The Canadian Conference for Fisheries Research (CCFFR)

and the

Society of Canadian Limnologists (SCL) Annual Meeting

St, John's, Newfoundland and Labrador

January 8-10, 2004

Delta Hotel, Gower Street, St. John's, NL

Short Tribute to Edwin J. Crossman (21 September 1929, 21 December 2003).

To their shock, many Canadians interested in fish learned of Ed Crossman's sudden death at home on Sunday morning, 21 December 2003.

Dr. E.J. (Ed) Crossman, PhD, was born in Niagara Falls, Ontario and received his early education there. He went to Queen's University, Kingston, Ontario where he received a BA in 1952. From there he went on to graduate work with F.E.J. Fry at the University of Toronto and received his MA in 1954. Ed completed his PhD in 1957 at the University of British Columbia with Peter Larkin. He then immediately joined the University of Toronto in 1957 as Assistant Curator in the Department of Ichthyology and Herpetology at the Royal Ontario Museum (ROM). Dr. Crossman worked mainly with freshwater fishes and particularly the group that includes the pike and muskellunge. His studies included the relationships and evolutionary history of the group, their distribution, and the biology of individual species. He was actively involved in a study of the biodiversity of the fishes of the Great Lakes, and had a special interest in the phenomenon of introduced fishes. He carried out expeditions and studies in various parts of Canada, the United States, Europe, Cuba, Malawi, and Far Eastern Russia. Dr. Crossman served as scientific advisor to a number of Provincial, Federal, Angler and international organizations, in Canada, the United States, England, and Germany. Up until the time of his death Ed was Curator Emeritus of Ichthyology at the ROM Centre for Biodiversity and Conservation Biology and Professor Emeritus, Department of Zoology, University of Toronto. Although officially retired, he regularly occupied his office at the ROM where he continued his studies and involvement in the curation of the important reference collection of fishes housed there.

Ed is the author or coauthor of approximately 180 publications, both scientific and interpretive, including "the" major text published in 1973 and co-authored with W.B. (Bev) Scott, entitled ***Freshwater Fishes of Canada***. This comprehensive book continues to be one of the most important and informative works on freshwater fishes in Canada. The concept of the book had its birth in 1960 in Newfoundland where Ed and Bev spent the summer there making the first formal collection of the freshwater fishes of Newfoundland. According to Bev, they had many nights that summer to discuss the concept of the book and argue the many points of interest. In the end it was the synergy that developed between them, Ed's knowledge of the west, Bev's knowledge of the east, their combined new knowledge of Newfoundland and their mutual willingness to learn about the prairies that eventually led to the book that has had two editions. Ideas for a 3rd edition had been evolving between Ed and Bev over recent years, but the future of those ideas is now unclear.

Ed will be sorely missed.

General Information for the Canadian Conference for Fisheries Research (CCFFR):

The CCFFR Officers for 2004 are as follows:

President:	Moira Ferguson *[mmfergus@uoguelph.ca]*
Programme Chair:	David Scruton *[ScrutonD@dfo-mpo.gc.ca]*
Secretary-Treasurer:	Andrew Cooper *[coopera@dfo-mpo.gc.ca]*
Local Arrangements:	Bob Gregory (Chair) *[GregoryR@dfo-mpo.gc.ca]*
	Joe Brown *[jabrown@mun.ca]*
	George Rose *[grose@caribou.mi.mun.ca]*
Nominations:	Bill Tonn *[bill.tonn@ualberta.ca]*
Meeting Arrangements:	Martha Robertson (Program, Registration)
	Corey Morris (Registration, T-shirts)
	Keith Clarke (Poster Session)
	Neil Ollerhead (Audio Visual)
	Ben Laurel (Web site)

The CCFFR 2004 Programme Themes and Theme-Chairs are:

(1) **Evidence and Impacts of Aquatic Regime Shifts** (Joint CCFFR/SCL)

Chair: Bob Gregory [GregoryR@dfo-mpo.gc.ca]

Venue: Salon A, Friday January 9, a.m. (in plenary), January 9, p.m.

- Food chain dynamics - especially studies utilising novel techniques, such as stable isotope and lipid/fatty acid analyses to trace energy flow;
- Influences of climate change on trophic responses of whole ecosystems;
- Investigations reporting changing migration and habitat use patterns;
- Large scale ecosystem changes and manipulations; and
- Disruption of predator-prey dynamics as evidence of regime shifts

(2) **Rebuilding Fisheries** (CCFFR)

Chair: George Rose [grose@caribou.mi.mun.ca]

Venue: Salon C, Saturday January 10, a.m. and p.m.

- Case studies of rebuilding fisheries degraded by habitat loss, pollution or over-fishing
- Methods to rebuild fisheries
- Methods to monitor fisheries
- Limitations to rebuilding fisheries potential

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(3) **Anthropogenic Effects on Fish** (CCFFR)

Chair: Dave Scruton [ScrutonD@dfo-mpo.gc.ca]

Venue: Salon D, Friday January 9, p.m., and Saturday January 10, a.m. and p.m

- Impacts of land use activities;
- Hydroelectric, oil and gas energy development effects;
- Environmental stress and toxicology effects of fish health;
- Fish migration and fish passage; and,
- Fish habitat improvement, restoration, and compensation options

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(4) **Aquaculture and the Environment** (CCFFR)

Chair: Joe Brown [jabrown@mun.ca]

Venue: Salon A, Saturday January 10 p.m.

- Shellfish or finfish farming interactions with surrounding aquatic ecosystems;
- Interaction of wild and farmed fish;
- Nutrition, genetic, health or husbandry issues related to fish/shellfish culture; and,
- Improving production efficiencies for commercial and alternative species

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(5) **Environmental versus Genetic Variation in Life History** (CCFFR)

Chair: Jeff Hutchings [Jeff.Hutchings@dal.ca]

Venue: Salon B, Friday January 9, p.m. and Saturday January 10, a.m. (to 10:30)

- Life history responses to natural or artificial selection;
- Adaptive phenotypic plasticity (i.e., GxE interactions);
- Experimental studies that incorporate a common-garden design;
- Field- or laboratory-based estimates of life history trait heritability; and,
- Relevance of GxE interactions to conservation biology.

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(6) **Adaptive Responses of Fisheries to Climate Variation and Change** (CCFFR)

Chairs: Kim Hyatt (HyattK@dfo-mpo.gc.ca)/Mark Johannes (mjohannes@shaw.ca)

Venue: Salon A, Saturday January 10 a.m.

- Influence of climate change events on the availability of fish resources to capture- or culture-fisheries (e.g., fish, invertebrates, plants);
- Responses (e.g. technological, social, legal, economic etc.) of fisheries sectors to climate induced changes in availability of fisheries resources; and,
- Institutional (science, management, political) responses to climate change in either fish resources, or capture or culture fisheries.

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(7) **Marine Biodiversity** (CCFFR)

Chair: Ellen Kenchington (KenchingtonE@dfo-mpo.gc.ca)

Venue: Salon C, Friday January 9, p.m.

- Studies of genetic diversity within and among species;
- Studies of species diversity;
- Studies of community diversity including habitat diversity;
- Field studies on anthropogenic impacts on biodiversity at the genetic, species or community levels; and,
- Studies on the conservation of marine biodiversity.

This theme will conclude with a discussion of a National Plan for the protection of Marine Biodiversity (Salon C, Friday January 9, 16:40-17:30).

(8) **General Contributed Papers** (CCFFR)

Chair: TBD

Venue: Salon B, Saturday January 10 a.m. (from 10:30) and p.m.

The J.C. Stevenson Memorial Lecture:

This is a prestigious lectureship instituted in memory of Cam Stevenson, the long-time Editor of the Canadian Journal of Fisheries and Aquatic Sciences (CJFAS), published by NRC Press and is conferred upon a young, energetic and creative researcher at the cutting edge of an aquatic discipline. Each year a Lecturer is selected by the Journal's Editorial Board. In the Spring of each year a call for nominations is sent to the Chairs of Zoology and Biology departments across Canada, as well as to the research directors of the federal Departments of Fisheries and Oceans and Environment Canada and the National Research Council. The list of nominees is then sent to the CJFAS Editorial Board, who provide recommendations and justification for their selections. The Lecturer delivers a stimulating presentation of their work as the keynote address in the opening session of the Annual CCFFR meeting. A written version of the presentation is normally published as the lead article in the January issue of CJFAS or sometime soon thereafter.

The 2004 Stevenson Lecturer is:

Dr. Jules M. Blais, Associate Professor , Department of Biology , University of Ottawa, 150 Louis Pasteur, Ottawa, ON, K1N 6N5. The title of the lecture is:

'Biogeochemistry of Persistent Pollutants: Processes Affecting the Transport of Contaminants to Remote Areas'

Abstract:

Many environmental contaminants, including mercury, pesticides, polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) are known to concentrate in cold environments as a result of progressive evaporation from warm regions, and condensation in colder regions. Some assimilate rapidly in biological tissues, and as a result, they may be biomagnified in food chains. In some cases, they reach concentrations in organisms from remote northern climates that are higher than those found in more industrialized parts of the world. Environmental processes responsible for this pattern of concentration in cold environments include distillation, biomagnification, and even biological transport by migratory species to remote environments. A multi-year program to study transport and fate of persistent organic pollutants in remote alpine and northern environments has revealed a systematic contamination of these areas by several environmental contaminants of concern. These patterns reveal a potential of risk to these environments, and they also show how many synthetic chemicals behave under a range of ambient conditions. This presentation will discuss some of the major factors that affect transport, preservation and bioaccumulation of persistent contaminants, and discuss potential risks.

Venue 2004:

This year's annual meeting of the Canadian Conference For Fisheries Research, January 8th to 10th 2004, will be held at the Delta Hotel, situated in downtown St. John's, NL. This hotel is located on the street of New Gower, just a short walk from Mile One Stadium, George Street (bars and restaurants) as well as a multitude of restaurants and shops on Water Street and Duckworth Street. Be sure to also walk around the nearby national historic site of Signal Hill and stop into the new Johnson Geo Center.

The special conference rate is $125 per night (single or double occupancy), plus applicable taxes. Additional people can share a room at $15.00 per person per night at a maximum of four total occupants per room.

The address of the **Delta Hotel** is:

120 New Gower St, St. John's, NL A1C 6K4
Tel: 1-709-739-6404
Fax: 1-709-570-1622
Canada-USA: Toll-free: 1-800-268-1133

Local Restaurants:

ABIGAIL'S RESTAURANT
199 Kenmount Road (Best Western Travellers Inn)
722-5540

AQUA RESTAURANT & BAR
310 Water Street
(709) 576-2782

BAGEL CAFE
246 Duckworth Street
(709) 739-4470

BIANCA'S
171 Water Street
(709) 726-9016

BONA VISTA
Fairmont Newfoundland Hotel (Cavendish Sq.)
(709) 726-4980

BREAD PIG
23 Queen's Road (at Prescott St.)
(709) 579-4788

BRIDIE MOLLOY'S PUB & EATERY
5 George Street
(709) 576-5990

CABOT CLUB
Fairmont Newfoundland Hotel (Cavendish Sq.)
(709) 726-4980

CASA GRANDE
108 Duckworth Street
(709) 753-6108

CELLAR RESTAURANT
152 Water Street, 4th Floor

579-8900

CHINA HOUSE RESTAURANT
Torbay Road Mall
(709) 754-2892

CHUCKY'S FISH 'N SHIPS
10 King's Road
(709) 579-7888

CIOPPINOS
248 Duckworth St.
(709) 739-6770

CLASSIC CAFE
32 George Street
(709) 579-4444

CROOKED CRAB & SAVAGE LOBSTER RESTAURANT
98 Duckworth Street
(709) 738-8900

DJANGO'S RESTAURANT
190 Duckworth Street
(709) 738-4115

DON CHERRY'S SPORTS GRILL
290 Freshwater Rd.
(709) 576-2583

DUCK STREET BISTRO
252 Duckworth Street
(709) 753-0400

EAST SIDE MARIO'S
180 Portugal Cove Rd. (Holiday Inn)
(709) 722-6900

EMERALD PALACE
56A Kenmount Road
(709) 726-7878

FOG CITY BREWING CO.
Avalon Mall, Kenmount Road
(709) 726-4949

GREEN SLEEVES PUB, LOUNGE & RESTAURANT
14 George Street
(709) 579-1070

GUV'NOR PUB & EATERY
389 Elizabeth Ave. (Guv'nor Motel)
(709) 726-3053

HONG KONG RESTAURANT
361 Water Street
753-8838

HUNGRY FISHERMAN
The Murray Premises (Water Street)
726-5791

INDIA GATE RESTAURANT
286 Duckworth Street
753-6006

JUNGLE JIM'S
George Street
753-5467

K CAFE
155 New Gower Street
754-2266

KENMOUNT RESTAURANT
75 Kenmount Road
753-8385

KLONDIKE JAKE'S
Village Mall (Topsail Rd.)
747-1897

MAGIC WOK EATERY
402-404 Water Street
753-6907

MAGNUM & STEIN'S
284 Duckworth Street
576-6500

MALU RESTAURANT & BISTRO
281 Duckworth Street

722-5769

MEA MEI WOK EATERY
12 Freshwater Road
726-8424

MY BROTHER'S PLACE
50 New Gower St. (Mile One Stadium)
(709) 576-2767

MY BROTHER'S PLACE
270 Torbay Road
754-2767

NAGEIRA'S RESTAURANT
283 Duckworth Street
753-1924

NAUTICAL NELLIES
201 Water Street
738-1120

NEW CHINA TOWN EATERY
27 Elizabeth Avenue
738-7388

NEW MOON RESTAURANT
656 Topsail Road
368-6698

OLIVER'S RESTAURANT CAFE
160 Water Street
754-6444

O'REILLY'S IRISH PUB
15-17 George Street
722-3735

P. J. BILLINGTON'S RESTAURANT
102 Kenmount Rd. (Hotel St. John's)
722-6615

P.J. BILLINGTON'S RESTAURANT
Airport Rd. (Airport Plaza Hotel)
753-3585

PAPA'S PIER 17
15 Rowan St., Churchill Square
753-7692

PASTA PLUS CAFE
223 Duckworth Street
(709) 739-6676

PEPPERMILL
178 Water Street
726-7585

PETER BELBIN'S STEAKHOUSE & SALAD BAR
223 Duckworth Street
(709) 753-8530

PRESS & BEAN RESTAURANT
Murray Premises (Harbour Dr.)
(709) 753-2457

QUINTANAS DE LA PLAZA
57 Rowan St. (Churchill Sq.)
579-7000

RED PEPPER RESTAURANT
31 Peet Street
(709) 753-5999

RED PEPPER RESTAURANT
38 Hamlyn Road
(709) 754-7600

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Hill O' Chips (Quality Hotel)
(709) 579-6000

