitats, it is suffering from the effects of an artificially modified water regime, eutrophication and invasive species. One of the invasive species of concern is Common Carp. Field observations and experimental studies have implicated Common Carp in several changes observed in the marsh, including increased turbidity, phytoplankton blooms and loss of submersed vegetation. A restoration plan is currently being developed for the marsh and minimizing Common Carp impacts is considered an important part of the plan.

Each fall, all large fish leave the marsh as it begins to freeze. Bar screens placed on the connecting channels would be able to exclude Common Carp when they return each spring. However, screens would exclude native species such as Walleye, Northern Pike and White Sucker that also use the marsh. To minimize screen impacts on these species several research studies are currently underway to determine optimum screen opening size and timing of screen placement. Fish passage through experimental screens of different size is being evaluated. In addition, the timing of fish movement into the marsh and the size structure of the large fish community is being determined.

Oral CCFFR (Habitat assessment)

ROUND GOBY (*NEOGOBIUS MELANOSTOMUS*) ATTRACTION TO CONSPECIFIC AND HETEROSPECIFIC EGG ODOURS

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The Round Goby, a fish invader, owes its success to its parental care, colonial breeding habits and broad diet. Parental males guard and maintain fertilized eggs, but may exhibit filial cannibalism when costs of care exceed benefits. Also, whenever parental males leave nests to chase intruders, juvenile Round Goby enter nests to consume eggs. Thus, egg odours may be attractants and cannibalism could be adaptive for species with high site fidelity. We hypothesized that chemical cues released by fertilized eggs of conspecifics and heterospecifics are equally attractive to Round Goby. Using a lab flume, we determined if juvenile Round Goby showed an increased preference to washings of conspecific (Lake Erie) eggs compared with washings of heterospecific, Rainbow Trout (*Oncorhynchus mykiss*), (hatchery) eggs. We also examined preference between egg washings vs. lake water. Juvenile Round Goby spent significantly more time ($t_{1,11} = 2.67$; $p = .021$) near washings of conspecific egg odours compared with control lake water, but preferred control lake water significantly more ($t_{1,11} = -2.99$; $p = .012$) than washings of heterospecific egg odours. There was no significant difference in time spent ($t_{1,11} = 1.67$, $p = .122$) by fish near washings between conspecific and heterospecific eggs when stimuli were presented simultaneously. Our findings show that conspecific egg odours rather than control lake water attract juveniles, and that there is a potential to lure fish to odours traps as a means of controlling their spread into new areas.

Oral CCFFR (General Session)

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