STONEHOUSE RENAISSANCE
8 Kenna's Hill
(709) 753-2425

SUNDANCE
George Street
753-7822

TAIWAN RESTAURANT
394 Kenmount Road

(709) 753-1818

TAJMAHAL RESTAURANT
203 Water Street
(709) 576-5500

GUV'NOR PUB & EATERY
210 Water Street
(709) 738-3018

VELMA'S RESTAURANT & LOUNGE
264 Water Street
(709) 576-2264

ZACHARY'S RESTAURANT
71 Duckworth Street
(709) 579-8050

ZAPATAS MEXICAN RESTAURANT
10 Bate's Hill
(709) 576-6399

DEVITOS
183 Duckworth Street
(709) 579-7071

FINNIGAN'S WAKE
283 Duckworth Street
(709) 753-9253

BATTERY HOTEL DINING ROOM
Signal Hill Road
(709) 576-0040

STAVROS GREEK RESTAURANT
272 Torbay Road (Fall River Plaza)
(709) 754-9767

SAIGON CAFE
319 Water Street
(709) 739-8892

JUNGLE JIM'S
Topsail Road
(709) 745-6060

JUNGLE JIM'S
286 Torbay Road
(709) 722-0261

KELLY'S PUB & EATERY
25 George St. (corner Adelaide St.)
(709) 753-5300

PASTA PLUS CAFE
Avalon Mall
(709) 722-6006

PASTA PLUS CAFE
Terrace on the Square (Churchill Sq.)
(709) 739-5818

MAMA SOULA'S
405 Torbay Road
(709) 738-7014

Social Program:

The Opening Reception/Mixer will be held at Delta Hotel from 19:00 to 22:00 on Thursday, January 8th, at Mickey Quinns Pub, Main Floor, adjacent to the Registration Desk. Hors d'oeuvres will be served and beer and wine will be available to purchase (2 free beer/wine tickets will be provided with registration).

The Banquet will be held at the Fluvarium, 1 Nagles Hill Road, adjacent to Pippy Park, from 19:30 to 22:00 on Friday, January 9th. Buses will depart from the Delta Hotel for the Fluvarium at 19:00. Buses will return from the Fluvarium to the Delta Hotel at the conclusion of the banquet, on a staggered schedule. The banquet will consist of local seafood, meats, salads, and deserts. Beer and wine will be available for purchase. Local entertainment will be provided (Traditional Irish).

At the conclusion of the conference on Saturday, January 10th, a Pub Crawl will be conducted to selected bars/pubs on George Street starting at 19:00. Participants in the pub crawl will convene in the Delta hotel Lobby at 18:45. Leaders of the pub crawl and participating bars/pubs are to be determined (there will be announcement during the meeting). There will be no cost for participation but participants will be responsible for the cost of their refreshments.

Oral Presentations:

Time allotted for oral presentations will be a total of 20 minutes, consisting of 15 minutes for presentation, followed by a 5 minute question period. Time limits will be rigorously adhered to.

All presentation rooms will have video data projectors (VDPs) and laptop computers and will have an assistant to oversee projection and to deal with any technical difficulties. PowerPoint presentations (97 or 2000 file format) should have been submitted prior to the start of the conference, as an e-mail attachment or mailed to the Programme Chair on CD-ROM. Alternatively, presenters must deliver a copy of their PowerPoint file, on either a 3.5" disk or a CD, to the Organizing Committee at Registration.

Presentations will be uploaded to a computer prior to the start of individual sessions. The Fortune Bay Room will be set up to allow presenters to preview their presentations. There will be no opportunity to edit presentations after delivery to the Organizing Committee.

If participants intend to use another presentation medium (e.g., overhead and/or 35mm slides), a limited number of projectors will be available at the conference. The Programme Chair should have been notified as to this requirement prior to December 16, 2003.

Poster Presentations:

Posters are to be installed during Registration on Thursday evening, January 8th, from 17:00 to 20:00, at the rear of Salon A. The Poster Session will be conducted on Friday January 9th, from 17:00 to 19:00. Refreshments will be served during the poster session. Materials necessary for mounting posters will be available. Posters can be removed anytime after the Poster Session.

Program 'At A Glance'
Canadian Conference for Fisheries Research (CCFFR) and the Society of Canadian Limnologists (SCL) Annual Meeting
St. John's, NL, January 8–10, 2004

Thursday Evening, January 8, 2004					
18:00 – 21:00	**Registration** (Main Lobby), **Poster Installation** (Salon A), **Social Mixer** (Mickey Quinn's)				
Friday Morning, January 9, 2004, **Plenary Session (Salon A)**					
08:00 – 08:40	**Welcoming Addresses and Program Announcements**				
08:40 – 09:20	**F.H. Rigler Lecture**				
09:20 – 10:00	**J.F. Stevenson Lecture**				
10:00 – 10:20	**Break**				
10:20 - 12:00	**Joint CCFFR/SCL Session: Evidence and Impacts of Aquatic Regime Shifts**, papers 1-1 to 1-5				
12:00 – 13:20	**Lunch**				
Friday Afternoon, January 9, 2004, Concurrent Sessions, CCFFR & SCL					
	Salon A	**Salon B**	**Salon C**	**Salon D**	**Conception Bay Room**
13:20 – 15:00	**Regime Shifts 2,** papers 1-6 to 1-10	**Genetic Variation vs. Life History 1,** papers 5-1 to 5-5	**Marine Biodiversity 1.** papers 7-1 to 7-5	**Anthropogenic Effects 1,** papers 3-1 to 3-5	**Northern Lakes Research – Where do we go from here?**
15:00 – 15:20	**Break**				
15:20 - 17:00	**Regime Shifts 3,** papers 1-11 to 1-15	**Genetic Variation vs. Life History 2,** papers 5-6 to 5-10	**Marine Biodiversity 2,** papers 7-6 to 7-9	**Anthropogenic Effects 2,** papers 3-6 to 3-10	**Northern Lakes Research** **Techniques in Aquatic Sciences**
16:40 - 17:30			**Discussion Panel**, National Marine Biodiversity Plan		
17:00 – 19:00	**Poster Session, Salon A, CCFFR Business Meeting**				
19:00	**Buses depart for Banquet**				
19:30 – 22:00	**CCFFR – SCL Banquet (Fluvarium)**				

Saturday Morning, January 10, 2004, Concurrent Sessions, CCFFR & SCL					
	Salon A	**Salon B**	**Salon C**	**Salon D**	**Conception Bay Room**
08:30 - 10:00	**Climate Change 1,** papers 6-1 to 6-5	**Genetic Variation vs. Life History 3,** papers 5-11-1-15	**Rebuilding Fisheries 1**, papers 2-2 to 2-5	**Anthropogenic Effects 3**, papers 3-11 to 3-15	**Effects of Human Activities on Aquatic Systems**
10:10 – 10:30	**Break**				
	Climate Change 2, papers 6-6 to 6-10	**General Contributed Papers 1,** papers G-1 to G-5	**Rebuilding Fisheries 2,** papers 2-6 to 2-10	**Anthropogenic Effects 4,** papers 3-16 to 3-20	**Effects of Human Activities on Aquatic Systems**
12:10 – 13:30	**Lunch**				
Saturday Afternoon, January 10, 2004, Concurrent Sessions, CCFFR & SCL					
13:30 – 15:10	**Aquaculture 1,** papers 4-1 to 4-5	**General Contributed Papers 2,** papers G-6 to G-10	**Rebuilding Fisheries 3,** papers 2-11 to 2-15	**Anthropogenic Effects 5,** papers 3-21 to **3-25**	**Multiple Stressors in Aquatic Ecosystems**
15:10 – 15:30	**Break**				
15:30 - 17:10	**Aquaculture 2,** papers 4-6 to 4-10	**General Contributed Papers 3,** papers G-11 to G-13	**Rebuilding Fisheries 4,** papers 2-16 to 2-20	**Anthropogenic Effects 6,** papers 3-26 to 3-30	**Aquatic Food Webs**
17:10	**Concluding Remarks**				
17:15	**SCL Business Meeting**				
18:45	**Convene for Pub Crawl**				
19:00	**George Street Pub Crawl**				

Detailed Program

Thursday Evening, January 8, 2004					
18:00 – 21:00	**Registration / Inscription, Poster Installation / Installation des Affiches** (Salon A) **Social Mixer / Cocktail** (Mickey Quinn's)				
Friday Morning, January 9, 2004 **Plenary Session / Assemblu pleniere**, Salon A, Convenor: R. Gregory					
08:00	**Welcoming Address – Bienvenue**, Moira Ferguson, CCFFR President				
08:10	**Welcoming Address – Bienvenue**, Peter Leavit, SCL President				
08:20	**Venue / Facility Announcements / Renseignments sur les activites hors conference** – Robert Gregory, FOC, Local Arrangements Chair				
08:30	**Program Announcements / Mis a jour du programme** - David Scruton, FOC, CCFFR Program Chair				
08:40 – 09:20	**F.H. Rigler Lecture / Presentation par F.H. Rigler,** Dr. W. Gary Sprules, Professor, Department of Biology, University of Toronto				
09:20 – 10:00	**J.F. Stevenson Lecture / Presentation par J.C. Stevenson,** Dr. Jules M. Blais, Associate Professor, Department of Biology, University of Ottawa				
10:00 – 10:20	**Break**				
	Joint CCFFR/SCL Session: Evidence and Impacts of Aquatic Regime Shifts Convenor: Robert Gregory, FOC				
10:20	**Montevecchi, W.A.**, G.K. Davoren, and ; J.E. Carscadden. Shifting Regimes in the Northwest Atlantic – Multi-species Signals from Seabirds (1-1)				
10:40	**Carruthers, E.H**., Neilson, J.D., Waters, C., and P. Perley. Long-term Changes in the Diet of Pollock (*Pollachius virens* L.) on the Scotian Shelf: Responses to a Dynamic Ecosystem. (1-2)				
11:00	**Mowbray, F.K.** Capelin Diet Shifts in the Newfoundland and Labrador Ecosystem: An Indicator of Changing Secondary Production? (1-3)				
11:20	**Laurel, B. J.** and R.S. Gregory. Linkages in recruitment variability between three species of gadids: Atlantic cod *Gadus morhua*, Greenland cod *G. ogac* and white hake *Urophycis tenuis*.(1-4)				
11:40	**Donald, D.B.** and R.S.Anderson. *Resistance of the Prey to Predator Ratio to Environmental Gradients and to Biomanipulations*. (1-5)				
12:00 – 13:20	**Lunch**				
Concurrent Sessions: CCFFR & SCL					
	Salon A	**Salon B**	**Salon C**	**Salon D**	**Conception Bay Room**

	Regime Shifts 2, R. Gregory	**Genetic Variation vs. Life History 1, J. Hutchings**	**Marine Biodiversity 1, E. Kechington**	**Anthropogenic Effects 1, D. Scruton**	**Northern Lakes Research – Where do we go from here?, R.Vinebrooke**
13:20	**Sherwood, G.D**. and G.A. Rose. *Stunted Cod? Evidence for Feeding Bottlenecks in the North Atlantic.*(1-6)	**McCairns, R.J.S.,** et al.. *Countergradient Variation in Growth and Associated Life-history Trade-offs in Brook Trout from Western Newfoundland*. (5-1)	**Ruzzante D.E.,** et al. Genetic *Differentiation Among Inshore and Offshore Atlantic Cod (Gadus Morhua) of Newfoundland And Labrador.* (7-1)	**Robertson, M. J.,** et al. *Effect of Short-Term Flow Fluctuations on the Behaviour of Atlantic Salmon Parr in Winter*. (3-1)	**Smol, J**. et al. *Arctic lakes and ponds: a paleoecological perspective of long-term environmental change*
13:40	**Linehan, J.E.**, et al. *Is The Seabed a Refuge From Piscivorous Fish, For Post-Settled Age 0 Juvenile Cod (Gadus spp.) in Nearshore Habitats?* (1-7)	**Hutchings, J.A** et al. *Genetic Determinants of Population Variation in Atlantic Cod Growth, Survival, and Phenotypic Plasticity.* (5-2)	**McCusker, M.R**., et al. *Phylogeography and Population Structure of the Atlantic Wolffish, Anarhichas lupus.* (7-2)	**Enders, E.C**., et al.. *A model of swimming costs in turbulent flow of juvenile Atlantic salmon (Salmo salar).* (3-2)	
14:00	**Sheppard, G.L.,** et al. *Mark-recapture of juvenile cod (Gadus spp.) in coastal Newfoundland indicate high site fidelity and low mortality.* (1-8)	**Marcil, J.**, et al. *Genetic Differences in Body Shape Among Populations of Atlantic Cod (Gadus morhua).* (5-3)	**Fuller, S.D.** *Marine Sponge (Phylum: Porifera) Biogeography and Ecological Function in the Northwest Atlantic: An Overview.* (7-3)	Murchie, K.M., and **K.E. Smokorowski.** *Relative Activity of Brook Trout and Walleye in Response to Flow in a Regulated River.* (3-3)	**McGowan, S**. et al. *Relative importance of climate, lake ontogeny and lake-specific processes in regulating lake primary production and community structure in two arctic lakes*
14:20	**Renkawitz, M.D**, et al. *Habitat influences the growth rate of three juvenile gadoids (Gadus morhua, Gadus ogac, Urophycis tenius) in*	**Wijekoon, M.P.A**., et al. *Inter-Population Differences in Growth, Food Conversion Efficiency and Swimming Performance of Juvenile*	**Kenchington, E**, et al. *Multi-Decadal Changes in the Megabenthos of the Bay of Fundy. (7-4)*	**Patterson, R.P.**, et al. *Effects of Flow and Ramping Rate from a Hydroelectric Dam on Macroinvertebrate Abundance and Diversity*	**Patoine, A**. & P. Leavitt. *Patterns and controls of prairie lake synchrony during the 20th century: evidence from fossil pigments*

	Newman Sound, Newfoundland. (1-9)	*Atlantic Cod* (*Gadus Morhua*). (5-4)		*Within the Magpie River, Wawa, Ontario*. (3-4)	
14:40	**Jordaan, A.**, et al. . *What Might Starving in Field Populations of Cod Larvae Look Like: Inferences from Laboratory Studies*. (1-10*)*	**Gosse, K.R**. and J.S.Wroblewski. *Variant Colourations of Atlantic Cod (Gadus morhua) in Newfoundland and Labrador Nearshore Waters*. (5-5)	**Ellis, J.,** et al. *Fishing disturbance and marine biodiversity: the role of habitat structure in simple soft-sediment systems.* (7-5)	**Peake, S.** *Critical Swimming Speed as a Metric for Estimating Maximum Allowable Water Velocities in Fishways and Culverts*. (3-5)	**Curtis, J.** et al. *Interactions among time, depth, and dissolved organic matter on UVR-attenuation and algal biomass in water from enclosures*
15:00 – 15:20	**Break**				
	Salon A	**Salon B**	**Salon C**	**Salon D**	**Conception Bay Room**
Concurrent Sessions	**Regime Shifts 3, R. Gregory**	**Genetic Variation vs. Life History 2, J. Hutchings**	**Marine Biodiversity 2, E. Kechington**	**Anthropogenic Effects 2, D. Scruton**	**Northern Lakes Research R.Vinebrooke**
15:20	**Trudeau, V.** and J. Rasmussen. *The Effect of Water Current Velocity on the Stable Carbon and Nitrogen Isotopic Signatures of Periphyton* (1-11)	**Gibson, R.J.** *Life History Strategies of Atlantic Salmon in Newfoundland*. (5-6)	**Kelly, M.C**. and P.V.R. Snelgrove. *Bentho-Pelagic Coupling: Does Quality, Quantity and Diversity of Food Supply Influence Infaunal Biodiversity?* (7-6)	**Goosney, R.F.** *Fish Passage and Hydro Generation on the Exploits River: A Case Study*. (3-6)	**Hogsden,K**. & R. Vinebrooke. *Does grazing pressure differ between stressed and recovered boreal lake ecosystems?*
15:40	**McWilliam, S**., et al. *Food Web Relationships in a Protected River System.* (1-12)	**Heath, D.D.** and E. Fillatre. *Bimodal Run Timing in Sockeye Salmon: Adaptive Life History or Accident of History?* (5-7)	**Snelgrove, P.V.R.** *Non-Coherence in Biodiversity Patterns in Ichthyoplankon and Zooplankton Assemblages.* (7-7)	O'Connor, L.M. **and T.C. Pratt.** *Do vertical slot fishways work? Preliminary results from two low-head sea lamprey barriers.* (3-7)	**Graham, M**. et al. *Concordance between abiotic and phytoplankton recovery trajectories of acidified boreal lakes over a 20-year period.*

					Techniques in Aquatic Sciences, R. Vinebrooke,
16:00	**Jamieson, R.E.,** et al. *Tracing the Influence of Terrestrial Production to the Nearshore Marine Habitats of Juvenile Atlantic Cod (Gadus morhua) Using the Stable Isotopes of Carbon, Nitrogen and Sulphur.* (1-13)	**Adams, B. K.** and J.A. Hutchings. *Comparative Life History Variation in Anadromous and Non-anadromous Atlantic Salmon (Salmo salar) Populations of Newfoundland.* (5-8)	**Quijon, P.A.** and P.V.R. Snelgrove. *The Utility of Taxonomic Pooling in Experimental Studies of Marine Benthic Diversity.* (7-8)	**Robillard. M**. and M.G. Fox. *Changes in the Fish Communities of the Kawartha Lakes, Ontario in Response to Anthropogenic Stressors.* (3-8)	**Prairie, Y.** *Spatial heterogeneity in lake metabolism*
16:20	**Tucker, S.**, et al. *Fatty Acid Signatures Reveal Diet Differences Among Age-classes, Years, and Foraging Locations of Harp Seals (Phoca groenlandica).* (1-14)	**Curry, R.A.** *Assessing the Reproductive Contributions of Sympatric Anadromous and Freshwater-Resident Brook Charr.* (5-9)	**Van Guelpen, L.,** et al. *The Atlantic Reference Centre: A Resource for Canadian Atlantic Biodiversity Information.*(7-9)	**Nelitz, M.A**., et al.. *Identifying "Temperature Sensitive Streams" for Forest Management: An Analysis of Stream Temperature Variation and Salmonid Thermal Requirements in the Central Interior of British Columbia.* (3-9)	**Ghadouani, A.** et al. *Can we accurately and rapidly estimate phytoplankton community structure in aquatic systems using new* in situ *technologies?*
16:40	**Paterson, G**.,et al. . *Persistent Organic Pollutants as Indicators of Bioenergetics in Fish*. (1-15)	**Olafsdottir, A**., and J. T. Anderson. *Early Life Growth of Icelandic Capelin (Mallotus villosus).* (5-10)	**Discussion Panel**, National Marine Biodiversity Plan	**Mitchell, S.C.,** et al . *Temporal and Spatial Variability of Stream Fish Populations in Two Undisturbed Streams of Eastern Canada.* (3-10)	**Mills, R**. et al. *Assessing lake turnover using three dimensional excitation emission fluorescence spectroscopy*
17:00-17:30					
17:00 –	**Poster Session / Session des Affiches, Salon A**				

19:00	**CCFFR Business Meeting**				
19:00	**Buses depart for banquet**				
19:30 – 22:00	**CCFFR – SCL Banquet (Fluvarium)**				
Saturday Morning, January 10, 2004					
	Salon A	**Salon B**	**Salon C**	**Salon D**	**Conception Bay Room**
Concurrent Sessions	**Climate Change 1, M. Johannes**	**Genetic Variation vs. Life History 3, J. Hutchings**	**Rebuilding Fisheries 1, G. Rose**	**Anthropogenic Effects 3, D. Scruton**	**Effects of Human Activities on Aquatic Systems, A.Ghadouani,**
08:30	**Catto, N.R.** *Impact of Climate Variation and Storm Dynamics on Capelin Beach Sedimentation, Eastern Newfoundland.* (6-1)	**Johnston, T.A**., et al. *Quantifying Inter-individual Variability in Contribution to Year-class Strength in an Iteroparous Fish.* (5-11)	**Rose, G.A.** *Rebuilding Atlantic Codstocks: What it Will Take?* (2-1)	**Clarke, K.D.** and D.A. Scruton. *Investigating the Role and Linkages of Lacustrine and Fluvial Habitats from a Population Perspective.* (3-11)	**Smokorowski, K**. et al. *The effect of large-scale wood removal on periphyton and invertebrates on submerged wood in lakes*
08:50	**Minns, C.K**. and Shuter. *Impact and Adaptation - Two Sides of One Coin: From Fish Through Fisheries to Fishers* (6-2).	**Fox, M.G**., et al *Life in the 'Old Country': Changes in Life History and Growth of a North American Sunfish (Lepomis gibbosus) Introduced into Europe.* (5-12)	**Shelton, P.A**., et al *Rebuilding Conditions for Overfished Groundfish Stocks Off the East Coast of Newfoundland and Labrador*. (2-2)	**Clair, T.A**., et al. *Past and future water chemistry changes in Atlantic Salmon rivers of Nova Scotia affected by acidification: A dynamic modeling approach.* (3-12)	**Campbell, C.** & D. Wells. *Could increased boat traffic in Western Brook Pond affect the spatial distribution of zooplankton?*
09:10	**Hyatt, K. D.,** et al *Climate Impact and Adaptation Responses of Salmon and Water Managers on the Somass River to the 2002 Fall*	**Windle, M**. J.,et al *Stable Isotope and Tagging Evidence for Resident and Migrant Types of Atlantic Cod (Gadus morhua).* (5-13)	Walsh, S.J. and **W. B. Brodie.** *Evaluation of Management Strategies Used in the Rebuilding of the Collapsed Grand Bank Yellowtail*	**Feduszczak, J.M.**, et al. *Stepping up the scale: Taking a provincial model for Walleye (Sander vitreus) productivity to the national level*. (3-13)	**Knoechel, R.** et al. *Bottom-up meets top-down: results of a long-term fertilization study. Part 1: response of the plankton and benthos*

	Drought in British Columbia. (6-3)		*Flounder Stock*. (2-3)		
09:30	**Mackenzie-Grieve, J.**, et al *Thermal habitat use by northern lake trout: energetics, production and conservation under climate warming.* (6-4)	**Jardine, T.J**.,et al *Resource Use by Salmonids in Riverine and Lacustrine Environments: Evidence from Stable Isotope Analysis.* (5-14)	**Powles, H.** *Protection and Recovery of Fishery Species Under Canada's New Species at Risk Act (SARA) – New Approaches to Stock and Species Rebuilding.* (2-4)	**Poos, M.S.**, et al. *Fish Species at Risk Assessment and Protection on the Sydenham River.* (3-14)	**Knoechel, R.** *Part 2: Response of the fish community and avian piscivores*
09:50	**Schneider, D.** and R. Ommer. *From Small Scale to Large and Back: Working with Coastal Communities on Climate Change.* (6-5)	**Mathews, M.** and R. Cunjak. *Atlantic Salmon Juvenile Emigration Strategies and Characteristics and Subsequent Adult Returns of Clearwater Brook.* (5-15)	**Johnston, F.D**. and J. R. Post. *Density Dependence in a Bull Trout Population in the Absence of Overfishing.* (2-5)	Mandrak, N. E., **J. Barnucz**, et al. *Developing Sampling Protocols for Fish Species at Risk in the Great Lakes Basin.* (3-15)	**Clark, B.** & A. Paterson. *Considerations in assessing impacts of shoreline development on the nutrient status of Ontario lakes*
10:10 – 10:30	**Break**				
	Salon A	**Salon B**	**Salon C**	**Salon D**	**Conception Bay Room**
Concurrent Sessions	**Climate Change 2, M. Johannes**	**General Contributed Papers 1**	**Rebuilding Fisheries 2, G. Rose**	**Anthropogenic Effects 4, D. Scruton**	**Effects of Human Activities on Aquatic Systems, A.Ghadouani,**
10:30	**Parkinson, E.** *Linking climate change to fisheries impacts in the BC rainbow trout lakes.* (6-6)	**Peterson, D.P.**, et al. *Verification and Refinement of an Electrofishing Catch-Per-Unit-Effort (CPUE) Method Used to Assess Juvenile Atlantic Salmon*	**Mello, L.G.S**. and G.A. Rose. *Simulating Conservation and Rebuilding Strategies for Placentia Bay Cod Fishery.* (2-6)	**Surette, H**., et al. . *Ecological Integrity in Uncharted Waters: Historical Changes in the Fish Assemblages of Point Pelee National Park of Canada.* (3-16)	**Bocaniov, S.** *Effect of damming on nutrient and sediment balance: the case of Iron Gate 1 Reservoir*

		Abundance. (G-1)			
10:50	**Rivkin, R.**, et al. *Influence of Climate Change on Patterns of Primary Production, Export and Sustainable Fisheries.* (6-7)	**Killen, S.S.** and J.A. Brown. *The Effects of Predatory Threat and Temperature on Energy Acquisition in Newly Hatched Ocean Pout (Macrozoarces americanus).* (G-2)	**Morris, C.J.**, et al. *Protecting and Rebuilding a Local Atlantic Cod Population in Gilbert Bay, Labrador, Through a Marine Protected Area.* (2-7)	**Brasfield, S**.,et al. *Use of Fish Populations in an Effects Based Assessment to Evaluate Non Point Stressors Associated with Agriculture.* (3-17)	**Tremblay, A.** *CO_2 fluxes from natural lakes and hydroelectric reservoirs in NewFoundland*
11:10	**Breau, C.,** et al. *The Effects of High Water Temperatures on the Physiology and the Social Behaviour of Juvenile Atlantic Salmon (Salmo salar).* (6-8)	**Austin, D.** , et al. *Stomach Temperature Telemetry Reveals Temporal Patterns of Foraging Success in a Free-Ranging Marine Mammal.* (G-3)	**Sargent, P.S.**, et al. *Artificial Reefs Increase Density of Coastal Marine Demersal and Benthic Fish and Crab Species.* (2-8)	**Doherty, C. A.**, et al. *Human Development and Environmental Monitoring: Assessing Fish Mobility and Performance Parameters*. (3-18)	Ginn, et al. (Presented by **Smol**). *Tracking acidification trends in Nova Scotia using paleoecological techniques*
					Toxic Effects, Convener /Président: Anas Ghadouani
11:30	**Hay, D.E.**, et al. *Identifying and separating impacts of climate change and anthropogenic effects on the distribution and abundance of small, pelagic fish in British Columbia (BC), with a focus on herring and eulachons.* (6-9)	**Cote, D.**, et al. *Habitat Selection and Early Winter Movements by Juvenile Atlantic Cod (Gadus Morhua L.) in a Coastal Area of Newfoundland.* (G-4)	**Grant, S. M.** *The Mortality of Snow Crab Discarded from Newfoundland and Labrador's Trap Fishery: At-Sea Experiments on the Effect of Drop Height and Air Exposure Duration.* (2-9)	**Askey, P.J.,** et al *The Effects of Municipal Nutrient Loading on Trophic Structure and Spatial Distribution of Fish in a Large River System.* (3-19)	**Muir, D.** et al. *Why are PCBs and toxaphene higher in lake trout from Lake Superior than in nearby small lakes?*
11:50	**Johannes., M.** Adapting to Climate Variation and Change: Issues for Aquaculture, Fisheries And	**Hasselman, D.J**. and R.G. Bradford. *Discrimination of Coregonid Fishes in*	**Curtis, J. M**. and A. C. J. Vincent. *Impacts of Non-Selective Fishing Gears on the*	**Freedman**, **J. A.,** et al. *Effects of pulp mill effluent on fish communities.* (3-20)	**Hamelin, S**. et al. *What happens to mercury, once trapped by epiphytic biofilm?*

	Fisheries Communities. (6-10)	*Maritime Canada.* (G-5)	*Population Structure of Two Seahorse Species in a Coastal Lagoon.* (2-10)		
12:10 – 13:30	**Lunch**				
	Salon A	**Salon B**	**Salon C**	**Salon D**	**Conception Bay Room**
Concurrent Sessions	**Aquaculture 1, J/ Brown**	**General Contributed Papers 2**	**Rebuilding Fisheries 3, G. Rose**	**Anthropogenic Effects 5, D. Scruton**	**Multiple Stressors in Aquatic Ecosystems, S. Arnott**
13:30	**Weir, L.K.,** et al. *Studs or duds?: The influence of artificial selection on the spawning behaviour of male Atlantic salmon.* (4-1)	**Purchase, C.F**., et al. *Predicting Life History Traits of Yellow Perch from Relationships with Environmental Variables.* (G-6)	**Winger, P.D.**,et al. *Gait Use, Behaviour, and Swimming Kinematics in American Plaice: Insights into the Herding of Flatfish by Bottom Trawl Sweeps*.(2-11)	**Payne, J.F.** *Oil Development on the Grand Banks of Newfoundland: A Perspective on Potential Impacts and Approaches to Monitoring.* (3-21)	**Yan, N.** et al. *Progress in the long-term recovery of zooplankton from severe historical acidification and metal contamination in Sudbury lakes*
13:50	**Lush. L.**, et al *Photomanipulation of Captive Atlantic Cod (Gadus morhua) Broodstock.* (4-2)	**Keeler, R.A.** and R.A. Cunjak. *Individual Movement of Passive Intregrated Transponder (PIT) Tagged Slimy Sculpin, Cottus.* (G-7)	**Hutchings, J.A.** *Life History Consequences of Over-Exploitation to Population Recovery of Northwest Atlantic Cod.* (2-12)	**Pinsent, D. L.,** et al. Eelgrass *Transplantation as Habitat Compenpensation for the White Rose Project.* (3-22)	**Leavitt, P.** et al. *Reduced ecosystem predictability arising from pollution: fossil and historical records of lake response to sewage, its diversion, and continued land use*
14:10	**Puvanendran, V**. and J.A.Brown. *Growth and Survival of Atlantic Cod Larvae From Four Latitudinally Separated*	**Hatton, I**. et al. *Graphical decision analysis: Applications to Porbeagle shark harvests and Atlantic cod*	**Fudge, S.B**. and G. A. Rose. *Fecundity of Northern Cod, Gadus morhua, in Two Newfoundland Coastal*	**Skinner, M**., et al. *Mummichog (Fundulus heteroclitus) Movement During the Ice-Free Season in the Miramichi*	**Ghadouani, A.** *The role of eutrophication in structuring zooplankton communities*

	Populations: Implications for Broodstock Development. (4-3)	*interactions with harp seals* (G-8)	*Areas*.(2-13)	*River Estuary.* (3-23)	
14:30	**Halfyard, L.C.**, et al. *The nutritional benefits (lipids, amino acids) versus economic costs of providing live Artemia and commercial diets to first-feeding common wolffish, Anarhichas lupus.* (4-4)	**Rennie, M.D.,** et al *Minimizing Error in Model Estimates of Consumption and Activity for Wild Fish Populations.* (G-9)	**Bradbury, I.R.**, et al. *Discrete spatial dynamics and essential habitat of coastal cod populations: conservation and management implications.* (2-14)	**Morinville, G.R**, and J.B. Rasmussen. *The Impact of Barriers on the Upstream Habitat Use of Resident and Migrant Brook Trout (Salvelinus fontinalis).* (3-24)	**Barnard, C**. et al. *St Lawrence estuarine transition zone (ETZ) invaders: Zebra mussel veligers and their feeding habits in the ETZ*
14:50	**Podemski, C.L.** , et al. A *Whole-Lake Experiment to Assess the Impact of Cage Aquaculture on Freshwater Ecosystems.* (4-5)	**Jiao*, Y.**, Y. Chen, and J. Wroblewski. *An application of generalized linear model in production model and sequential population analysis.* (G-10)	**Rowe, S.** and J.A. Hutchings. *Implications of Mating Systems for the Collapse and Recovery of Atlantic Cod*. (2-15)	**Lawrie, M.K.** and R.W. Mackereth. *Small Stream Habitat Use by Brook Trout, Salvelinus* fontinalis, in Northwestern Ontario. (3-25)	**Radomski, E.** et al. *The effect of dissolved organic carbon (DOC) and inorganic nutrients on phytoplankton and bacterioplankton biomass and productivity*
15:10 – 15:30	**Break**				
	Salon A	**Salon B**	**Salon C**	**Salon D**	**Conception Bay Room**
Concurrent Sessions	**Aquaculture 2, J/ Brown**	**General Contributed Papers 3**	**Rebuilding Fisheries 4, G. Rose**	**Anthropogenic Effects 6, D. Scruton**	**Aquatic Food Webs, C. Ramcharan,**
15:30	**McKenzie, C.H**, et al. *Harmful Algae Detection at Newfoundland Aquaculture Sites – A Product Management and Marketing Issue.* (4-6)	**Gillis, D.M.**, et al *Information Use in Commercial Co-Management: Surveys and Snow Crabs.* (G-11)	**Post, J.R.** *Life History Variation and Sustainable Harvest with Regulations in Lake Trout, Salvelinus Namaycush, Populations.* (2-16)	**Parker, S.A.** and R.W. Mackereth. *Landscape Scale Characteristics Influencing the Presence and Relative Abundance of Brook Trout (Salvelinus fontinalis) in Beaver Ponds in Northwestern Ontario.*	**Hudson, J**. *Effects of consumers on nutrient kinetics in planktonic food webs*

				(3-26)	
15:50	**Ryan, J.**, et al. *The Effects of Mytilus spp. Farming on the Benthic Environment at Two Newfoundland Aquaculture Sites.* (4-7)	**Reardon, K.** and C. Wilson. *Development of a trap to exclusively target Jonah crab (Cancer borealis) in near shore Gulf of Maine.* (G-12)	**E. Colbourne**, et al. *Impact of extreme ocean climate events on marine resources – the Smith Sound example.* (2-17)	**Browne, D. R**., and J. B. Rasmussen. *Alternative States in Brook Charr Fisheries: The Role of Spatial Refuges in Mediating Interspecific Competition.* (3-27)	**Jackson, V**. & W. Taylor. *Importance of protozoa to the pelagic food web of Lake Victoria, East Africa*
16:10	**Stacey, J.** and D. Deibel. *The Effects of Mussel (Mytilus Sp.) Farming on the Zooplankton Communities of Notre Dame Bay, Newfoundland.* (4-8)	**Alkanani, T.,** et al. *Lipid and non-esterified fatty acid profiles in the plasma of North Atlantic cod (Gadus morhua) from Newfoundland.* (G-13)	**Lilly, G.**, et al *The Mass Mortality of Atlantic Cod (Gadus morhua) in Smith Sound, Eastern Newfoundland, in April 2003.* (2-18)	**Swanson, H.K.,** et al. *Mercury Dynamics in Forage Fish Communities: A Growth Story.* (3-28)	**Bouchard, G**. et al. *Freshwater diatom biogeography of the Canadian arctic archipelago*
16:30	**Hartstein**, **N.D.** *Seabed dispersal of mussel farm debris.* (4-9)		**Anderson, J.T.,** et al. *Spatial Utilization of Benthic Habitat by Demersal Fish on the Scotian Shelf.* (2-19)	**Vallis, L.**, D. et al. *The Potential Use of Rock Gunnel (Pholis gunnellus) as a Bioindicator Species in Saint John Harbour, New Brunswick, Canada.* (paper 3-29)	**Marty, J**. & D. Planas. *Carbon and nitrogen stable isotope in zooplankton: what's up in reservoirs?*
16:50	**Chamberlain, J**., et al. *Assessing Site Suitability for Suspended Mussel Aquaculture – A Modeling Approach.* (4-10)				**Ramcharan, C.** *Zooplanktivory in lakes: have we nabbed the wrong suspect?*
17:10	**Concluding Remarks**				
17:15	**SCL BUSINESS MEETING**				
18:45	**Convene for Pub Crawl**				
19:00	**George Street Pub Crawl**				

Posters, Keith Clarke
Retzlaff, A. and R. Hooper. Changes in Snow Crab (*Chionoecete opilio*) Feeding Ecology in Bonne Bay, Newfoundland and Labrador (Canada) from 1990 to 2003. (P-1)
Cleary, J.S. Lipid Analysis in Juvenile Salmon: Examining the use of Lipid Analysis as an Indicator of Fish Habitat Condition in Large Rivers of central British Columbia. (P-2)
Sherwood, G.D. Stable Isotope Analysis of Some Representative Fish and Invertebrates of the Newfoundland and Labrador Continental Shelf Food Web. (P-3)
Klassen, C.N. and S.J. Peake. Potential of Black Fly Larvae (Diptera: Simuliidae) as an Alternative Food Source for Hatchery Production of Lake Sturgeon (Acipenser fulvescens). (P-4)
Ng, R.Y., D.R. Browne and J.B. Rasmussen. Examining the Life History Response of Yellow Perch to Mass Removal. (P-5)
Reid, J.E., and S. Peake. A Preliminary Study on the Performance of Non-Salmonids in a New Experimental Fishway. (P-6)
Walker, E.M. and S. Peake. The Effects of Acute Sedimentation Events on the Survival and Growth of Aquatic Organisms in an Experimental Flume: A Preliminary Study. (P-7)
Wells, J.M., D.A. Scruton, J.A. Brown, and K.D. Clarke. Effects of Managed Buffer Zones on Fauna and Habitat Associated with a Headwater Stream in the Indian Bay Watershed in Northeast Newfoundland. (P-8)
van Zyll de Jong, M.C., W. Norris, N. P. Lester and R. M. Korver. Managing the Exploitation of Brook Trout Salvelinus fontinalis (Mitchill) Populations in Newfoundland Lakes. (P-9)
Robertson, M. J., D. A. Scruton, M. R. Anderson, and G. J. Robertson. Mercury Concentrations in Freshwater Fishes of Labrador in Relation to Biological and Environmental Variables. (P-10)
Ollerhead, L.M.N., D.A. Scruton, M.J.Morgan, and B. Marrie. Mapping Spawning Times and Locations for Ten Commercially Important Fish Species Found on the Grand Banks of Newfoundland. (P-11)
Decker, R., D.A. Scruton, and K.D. Clarke. The Newfoundland Small Stream Buffer Study Phase I: Impacts of current forest harvesting practices on stream habitat and biota. (P-12)
Harford, W.J. and Robert L. McLaughlin. Variation in the Effect of Sea Lamprey Barriers on Non-Target Fishes: the Influence of Sampling (Chance) on Effect Size. (P-13)
Payne, J.F., **C. Andrews**, L. Fancey, J. Wells, B. French, and F. Power. Evaluation of Acute and Chronic Toxicity Aspects of the Aliphatic Hydrocarbon Based Drilling Fluid Being Used on the Grand Banks of Newfoundland. (P-14)
Scruton, D.A. and K.D. Clarke. Effectiveness of Re-Watering and Enhancement of a Flood Overflow Channel as Compensation for Habitat Lost Due to Hydroelectric Development. (P-15)
J.F. Payne, L.L. Fance1, **L. Park**, C. Andrews, S. Whiteway and B. French. Microbial Pollution: A Key Factor to Consider in the Management of Municipal Wastewater Effluents from the "Smallest" of Sewage Outfalls. (P-16)
DuRand, M. D., C.H. McKenzie, C.C. Parrish, and R.J. Thompson. Phytoplankton Community Dynamics, Environmental Conditions, and Mytilus

Spp. Growth at Two Mussel Aquaculture Sites in Newfoundland. (P-17)
Anderson, M. R., C. Stirling, A. Roy, J. Ryan, T. Strang, and R.J. Thompson. Potential For Habitat Modification in Hypoxic and Anoxic Sediments Under Longline Mussel Farms. (P-18)
Park, K. and W.R. Driedzic. Rates of Protein Synthesis are Similar in Juvenile Cod Despite Differences in Population, Feeding Level, and Small Temperature Change. (P-19)
Alkanani, T., C.C. Parrish, K.J. Rodnick, and K. Gamperl. Specific methylation of plasma non-esterified fatty acids: Assessment of selectivity. (P-20)
Alkanani, T., C.C.Parrish, C.H. McKenzie, R.J. and Thompson. Role of fatty acids in cultured *Mytilus edulis* grown in Notre Dame Bay, Newfoundland. (P-21)
Strang, T.J. and M. R. Anderson. Nutrient Regeneration Under Mussel Farms: The Environmental Effects of Mussel Aquaculture in Coastal Bays. (P-22)
Bradbury, I.R., and P. Bentzen. Covariates of Migratory Phenotype and Life Histories in Anadromous Fish. (P-23)
Chippett , J. Assessing the status of a Newfoundland species: Fundulus diaphanus, the banded killifish. (P-24)
Pritchett , R. Fourier Analysis of Brook Trout (*Salvelinus fontinalis*) Otoliths for Stock and Population Discrimination. (P-25)
Adams, B. K. and J. A. Hutchings. Microgeographic Population Structure of Brook Char, *Salvelinus Fontinalis* L.; A Comparison of Microsatellite and Mark-Recapture Data. (P-26)
Kaufman, S., J. Gunn and G. Morgan. Optimal Foraging and Growth of Walleye (*Sander vitreus*). (P-27)
Shaw, J., R. A. Curry and S. L. Currie. Growth of the Sympatric Rainbow Smelt (*Osmerus mordax*) Complex of Lake Utopia, New Brunswick. (P-28)
Hardie, D.C. and J.A. Hutchings. Genetics and Life History of Landlocked Atlantic Cod (*Gadus morhua*) Populations from Coastal Arctic Lakes at the Extreme of the Species' Range. (P-29)
Cheeseman, J. Frog Research in Indian Bay. (P-30)
O'Brien-MacDonald, K. and J.A. Brown. Meristic and enzymatic responses of peri-metamorphic Atlantic cod (*Gadus morhus*) larvae to diets of enriched *Artemia*. (P-31)
Monk, J., J.A. Brown V and Puvanendran. Improving Survival in Larval Cod, *Gadus morhua:* An Investigation of Three Different Light Rearing Regimes. (P-32)
Roux, M-J. R. Anderson, M. Wadleigh, M.J. Robertson, and D. Planas. Using Stable Isotopes of Carbon and Nitrogen to Investigate Bi-Dimensional Food Web Structure as Determinant of Mercury Levels in Fish from Labrador Lakes Exploited by Innu Fishers. (P-33)
Dennis, B., Fisheries Research Projects. (P-34)

SCL Posters
Allaway*, C., and F.R. Pick. *Factors controlling nitrogen removal in a riverine network.*
Bogard, Matthew. *Effect of climate change on the long-term pattern of phytical, chemical, and biological properties in Jackfish Lake, Saskatchewan*
Bunbury, J. and Gajewski, K. Lacustrine variability and the development of paleolimnological transfer functions.

Campbell, L. M., Szabo, R, Greenwood, D., Thacker, R., Barton, D., Muir, D. C. G. and Hecky R. E. *Transfer of mercury and other metals in Eastern Lake Erie: How does the round goby fit in?*
Dessouki, T. C. E., Hudson, J. J., Neal, B. R. and Turner, A. *Removal of surface water contaminants using phyto-remediation*
Dubois*, K , Carignan, R. and Veizer, J. *Using stable isotopes to determine P/R ratios in lakes.*
Holzapfel*, A.M, Donald, D.B., Vinebrooke, R.D. *Does environmental warming increase invasion of coldwater zooplankton assemblages?*
Muir, D.C.G.*, N. Nguyen, C. Cannon, F. Yang, X. Wang, and D. Halliwell, J. Smol, M. Douglas, R. Pienitz, W., A. Wolfe, and Günter Köck *Spatial trends and historical inputs of mercury and lead in eastern and northern Canada inferred from lake sediment cores.*

Abstracts

Theme 1 - Evidence and Impacts of Aquatic Regime Shifts

Shifting Regimes in the Northwest Atlantic - Multi-species Signals from Seabirds.
Montevecchi, W.A.[1], G.K. Davoren[2], and J.E. Carscadden[3]. [1]Cognitive and Behavioural Ecology Program, Memorial University of Newfoundland, St. John's, NL; [2]Zoology Department, University of Manitoba, Winnipeg, MB: [3]Fisheries and Oceans Canada, St. John's, NL (paper 1-1)

Abstract:

We overview the trophic involvements of generalist (gannets) and specialist (murres) diving birds and the breeding production of surface-feeders (kittiwakes) and divers (murres, puffins) as reflections of significant decadal changes in the pelagic food webs and ecology of the Northwest Atlantic. A historically significant cold-water event in the early 1990s has continued to have pervasive ecological effects on pelagic food webs even well after physical oceanographic conditions reverted to pre-perturbation levels. Initial indications of this shift came from long-term studies with marine birds. Findings showed that large migratory warm-water pelagics, such as mackerel, short-finned squid and Atlantic saury, were replaced by cold-water species, such as capelin and to a lesser degree Atlantic salmon, in diets of gannets nesting on Funk Island off the northeast coast of Newfoundland (NAFO area 3K). Commercial fisheries for mackerel and squid have ceased. Predation by gannets on post-smolt Atlantic salmon increased by an order of magnitude from the 1970s/80s to the 1990s, and yet again from 2000 onward. Surface-feeding kittiwakes exhibited extensive nesting failures in Newfoundland (NAFO 3K3L) and Labrador (NAFO 2J) that contrasted with the success of diving birds, indicating shifts in the spatial and temporal distributions of capelin, the major forage fish in the Northwest Atlantic. Throughout the 1990s, there have been decreases in the percent gravid and conditions of capelin delivered to murre chicks at the world's largest colony on Funk Island. As a consequence, the energy delivered to Chicks and their conditions also decreased. Moreover, murres breeding in Labrador showed marked decreases in the proportions of capelin in their diets. We interpret these patterns as reflections of radical changes in the behaviour and ecology of capelin. Concurrent changes in the diets of other large predators such as Arctic char and cod also mirror these trends and patterns. We emphasize that long-term, large-scale multi-disciplinary, multi-species research programs that investigate biophysical and trophic interactions within dynamic oceanographic contexts are required for comprehensive understanding of the temporal and spatial aspects of these shifts and for the effective management of marine ecosystems.

Long-term Changes in the Diet of Pollock (*Pollachius virens* L.) on the Scotian Shelf: Responses to a Dynamic Ecosystem. **Carruthers, E.H.**, Neilson, J.D., Waters, C., and P. Perley. Marine Fish Division, Dept. of Fisheries and Oceans, St. Andrews Biological Station, St. Andrews NB, E5B 2L9 (paper 1-2)

Abstract:

Pollock (*Pollachius virens*) diets and feeding intensity have changed markedly since the last published account in 1963 for Canadian waters. We analysed stomach content data from pollock collected from the Scotian Shelf and Bay of Fundy for the periods 1958-67 and 1996-2002 (2078 and 1230 samples were examined, respectively). Feeding intensity was significantly lower during the recent period, and the overall fullness index decreased from 1.43 in the early period to 0.84. Pollock stomachs were collected on a variety of surveys, thus, there were differences in sample distribution among factors such as location, predator size and time sampled. Although these factors did have an effect on prey weight, an analysis of variance indicated a significant difference between the sampling periods. Data from stomachs collected in the early period confirmed previous reports of euphausiids being the primary prey (present in 65% of stomachs examined). This was not reflected in the later period; euphausiids were present in 9% of stomachs examined. The partial fullness indices for euphausiids decreased from 0.84 to 0.04. There was little change in the importance of fish prey in the diet, occurring in roughly 1/3 of the stomachs and accounting for a similar partial fullness index, but there were changes in the importance of different fish forage species. Changes in pollock diet were compared with data on prey abundance as indicated from Continuous Plankton Recorder and research vessel survey data, and appeared to reflect the abundance of significant prey on the Scotian Shelf. Such changes in the feeding opportunities for pollock were concurrent with significantly lower pollock condition during the later period.

Capelin Diet Shifts in the Newfoundland and Labrador Ecosystem: An Indicator of Changing Secondary Production? **Mowbray, F.K.** Northwest Atlantic Fisheries Center, Fisheries and Oceans, St. John's, Newfoundland (paper 1-3)

Abstract:
Stomach contents of capelin (Mallotus villosus) from the Newfoundland and Labrador ecosystem collected during spring (1999-2002) and fall (2001-2002) feeding periods were examined. Compared with spring diet data from the late 1980s, the frequency of occurrence of the larger prey items (euphausiids, mysids and gammarids) declined, although the overall range of prey types was similar. These changes are discussed in relation to changes in capelin distribution, behaviour and biological characteristics. It is argued that taken together these data infer a decline in certain zooplankton since the early 1990s.

Linkages in recruitment variability between three species of gadids: Atlantic cod *Gadus morhua*, Greenland cod *G. ogac* and white hake *Urophycis tenuis*. **Laurel, B.J.** and R. S. Gregory. Department of Fisheries and Oceans. Science Branch, PO Box 5667, St. John's, Newfoundland A1C 5X1 (paper 1-4)

Abstract:
Three species of gadids (Atlantic cod-*Gadus morhua*, Greenland cod-*G. ogac* and white hake-*Urophycis tenuis*) settle to demersal habitats in late summer and comprise nearly 80% of the nearshore fish community in Newfoundland during their first year of life. However, little is known on the interspecific interactions, habitat requirements and environmental conditions that affect recruitment variability in these species. We examined these relationships using 8 yrs of beach seine data from 1996-2003 collected from Bonavista Bay, Newfoundland. All three species were found more commonly in eelgrass relative to mineral substrates. Furthermore, total gadid abundance varied little in eelgrass habitat between years, suggesting eelgrass was at its carrying capacity for these species. However, there was high interannual variation in recruitment to these habitats in both Atlantic cod and hake populations. In these two species, we found a strong inverse relationship in yearly recruitment to the nearshore ($r^2 = 0.86$). Age 0 hake growth was found to be significantly higher than Atlantic cod and diet analysis showed that hake fed on similar invertebrate prey and occasionally consumed Atlantic cod of the same year class. We explore the possibility that competitive interactions between hake and Atlantic cod in the nearshore contribute to year-class fluctuations in these species.

Resistance of the Prey to Predator Ratio to Environmental Gradients and to Biomanipulations. **Donald, D.B.**[1] and Anderson, R.S.[2]. [1]Environment Canada, Room 300 Park Plaza, 2365 Albert Street, Regina, SK, S4P 4K1; [2]P.O. Box 127, New Sarepta, AB, TOB 3M0 (paper 1-5)

Abstract:
Species and their abundances change along environmental gradients, and populations of some species are decimated by introductions of foreign species. We show that the prey to predator species ratio is resistant to change. We determined that ratios were about 3/1 for fifty lakes with diversity ranging from 5 to 58 taxa, and with a total combined fauna of 140 insects, crustaceans, and fish. Ratios were not related to chemical, thermal or physical characteristics of lakes. Ratios were generally the same for fishless lakes, those with one or two introduced predators (salmonids), and for lakes with more complex communities with up to 14 predators including five fish species. For the simplest model, this suggests that when a fish species is introduced and becomes established in a lake there is a fundamental ecological compensatory adjustment with either a three species increase in the diversity of prey or the loss of a predator (but no change in diversity). However, we show more complex prey-predator ratio changes occur because certain keystone species regulated community structure and prey diversity. When the keystone fish (a predatory salmonid) was removed from 5 lakes, the penultimate littoral predator (lake chub) occupied both the pelagic and littoral zones. Consequently, amphipod density decreased, chironomid density increased, and total zooplankton and benthic diversity increased by 31% or 7.8 taxa per lake on average. The mean prey/predator ratio for these five lakes increased significantly from 2.32/1 to 4.16/1. These community based prey/predator ratios were established by single keystone species from their influence on prey, other predators, and community structure.

Stunted Cod? Evidence for Feeding Bottlenecks in the North Atlantic. **Sherwood, G.D.** and Rose, G.A. Fisheries Conservation Chair, Fisheries and Marine Institute of Memorial University of Newfoundland and Labrador, St. John's NL (paper 1-6)

Abstract:
Growth in fish is inherently variable among populations. As such, it is often difficult to identify when fish are stunted, especially when stunting is defined as 'poorer than normal growth' (Merriam-Webster). Here, we introduce an age-independent method for identifying stunted fish. Our approach, as opposed to relying solely on growth estimates (i.e. size-at-age, which may be biased in stunted populations), evaluates how smoothly fish make transitions from one diet stage to the next based on biological condition indices. In cases where food-web

complexity allows, diet shifts (to bigger and/or 'better' prey) tend to be regular and fish condition increases monotonically with size, thereby allowing for 'normal' growth. In cases where important diet stages are missing or scarce, foraging costs may increase or returns may decline, resulting in poorer biological condition and ultimately stunting. We will present studies of growth and diet in yellow perch (*Perca flavescens*) from inland lakes in Quebec that corroborate this conceptual model of stunting. We will then provide evidence that similar stunting patterns exist for cod (*Gadus morhua*) inhabiting Newfoundland and Labrador continental shelf waters (NAFO divisions 2J3KL + 3Ps). Specifically, all cod sampled in 2002 displayed negative size-dependency for various condition indices (Fulton's condition index, liver index, and lactate dehydrogenase activity, a potential biochemical indicator of anaerobic condition) from about 40-60 cm length, suggesting that some kind of feeding bottleneck occurs in this size range. Diet and stable isotope ($\delta^{13}C$, $\delta^{15}N$) analyses revealed that these condition minima coincided with maximum capelin (*Mallotus villosus*) feeding (where capelin were present). Cod appeared to recover from this energetic bottleneck only as a result of shifting back to more benthic modes of feeding. We argue that capelin, the once predominant forage species in Newfoundland and Labrador waters, may represent an important and now missing 'stepping stone' to the normal growth of cod.

Is The Seabed a Refuge From Piscivorous Fish, For Post-Settled Age 0 Juvenile Cod (Gadus spp.) in Nearshore Habitats? **Linehan, J.E.**, M. Pink, and R.S. Gregory. Department of Fisheries and Oceans, St. John's, NL (paper 1-7)

Abstract:

Recently settled age 0 juvenile cod (Gadus spp.) are distributed in shallow water (<10 m) in coastal Newfoundland. Age 0 cod (Gadus spp.) are known to settle into habitats that promote survival. We tested the hypothesis that predation risk is lowest at the seabed and highest off bottom. We determined relative risk of tethered age 0 cod prey to predation by piscivorous fish in field experiments conducted in Newman Sound, Newfoundland. Age 0 prey were tethered at 0.25, 1.5, 5.0, 7.5, and 9.25 m from the seabed at a bottom depth of 10 m during day, dusk and night, during both summer and autumn. Predation was lower at night than during either dusk or day in both summer and autumn. Predation was higher during day and dusk throughout the water column in the summer. Contrary to predictions, predation was highest at the treatments closest to the bottom during all diel and both seasonal periods. We rejected our hypothesis. Our results do not support the long-held notion that age 0 cod settle from the pelagia to escape elevated risk to predators higher in the water column. Our results suggested that post-settled age 0 cod were safer higher in the water column at a bottom depth of 10 m.

Mark-recapture of juvenile cod (*Gadus* spp.) in coastal Newfoundland indicate high site fidelity and low mortality. **Sheppard, G.L.**, Schneider, D.C. and Gregory, R.S. Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL (paper 1-8)

Abstract:

In coastal Newfoundland, pelagic juvenile cod have been found to inhabit eelgrass (*Zostera marina* L.) after settling to decrease predation risk and increase food availability. I hypothesized that demersal juvenile cod experience low mortality and high site fidelity in eelgrass habitat. To determine the site fidelity and mortality rates of age 0 Greenland cod (*Gadus ogac*) and age 1 Atlantic cod (*G. morhua*), inhabiting eelgrass in the nearshore of Newman Sound, Bonavista Bay, I conducted multiple mark-recapture studies using partial fin-clips and soft visible implant alphanumeric (VIalpha) tags. From October-November 2002, I fin-clipped 818 age 0 Greenland cod at a sheltered embayment, with a recapture percentage, via beach seine, of 7%. To contrast site fidelity between a sheltered eelgrass site and a more exposed beach site with expansive eelgrass meadows, a mark-recapture experiment was conducted where 745 and 835 age 1 Atlantic cod were fin-clipped, respectively. Observed recapture percentages suggested that site fidelity was higher and mortality was lower in sheltered areas (15%) compared to more exposed shorelines (10%). VIalpha tags were used to mark a total of 800 age 0 Greenland cod at two coves and a beach site during October-November, 2003. Recapture rates similar to those observed in 2002 indicated lower site fidelity and higher mortality for the species and season. Mortality rates and site fidelity of demersal juvenile cod vary between species, between seasons, and between the sites.

Habitat influences the growth rate of three juvenile gadoids (*Gadus morhua, Gadus ogac, Urophycis tenius*) in Newman Sound, Newfoundland. **Renkawitz, M.D.**, R.S. Gregory, and D.S. Schneider, Ocean Science Centre, Department of Biology, Memorial University of Newfoundland, St. John's, NF (paper 1-9)

Abstract:

In Newman Sound, Newfoundland, juvenile fish settle in shallow near-shore waters and are highly associated with eelgrass beds of intermediate complexity. While it is well established that complex habitats provide a refuge from

predators, little is known about the potential energetic reward associated with them. We determined that the settlement and subsequent association of juvenile fish with structurally complex habitat (i.e. eelgrass) was partially in response to energetic reward. Juvenile white hake (*U. tenius*), Atlantic cod (*G. morhua*), and Greenland cod (*G. ogac*) were placed in 1 m^3 plastic mesh enclosures among eelgrass, barren mud, and pelagic habitats from 2002 to 2003. Changes in standard fish length (mm) were measured throughout the trials, and relative growth rates were determined for each habitat. Preliminary analysis suggests that in the fall 2002, there was no difference in growth rates of age-0 Greenland cod among the three treatments. Over-winter growth rates of Atlantic cod did not differ significantly either. In spring 2003, mean growth rates of age-1 Atlantic cod were significantly greater in eelgrass than barren mud or pelagic habitat (0.34 mm day^{-1}, 0.29 mm day^{-1} and 0.07 mm day^{-1} respectively). In addition, age-0 white hake grew more rapidly in eelgrass habitat (0.59 mm day^{-1}) than barren mud and pelagic habitats during the summer 2003 (0.26 mm day^{-1} and 0.19 mm day^{-1} respectively). These data suggest that in addition to refuge from potential predators, juvenile fish may settle and occupy structurally complex habitat for energetic reward.

What Might Starving in Field Populations of Cod Larvae Look Like: Inferences from Laboratory Studies.
Jordaan[1], A., Brown[2], J.A. and L.J.Kling[1]. [1]School of Marine Sciences, University of Maine, Orono, ME, US, 04469; [2]Ocean Sciences Centre, Memorial University of Newfoundland, St. John's. NL A1B 3X9 (paper 1-10)

Abstract:

Starvation has been viewed as an important factor involved in the mortality of larval fish for many decades, as evidenced by the critical period and match- mis/match hypotheses. Despite the plausibility of starvation as a regulator of larval abundance, there remain few examples that unequivocally relate starvation to survival in a field study of cod or other larval fishes. We carried out two experiments using Newfoundland source cod eggs that may help provide insight into the effect of starvation on the survival, growth, activity and appearance of cod larvae, as influenced by age and temperature. The first study assessed the effect of age on susceptibility to starvation and the second experiment examined the relationship between growth and temperature. The results indicate that cod larvae do not invest energy towards offsetting periods of starvation beyond short-term events. Furthermore, periods associated with increased growth had the highest risk of starvation. Activity levels were reduced in starving populations and as individuals began to starve, they sank. The results will be used to outline how populations of cod that are starving, or that contain starving individuals, may appear in the field at different ages and under different thermal regimes.

The Effect of Water Current Velocity on the Stable Carbon and Nitrogen Isotopic Signatures of Periphyton.
Trudeau, V. and J. Rasmussen. Department of Biology, McGill University, Montreal, PQ (paper 1-11)

Abstract:

Stable carbon and nitrogen isotopic analyses are increasingly used in ecology, especially for looking at trophic position and food web linkages in aquatic systems. The isotopic signatures of primary producers in aquatic food chains are known to be affected in part by abiotic factors. In particular, boundary layer thickness may play an important role in determining primary producer C and N isotopic signatures. The boundary layer on the surface of aquatic plants found in low energy environments is assumed to be thicker. This should result in lower diffusion rates of nutrients and reduced isotopic discrimination against heavier ^{13}C and ^{15}N, and in turn cause C and N isotopic signatures of plant tissue to increase. The opposite is expected in high energy environments. The present study tests the effect of water current velocity on stable C and N isotopic signatures of periphyton growing in artificial streams. The results indicate that current velocity, over the range commonly encountered in rivers and streams, has a significant effect on the isotopic signatures of periphyton. Although the effect is more significant for C compared to N, both isotopic signatures tend to increase as current velocity decreases. This experiment does not explain all of the variability observed in stable isotopic signatures, however, it allows a better understanding of this variability. Further study of periphyton isotopic signatures in flowing water may prove to be rewarding, since these signatures seem to reflect important underlying processes. Furthermore, periphyton presents a baseline of isotopic signatures that are passed on to benthic invertebrates and fish through the food web, providing potentially useful habitat tracers.

Food Web Relationships in a Protected River System. **McWilliam, S.**, Sutherland, R. and Cunjak, R. Department of Biology, University of New Brunswick, Fredericton, NB (paper 1-12)

Abstract:

The objective of this study was to quantify and describe food web relationships in the Upper Salmon River, New Brunswick, a 390km long river in which 49% flows through Fundy National Park. Within this objective were two specific goals: 1) to differentiate between relative contributions of terrestrially-derived (allochthonous) carbon sources versus aquatically-derived (autochthonous) carbon sources that sustain populations of fish throughout the

river system, and 2) to determine trophic relationships of different aquatic taxa and age-classes of fish. To fulfill these goals, we analyzed stable isotope ratios of carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$). Inferences as to a consumer's diet are made by comparing its isotopic ratios (reported as $\delta^{13}C$ and $\delta^{15}N$) with those of other species in its food web. Stable carbon ratios are effective food source tracers because little alteration (0-1‰) occurs as the element is transferred through the food chain. Alternatively, large increases in ^{15}N at progressively greater food chain levels (3-4‰) allow quantification of the trophic status of individual organisms. Collections were made of algae (diatoms), riparian zone vegetation, functional feeding groups of aquatic invertebrates, and different species and life stages (age classes) of fish. These were collected seasonally between April and September of 2003. Spatially, the sampling was carried out from headwaters to river mouth (below head of tide) with nine study sites reflecting the predominant habitat-types (riffles and pools) and stream orders present. Samples were oven-dried, homogenized and analyzed for isotopic ratios at the Stable Isotopes in Nature Laboratory, University of New Brunswick, Fredericton, NB. Results will be presented and discussed in the presentation.

Tracing the Influence of Terrestrial Production to the Nearshore Marine Habitats of Juvenile Atlantic Cod (*Gadus morhua*) Using the Stable Isotopes of Carbon, Nitrogen and Sulphur. **Jamieson, R.E.**[1], R.S. Gregory[2], and M.A. Wadleigh[1]. [1] Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland; [2]Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre, St. John's, NL (paper 1-13)

Abstract:

The coastal environment provides important habitat for juvenile Atlantic cod (*Gadus morhua*) however the contribution of terrestrial processes to the productivity of these environments is poorly understood. A multiple isotope approach involving carbon, nitrogen and sulphur stable isotopes was used to examine these food web linkages and how they vary over space and time. Samples of both marine and terrestrial primary producers, intermediate consumers (zooplankton, amphipods, and mysid shrimp) and juvenile cod (age 0 and age 1) were collected during the period from June to November 2002. Collections were taken from two main sites in Newman Sound, Bonavista Bay, Newfoundland on six separate occasions. On two of these occasions, samples were collected from an additional four sites in the Sound as well as from Eastport, Bonavista Bay, and Leading Tickles, Notre Dame Bay. These sites all contain eelgrass (*Zostera marina*) which is an important habitat for juvenile cod. During their first year, juvenile cod settle to the shallow, nearshore environment and our initial results clearly reflect this movement. An increasing benthic influence is revealed in parallel changes in the $\delta^{13}C$ and $\delta^{34}S$ signatures of the cod. A progressive decline in $\delta^{34}S$ values of approximately 7‰ along with an increase in $\delta^{13}C$ values of approximately 5 ‰ were observed. Age 0 and age 1 cod are clearly separated in terms of $\delta^{15}N$ pointing to a difference in trophic level with age 1 cod feeding almost one trophic level higher. Cod seem to most clearly reflect a marine benthic carbon source, likely feeding on both mysids and amphipods which have $\delta^{13}C$ and $\delta^{15}N$ values intermediate between cod and marine primary producers. There is no apparent spatial variation in the isotope signatures either within Newman Sound or between sites from different bays. This indicates that isotopic shifts observed in cod can be explained solely by changes in habitat usage.

Fatty Acid Signatures Reveal Diet Differences Among Age-classes, Years, and Foraging Locations of Harp Seals (*Phoca groenlandica*). **Tucker, S.**[1], S. Iverson[1], D. Bowen[2] and G. Stenson[3]. [1] Department of Biology, Dalhousie University, Halifax, NS; [2] Marine Fish Division, Bedford Institute of Oceanography, Dept. of Fisheries and Oceans, Dartmouth, NS; [3] Northwest Atlantic Fisheries Centre, Dept. of Fisheries and Oceans, St John's, NL (paper 1-14)

Abstract:

Harp seals are the most abundant phocid in the North Atlantic. However, very little is known about feeding habits over their entire range, particularly the offshore. Fatty acid (FA) signature analysis is an emerging tool which can provide detailed dietary information based on the principle that most dietary FA are deposited in predator fat stores with minimal modification. FAs can be used to make quantitative estimates of the proportions of prey species in the diet, provided that prey can be differentiated by their FA signature. We analyzed the FA composition (69 FAs) of harp seal blubber collected between 1994-2002; a time period that saw major ecosystem level changes in the Northwest Atlantic. There were large significant differences in FA signatures between animals sampled in the nearshore and offshore, as well as large inter-annual differences. Signatures also differed significantly between juveniles and adults. However, there was no difference in FA composition between males and females. These variations in signatures indicate differences in diets among demographic groups as well as over time and space. To asses the feasibility of making quantitative estimates of harp seal diets, we determined the FA composition of 26 species of fish and invertebrates (n=533) from the Northwest Atlantic. FA signatures accurately distinguished prey species, with up to 98% of individuals correctly classified using discriminant and hierarchical cluster analysis. To investigate the reliability with which prey could be distinguished in the quantitative diet estimation model, we

performed simulation studies. We constructed three diets, each composed of specific proportions of 4-5 prey species, using previous results from stomach contents analysis. We used these to construct "pseudo-seals" (i.e., as if a seal had had consumed this FA diet), which were then modeled on all prey in the database. This procedure was repeated 1000 times for each diet. Major prey species in the constructed diet were well estimated with misidentification of diet composition ranging between 2-15%. Combined, these results suggest that FA signatures accurately characterize forage species within this system and can subsequently be used to quantify harp seal diets.

Persistent Organic Pollutants as Indicators of Bioenergetics in Fish. **Paterson, G.**, Drouillard, K.G. and Haffner, G.D. Great Lakes Institute, University of Windsor, Windsor, ON (paper 1-25)

Abstract:

Current bioenergetics modeling efforts require substantial resources and database information to accurately calculate stock consumption and production estimates. The development and use of bioenergetically neutral markers that track changes in stock consumption and production will prove beneficial to the bioenergetics paradigm. Persistent organic pollutants such as PCBs and chlorinated pesticides and insecticides possess the appropriate characteristics for use as markers of energy transfer in aquatic food webs. In this study, PCB, stable isotope and gut contents analyses were completed using two centrarchid species collected from the Detroit River. PCB concentrations in fish were better indicators of ontogentic diet shifts and more strongly correlated with growth than were stable isotopes. This research demonstrates that persistent organic pollutants possess the potential to track changes in stock consumption and are better indicators of trophic transfer than other potential markers such as stable isotopes.

Theme 2 – Rebuilding Fisheries

Rebuilding Atlantic Codstocks: What it Will Take. **Rose, G.A.** Fisheries Conservation Chair, Marine Institute, Memorial University, St. John's, NL A1C 5R3 (paper 2-1)

Abstract

Over-fished Atlantic Canadian cod stocks have not rebuilt at predicted rates during the past decade despite fishing moratoria. The situation and problems will be outlined using examples from Nova Scotia and Newfoundland, and solutions discussed. Three stocks are highlighted: 1) the Banquereau Bank (NAFO 4VsW) stock that has declined under a fishing moratorium since 1993 and now at its lowest recorded level; 2) the southern Newfoundland (NAFO 3Ps) stock that has increased and shown strong recruitment with a limited fishery since 1997; and 3) the northern cod (NAFO 2J3KL) that had a growing coastal sub-stock under a limited fishery, and declining bank sub-stocks under moratorium. The complexity of these ecosystems, and current states of recruitment, mortality, and changes in feeding, condition, and competing fisheries, are emphasized. Cod ecosystems need rebuilding and not conservation in their present state. So what will it take? For the past decade fishery closures and a wait and see approach has been adopted. A more pro-active strategy is recommended. Conservation measures beyond simple fishery closures include gear restrictions, local management, closed areas to protect spawners and juveniles, juvenile stocking, forage fish protection, and predator control. All measures should be experimental, with accompanying scientific monitoring and assessment. Perhaps we can learn our way back to rebuilt cod fisheries.

Rebuilding conditions for overfished groundfish stocks off the east coast of Newfoundland and Labrador. **Shelton, P.A.**, W.R. Bowering and M.J. Morgan. Northwest Atlantic Fisheries Centre, Department of Fisheries and Oceans, NL (paper 2-2)

Abstract:

Most cod and flatfish stocks off the east coast of Newfoundland and Labrador (NAFO Subarea 2 and Divisions 3KLMNO) have declined or collapsed, largely as a result of commercial overfishing. Northern cod (2J3KL) and southern Grand Bank cod (3NO) have been listed as "endangered" by COSEWIC and American plaice is on the high priority candidate list for assessment as a species at risk. Northern cod, southern Grand Bank cod, 2J3K American plaice and Grand Bank American plaice stocks are all under moratora from directed fishing. Recently, the status of the Greenland halibut stock (Subarea 2 and Divisions 3KLMNO) has been estimated to be at historical low levels leading NAFO to cut the TAC by more than 50% between 2003 and 2004 as part of a rebuilding plan. Canada, through the Oceans Act and international agreements such as UNFA, supports a Precautionary Approach to fisheries management in which stocks will not be harvested outside safe biological limits. We evaluate the conditions, in terms of both fishing mortality and fish biology, required to rebuild the 5 groundfish stocks to within safe biological limits. While a major reduction in targeted fishing mortality is a prerequisite to stock rebuilding, even moratoria may not be effective if stock productivity is too low or bycatch and unreported fishing mortality remain relatively high. Depleted stocks often have a reduced age composition and may have gone through other

biological changes which make them less fit in an unpredictable environment. Rebuilding plans require consideration of time horizons longer than those normally considered in stock assessments and pose particular methodological and conceptual challenges that need to be overcome if they are going to be useful in guiding fisheries management decision making.

Evaluation of management strategies used in the rebuilding of the collapsed Grand Bank yellowtail flounder stock. Walsh, S.J. and **W. B. Brodie.** Northwest Atlantic Fisheries Centre, P.O. Box 5667, St. John's, NL A1C 5X1 (paper 2-3)

Abstract:

By 1994, the spawning stock biomass (SSB) of the Grand Bank yellowtail flounder stock had decreased by 78% from its high 1984 value. The biomass of this straddling stock and the strength of incoming year-classes had been greatly diminished by overfishing in the mid-1980s, and by the large removals of juveniles in the nursery area during the late 1980s by non-Canadian fleets fishing outside Canada's EEZ. The stock responded by contracting its northern range southward to a central location on the southern Grand Bank. Significant policy and legal responses at both the national and international levels followed. In the beginning of 1994, under the Fisheries Act, Canada ordered its fleet, which is allocated 97% of the TAC for yellowtail flounder, to cease all directed fishing for yellowtail flounder, as well as American plaice. In the fall of the same year, the NAFO Fishery Commission placed the Grand Bank yellowtail flounder stock under complete fishery moratorium and also extended this moratorium to American plaice, witch flounder and Atlantic cod fisheries in the same area.

Protection and Recovery of Fishery Species Under Canada's New Species at Risk Act (SARA) – New Approaches to Stock and Species Rebuilding. **Powles, H.** Biodiversity Science Branch, Fisheries and Oceans, Ottawa, ON (paper 2-4)

Abstract:

Canada's new Species at Risk Act (SARA) sets standards for species protection and recovery which should support rebuilding of fisheries to productive sustainable levels. Consistent with the precautionary approach, which calls for strong measures to manage risk of irreversible harm, SARA contains mandatory protection and recovery measures for species which are at risk of biological extinction. SARA provides for assessment of risk status by the Committee on Status of Endangered Wildlife in Canada (COSEWIC); for species at risk to be added to a legal protection list by the federal government; for automatic prohibitions on harming listed endangered or threatened species, except under specific circumstances; and for mandatory preparation of recovery strategies and recovery action plans, including consideration of critical habitat. A number of fishery-related species and populations are considered endangered or threatened by COSEWIC, including species targetted by commercial fisheries (eg populations of Atlantic cod, populations of Pacific coho and sockeye salmon), species of importance for aboriginal subsistence (eg beluga and bowhead whales), and species incidentally caught (eg leatherback turtle, northern and spotted wolffishes, bocaccio). Under SARA, recovery population and distribution objectives will have to be established, allowable levels of mortality will have to be determined for issuing permits, and the level of population below the species level which is eligible for protection will have to be determined. These scientific problems are similar to those in fishery assessment and management, but will have to be addressed for a wider range of species than previously, including data-poor unexploited species. SARA requires a level of specificity in addressing these issues which is not found in previous conservation legislation, and this may lead to changes in how scientists review and formulate advice relative to species at risk.

Density Dependence in a Bull Trout Population in the Absence of Overfishing. **Johnston, F.D.** and J.R. Post, Department of Biological Sciences, University of Calgary, AB (paper 2-5)

Abstract:

Like many sport fish populations in Canada, bull trout populations have declined in abundance and distribution. Due to their slow growth, late maturity and opportunistic nature bull trout are extremely susceptible to overfishing. Increased access of anglers to more remote mountain streams and lakes has also contributed to their decline. In Lower Kananaskis Lake, Alberta, the bull trout population had declined to 60 spawning adults by the fall of 1992. In 1991 half of the adult population was harvested and 70% of the fish harvested were immature. In an attempt to restore this population, angling regulations in the reservoir were changed in 1992 to catch-and-release and a bait ban was implemented. The spawning population has been monitored since 1992 to determine its response. The adult population has increased to approximately 1650 individuals in the last decade, and appears to be reaching a carrying-capacity at this abundance. Density-dependence has influenced overall adult abundance in the system through changes in a number of life history traits. Individual growth rates have declined in the system as density has increased, however size-at-maturity has not followed the same trend, at least not in both sexes. Preliminary results

indicate that males are maturing at a larger size, suggesting that they are delaying maturity when under conditions of increased density. The relationship between size- and age-at-maturity is less clear in the female population. Density also appears to have affected the spawning frequency in this system. There has been an increase in the frequency of non-repetitive spawning with increases in density. Surprisingly alternate-year spawning strategies are more prevalent and occur earlier in the male portion of the bull trout population. These results are counter to what one might expect due to the differences in the physiological costs of reproduction between the sexes, and need to be examined further. However, it is clear that the density-dependent response of this population has important implications for future management strategies implemented in this system.

Simulating conservation and rebuilding strategies for Placentia Bay cod fishery. **Mello, L.G.S.** and G.A. Rose. Fisheries Conservation Chair, Marine Institute, Memorial University, St. John's, NL A1C 5R3 (paper 2-6)

Abstract:

This study investigated through simulation temporal trends in abundance and catch of the cod fishery in Placentia Bay (Newfoundland) subjected to various harvesting scenarios, and evaluated different management measures in light of conservation and rebuilding strategies. The simulations accounted for gear-specific selectivity, and seasonal variations in fish weight, age composition, and age-specific fecundity of the stock, and suggest that stock growth is driven primarily by the survival of young age-classes. Variations in catch reflected mainly changes in gear-specific fishing effort over different age-classes and seasons. When the fishery targeted older age-classes or was relatively low for all age-classes the population grew over the projection horizon (10 years) and resulted in a sustainable fishery. However short-term maximum catch was obtained when the fishery targeted the younger and intermediate age-classes. Targeting younger age-classes greatly affected overall abundance, resulting in stock collapse in less than one generation. In fisheries the performance of stock assessment models is often limited by the availability of data and how well it represents the actual and future trends of stock abundance and catch. Simulations are becoming a useful tool for fisheries management. However, assumptions used may be arbitrary and *ad hoc* (e.g., egg survival rate) and oversimplifications such as age-independent natural mortality and density-independence of fecundity and recruitment, limit forecasting at present. Nevertheless, simulations are thought to provide a useful tool to guide conservation and rebuilding strategies in fisheries.

Protecting and rebuilding a local Atlantic cod population in Gilbert Bay, Labrador, through a Marine Protected Area. **Morris, C.J.**[1], J. Simms[1], and J.M. Green[2]. [1]Department of Fisheries and Oceans, St. John's, NL; [2]Department of Biology, Memorial University, St. John's, NL (paper 2-7)

Abstract:

A marine protected area (MPA) is being developed in Gilbert Bay, Labrador to protect and rebuild a local population of Atlantic cod. The population's home range (~ 60 km ^{2}) was estimated by tracking fish implanted with acoustic transmitters, through the recapture of fish marked with external T-bar tags, and from local knowledge of fishers. Tracking of immature cod (30 cm TL) and mature cod (45-60 cm TL) indicated that the former move little from tagging sites while some (~ 50 %) of the latter move from the inner parts of the bay where they spawn in the spring to the outer parts of the bay where they forage in the summer. Recapture data from the commercial fishery near the mouth of the bay in 1998 and 1999 indicated that it was the larger fish that were most susceptible to capture. The length and age structure of the population and past catch data indicate that the population is below its former size. Protecting the entire range of the population is necessary to maintain large fish in the population and to facilitate a more rapid recovery. MPA boundaries should encompass the entire geographical range of the population but not necessarily that of strays.

Artificial Reefs Increase Density of Coastal Marine Demersal and Benthic Fish and Crab Species. **Sargent, P.S.**[1], R. S. Gregory[2] and D. C. Schneider[1].[1] Memorial University of Newfoundland, Ocean Sciences Centre, St. John's Newfoundland A1C 5S7; [2] Department of Fisheries and Oceans, Environmental Sciences Section, P.O. Box 5667, St. John's, Newfoundland A1C 5X1 (paper 2-8)

Abstract:

Structurally complex habitats influence animal distribution patterns by providing both refuge from predators and foraging areas. Artificial reefs have been advocated as fisheries enhancement tools because they generally increase aquatic habitat complexity. We employed artificial reefs to test the hypothesis that increased habitat complexity increases density of demersal and benthic fish and crab species in coastal Newfoundland waters. In contrast to most artificial reefs studies our study employed controls and replication. Four paired 80 m long artificial reef and control transects and three additional control transects were deployed in Newman Sound, Newfoundland, Canada along the 15 m isobath. Reefs were tetrahedral, 1.9 m high (vertical relief) and 1.8 m across the base, constructed of tires and

rebar and anchored to the seabed using concrete construction blocks. We quantified increased habitat complexity of artificial reefs relative to control transects as the fractal dimension (*D*) of substrate rugosity measurements taken at five resolutions (0.035 - 3.5 m). Rugosity of control transects was Euclidean (*D* = 1.00 and 1.01), in contrast with reef transects, which was fractal (*D* = 1.16), indicating artificial reefs increased habitat complexity. Densities of three demersal fish species (cunner *Tautogolabrus adspersus*, juvenile Atlantic cod *Gadus morhua*, and juvenile rock cod *G. ogac*) and four benthic species (winter flounder *Pseudopleuronectes americanus*, yellowtail flounder *Limanda ferruginea*, toad crab *Hyas araneus*, and rock crab *Cancer irroratus*) were measured using scuba during three 1999 autumn surveys and four 2000 summer surveys. Unlike previous artificial reefs studies we demonstrate that species densities attenuate with distance from reefs and that artificial reefs have a measurable scale of effect on individual species. Densities of cunner, juvenile Atlantic cod, juvenile rock cod, winter flounder and toad crab were highest near artificial reefs during the day and attenuate to a baseline 10-20 m from reefs. Yellowtail flounder and rock crab did not associate with reefs. Several species exhibited diel (Atlantic cod, cunners, rock cod, rock crabs and winter flounder) and seasonal changes (Atlantic cod, cunners, rock cod, toad crabs and winter flounder) in abundance and distribution patterns, which appear linked to corresponding temperature changes. Increased habitat complexity due to artificial reefs resulted in increased density of several demersal and benthic species. We suggest that artificial reefs represent an effective tool for enhancing abundance of some fish and crab species.

The Mortality of Snow Crab Discarded from Newfoundland and Labrador's Trap Fishery: At-Sea Experiments on the Effect of Drop Height and Air Exposure Duration. **Grant, S. M.,** Centre For Sustainable Aquatic Resources, Fisheries And Marine Institute Of Memorial University Of Newfoundland (paper 2-9)

Abstract:

The survivability of undersized immediate prerecruits (70-94 mm carapace width, CW) and high graded (95-101 mm CW) snow crab (*Chionoecetes opilio*) discarded in Newfoundland and Labrador=s recruitment dependent fishery has been a growing concern among harvesters and fisheries managers in recent years. Many fear that the long-term conservation of the stock may be threatened because tonnes of discarded crab are mishandled every year when they are dropped onto hard surfaces and held out of the water for prolonged periods of time before being returned to the ocean. This study investigated whether drop heights of two, four, and six feet (0.3, 1.2, and 1.8 m) and air exposure durations of five, 30, 60, and 120 3 minutes negatively influence the survivorship of male hard-shelled snow crab within a 74 to 101 mm CW size range. At-sea experiments were conducted from 19 June to 19 July, 2002. Drop and air exposure related instant and delayed mortality were assessed and combined to provide estimates of total mortality. Instant mortality was assessed within three hours of subjecting crab to a treatment and delayed mortality was assessed by holding crab on the ocean floor at depths ranging from 174 to 201 m for 24 to 25 days. There were no mortalities in the control treatments (i.e., no-drop and 5 3 minute air exposure) of either instant or delayed mortality. These results indicate that survival can be maximized (100%) when discarded crab are handled gently and quickly returned to the ocean. Both instant and delayed mortality increased substantially with an increase in drop height and air exposure duration, and analysis of delayed mortality indicated that both factors had a significant negative effect on survival. It is concluded, based on the levels of mortality demonstrated in this study and reports of high commercial catch rates of immediate prerecruits during the two to three year period before they recruit to the fishery, that mishandling of discarded crab by dropping and holding them out of the water for more than 5 3 minutes can have a substantial negative effect on the quantity of legal-sized crab available to the fishery.

Impacts of Non-Selective Fishing Gears on the Population Structure of Two Seahorse Species in a Coastal Lagoon. **Curtis, J. M.** and A. C. J. Vincent. Department of Biology, McGill University, Montreal, Quebec (paper 2-10)

Abstract:

Incidental bycatch in non-selective fisheries is a concern for many marine species, especially those that are threatened. Seahorses, included in CITES Appendix II and the 2003 IUCN Red List, are caught around the world in non-selective fishing gears. Fisheries dependent data (catches) from Florida suggest that non-selective, bottom-trawl gears may alter seahorse population structure, potentially leading to reduced abundance and reproductive output. Our study in Portugal indicated that moderate levels of localised non-selective, small-scale fishing may affect abundance (in either direction) without disrupting population structure. Using both catch data and fisheries independent surveys (underwater visual censuses), we examined the effects of seining on the population structure of two sympatric species, *Hippocampus guttulatus* and *H. hippocampus*. We surveyed 16 sites in both 2001 and 2002. Twelve sites were experimentally fished with seines each month during the first year, but not fished during the second year. In four sites, fishing effort was held constant across years. Capture efficiencies using seines were approximately 50% greater for *H. guttulatus* than for *H. hippocampus*. The end of seining led to significantly increased density of *H. guttulatus,* which was the more common of the two species, but significantly decreased the

density of its less abundant congener. One hypothesis could be that *H. guttulatus* was the superior competitor of the two species, such that *H. hippocampus* was suppressed when *H. guttulatus* was no longer being disproportionately removed through seining. We found no effect of seining on size structure, sex ratio, reproductive state, or condition of either species.

Gait use, behaviour, and swimming kinematics in American plaice: insights into the herding of flatfish by bottom trawl sweeps. **Winger, P.D.**[1], S.J. Walsh[2], P. He[3], and J.A. Brown[4]. [1]Centre for Sustainable Aquatic Resources, Marine Institute, Memorial University of Newfoundland, St. John's, NL; [2]Fisheries and Oceans Canada, St. John's, NL, [3]University of New Hampshire, Durham, NH, USA, [4]Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL (paper 2-11)

Abstract:

Bottom trawls are the most common gear type used for the commercial prosecution of flatfish stocks. Improving the size-selectivity of these gears is a necessary step in achieving sustainable fishing practices. Theoretical modelling has previously indicated that the herding efficiency of flatfish by bottom trawl sweeps is highly sensitive to subtle changes in fish behaviour. Yet the degree of variation in herding behaviour within a species, population, or individual remains poorly understood because of the difficulty observing and measuring fish behaviour in this region of the gear. The purpose of this study was to simulate herding under laboratory conditions in order to examine characteristics of flatfish swimming. Using a large flume equipped with a moving floor, we examined the effect of fish size on gait use, behaviour, and swimming kinematics in American plaice (*Hippoglossoides platessoides*). While swimming at a speed comparable to the herding speed of trawl sweeps (0.3 m/s), smaller plaice (< 30 cm) spent a large percentage of time using the kick-swim gait, while larger fish (≥ 30 cm) preferred cruising. Sixty-five percent of plaice exhibited settling behaviour, analogous to the swim-and-settle behaviour observed in response to trawl sweeps. Tail beat frequency and tail beat amplitude were both linearly related to fish length. Together, these observations support the hypothesis of size-selective herding, suggesting that longer sweeps and wider door spreads may be an effective means of reducing the proportion of undersized plaice caught and discarded at sea.

Life History Consequences of Over-Exploitation to Population Recovery of Northwest Atlantic Cod. **Hutchings, J.A.**; Department of Biology, Dalhousie University, Halifax, NS B3H 4J1 (paper 2-12)

Abstract:

Severe over-exploitation has been associated with significant changes to life history traits in some populations of Atlantic cod in the Northwest Atlantic. Reductions in age and size at maturity over the past 30 to 40 years cannot be explained as phenotypic responses to the environment, given that these changes have not been concomitant with increased growth rate and/or increased condition. All else being equal, one would predict that reduced age at maturity would be associated with increased natural mortality, slower post-reproductive growth, and reduced longevity, all of which can be expected to negatively influence recovery. With decreased size at maturity, females can be expected to produce fewer, smaller eggs and to reproduce over a relatively short spawning period. The latter has been hypothesised to reduce the mean of, and increase the variance in, larval survival. Using data for 2 cod stocks, I evaluate the consequences to population recovery of changes to life history, as reflected by reduced age and size at maturity, and as manifested by reduced post-reproductive survival and decreased production of offspring.

Fecundity of Northern Cod, Gadus Morhua, in Two Newfoundland Coastal Areas. **Fudge, S.B.** and George A. Rose. Fisheries Conservation Chair, Marine Institute, Memorial University of Newfoundland, St. John's, NL (paper 2-13)

Abstract:

This study focuses on fecundity trends for Northern cod from both Smith Sound (Trinity Bay, NAFO subdivision 3L), and Hawke Channel (NAFO subdivision 2J). Large aggregations of cod over-winter in Smith Sound, the cod spawn in the spring then move out of the area, a behaviour that has been observed for several years. In Hawke channel, cod aggregations are comprised of smaller cod, and mature at an earlier age (3-4 years) compared to Smith Sound (5-6 years.) Cod surveyed in Hawke channel have also occupied the same area for several years. Maturing female gonads were sampled prior to the spawning season in January 1999 and 2003 in both areas as well as in June 2003 in Hawke Channel. A total of 82 gonads were sampled in Smith Sound, sampled lengths ranged from 35-94cm. 46 gonads were sampled in Hawke Channel with the fish length range of 40-61cm. Estimates of total numbers of eggs in each gonad were made by manual counting of a defined number of subsamples using a stereoscope, and by multiplying by the appropriate ratio. Subsamples were produced using a Motoda splitter, which has historically been used for subsampling plankton. The Motoda splitter technique is compared to the better-known whirling vessel

technique. Dependency of fecundity on length, age and gonad weight is investigated, and differences in fecundity between the two areas examined. Our results are compared with historical fecundity estimates.

Discrete spatial dynamics and essential habitat of coastal cod populations: conservation and management implications. **Bradbury, I.R.**[1], B. Laurel[2], D. Robichaud[1], G. Rose[3], P.V.R. Snelgrove[3], R. Gregory[4], and D. Cote[5]. [1]Department of Biology, Dalhousie University, Halifax, NS; [2]Memorial University of Newfoundland, St. John's, NL; [3]Marine Institute, Memorial University of Newfoundland and Labrador, St. John's NL; [4]Department of Fisheries and Oceans, St. John's, NL; [5]Terra Nova National Park of Canada, Gen. Del., Glovertown, NL, A0G 2L0 (paper 2-14)

Abstract:

Recent anthropogenically-induced shifts in commercial fish distributions and increased recognition of the role of local recruitment in marine populations suggests current spatial dynamics of many marine species may differ from historic interpretations. We examined the spatial dynamics of Atlantic cod, *Gadus morhua*, through its life history stages along the northeast and southeast coasts of Newfoundland; coastal embayments contain the highest cod populations following the collapse in the early 1990s. In light of continued potential harvest pressure, our goal was to determine the spatial scale at which these populations function, and furthermore, to evaluate the efficacy of spatial management options such as marine protected areas. Repeated hydroacoustic surveys across the northeast Newfoundland shelf from 1990-2000 indicated a shift in Northern cod distribution from offshore areas to inshore embayments. Further inshore surveys identified local spawning aggregations, and passive tagging of adults suggests reuse of spawning grounds in subsequent years. Movement of displaced adults tracked using passive and acoustic tags demonstrated homing to local spawning grounds. Dispersal during the egg and larval period was consistently offshore during spring, and localized (within bay) hatch was restricted to warm summer months. Beach seine surveys of 0-group cod both in Placentia Bay and Bonavista Bay strongly suggest self-recruitment given that abundances decreased with proximity to spawning. Near nursery habitats, at scales of less than 10's of km, this pattern broke down with development suggesting active habitat selection. Home ranges of 2-3 yr olds, based on sonic tagging of juveniles in Newman Sound, were often less than 10 ha. Spatial pattern through development stages showed clear associations with specific habitat types, particularly 0-group cod, which displayed clear habitat association in response to manipulation experiments. Our results suggest self-recruitment and critical life history events (i.e., spawning, settlement, maturity) may occur within local embayments. Thus, conservation of Newfoundland cod may benefit greatly from the establishment of small discrete marine protected areas located in local embayments encompassing vulnerable life history stages and critical habitat.

Implications of Mating Systems for the Collapse and Recovery of Atlantic Cod. **Rowe, S.** and J.A. Hutchings. Department of Biology, Dalhousie University, Halifax, NS B3H 4J1 (paper 2-15)

Abstract:

Atlantic cod (*Gadus morhua*) have been severely over-exploited and are currently at historic population lows, having declined 90% in the North Sea and 99% off northeast Newfoundland in recent decades. Slow rates of recovery and continuing declines may be attributable to depensation, defined as a reduction in population growth rate concomitant with reduced population size. Several potential causes of depensation relate to low mating success and consequent reduced production of offspring. However, until recently, very little was known about even basic aspects of cod reproductive behaviour. We hypothesize that mate competition, mate choice and other components of the Atlantic cod mating system can deleteriously affect population growth rate during and after periods of intense exploitation. In particular, using egg fertilisation and male abundance data from 21 experimental population treatments generated by 3 independent research programmes, we find support for the hypotheses that as population size declines (a) fertilisation rate also declines and (b) variance in fertilisation rate increases. The former identifies one potential mechanism underlying depensation in Atlantic cod. The latter has negative genetic consequences for effective population size (N_e), resulting in a decline in the ratio of N_e to census population size (N_e/N_c) with declining abundance. Our results have important implications for the conservation biology of broadcast spawning marine fish, particularly those with mating systems similar to that of Atlantic cod.

Life History Variation and Sustainable Harvest with Regulations in Lake Trout, *Salvelinus Namaycush,* Populations. **Post, J.R.** Division of Ecology, University of Calgary, Calgary, AB T2N 1N4 (paper 2-16)

Abstract:

Lake trout populations exhibit substantial variation in life history characteristics across their geographic range. In particular, variation in growth rates, age- and size-at-maturity, survival, and longevity can be substantial and vary with trophic status, climate, lake size and maybe density. Clearly, variation in these traits will impact the abundance

and age- and size-structure of lake trout populations and consequently will determine levels of sustainable harvest by fisheries. The importance of life history variation to levels of sustainable harvest in lake trout will be assessed with a size-structured population model. The functions and rates describing the biology and recreational fishery were derived from a variety of sources including published and unpublished information on lake trout and other related species. We assess the ability of minimum size and catch & release regulations to sustain lake trout fisheries and quantify the tradeoffs between fishing quality, regulations and fishing effort by examining catch, harvest, CPUE and mean size in creel for lake trout populations that vary in life history traits. We will contrast the ability of regulations to sustain quality lake trout fisheries across climatic, productivity and fishing effort gradients.

Impact of Extreme Ocean Climate Events on Marine Resources – The Smith Sound Example. **E. Colbourne**[1], J. Brattey[1], G. Lilly[1] and G. A. Rose[2]. [1]Department of Fisheries and Oceans, Northwest Atlantic Fisheries Centre, P.O. Box 5667, St. John's, NL A1C 5X1; [2]Fisheries Conservation Chair, Marine Institute, Memorial University, St. John's, NL A1C 5R3 (paper 2-17)

Abstract:

The large over-wintering aggregation of cod inhabiting Smith Sound on the east coast of Newfoundland since the mid-1990s suffered perhaps the largest documented natural mortality in Newfoundland and Labrador waters during the spring of 2003. The ocean environment on the inner Newfoundland Shelf during this period was among the coldest observed in about a decade. This followed a period of intense cyclonic atmospheric circulation over the Labrador Sea, resulting in an unusually cold winter that brought the heaviest sea-ice cover to the region since the early 1990s. Oceanographic observations conducted during the mass mortality incident in early April revealed that the water column had cooled significantly compared to January and indeed to the past 10 years. Observed temperatures ranged from-1.4°C at surface to a minimum of -1.73°C near 100-m depth and about –1.6°C near bottom at 200-m depth. In effect, the entire sound was flooded by very cold water with no water temperatures observed above -1.4°C, except outside the Sound in the deeper water of Trinity Bay, where values of >0.5°C were observed below 300 m depth. It appears likely that the source of the extremely cold sub-surface water within Smith Sound during the spring was the result of intense winter convection on the Newfoundland and Labrador Shelf. These cold sub-surface waters which are continuously advected southward by the Labrador Current penetrated to the inner reaches of Smith Sound by early April. The rate of decrease in the water temperature from near 0.5ºC in late January, to a minimum of -1.73ºC by early April, is considered anomalous and may be a significant factor that led to the fish mortality. In any event, the extremely cold water that these fish were subjected to was most likely the underlying cause of the mortality.

The Mass Mortality of Atlantic Cod (*Gadus morhua*) in Smith Sound, Eastern Newfoundland, in April 2003. **Lilly, G.**[1], J. Brattey[1], G. Fletcher[2], and E. Colbourne[1]. [1]Department of Fisheries and Oceans, Northwest Atlantic Fisheries Centre, P.O. Box 5667, St. John's, NL A1C 5X1; [2]Ocean Sciences Centre, Memorial University of Newfoundland, P.O. Box 21233, St John's, NL A1A 5B2 (paper 2-18)

Abstract:

On Saturday, 5 April 2003, residents of villages along the shores of Smith Sound on the east coast of Newfoundland awoke to find frozen cod floating on the water and washed onto shore. During the following 3 weeks fishermen collected fish one by one from the surface, accumulating a total of 790 tonnes. This presentation will describe many of the observations of fish appearance, behaviour and physiology obtained from fish picked from the surface, captured on or near bottom with a bottom-trawl, observed with video on a remotely operated vehicle, and mapped with hydroacoustics. The fish were found to have very low levels of antifreeze, and were clearly supercooled (undercooled). However, it is not immediately apparent why they froze, because the main body of fish was at a depth of about 200m, perhaps beyond the depth to which ice crystals could penetrate. The deaths do appear to be related to the unusually low water temperatures (as low as –1.7°C), but to date there is no single hypothesis that is consistent with all observations. The mass mortality is of interest because of its magnitude, duration, and very small spatial scale. In addition, it occurred in a fjord which is considered to be the overwintering area of the largest population remaining in the stock area of the northern cod, a stock which is severely depleted and considered by COSEWIC to be endangered.

Spatial Utilization of Benthic Habitat by Demersal Fish on the Scotian Shelf. **J. Anderson**[1], D. Gordon[2], R. Courtney[3], E. Dalley[1], G. Evans[1], G. Fader[3], K. Gilkinson[1], R. Gregory[1] P. Hurley[2], E. Kenchington[2], C. Lang[1], D. McKeown, J. Simon[2], P. Vass[2]. [1]Northwest Atlantic Fisheries Centre, Department of Fisheries and Oceans, P. O. Box 5667, St. John's, NL A1C 5X1; [2]Bedford Institute of Oceanography, Department of Fisheries and Oceans, 1

Challenger Drive, Dartmouth, NS B2Y 4A2; [3]Bedford Institute of Oceanography, Natural Resources Canada, 1 Challenger Drive, Dartmouth, NS B2Y 4A2 (paper 2-19)

Abstract:

A large team of DFO and NRCan scientists, based at the Bedford Institute of Oceanography and the Northwest Atlantic Fisheries Centre, is conducting a mulit-year project to improve understanding of the relationships between seabed habitat, benthic communities and demersal fish. Project modules include project management, data management, acoustic fish and seabed classification, imagery of habitat, benthos and fish, trawable fish, and data synthesis and extrapolation. Using historical DFO groundfish data (1970-2001), paired study sites (10 x 10 km) were selected on Emerald, Western and Sable Island Bank. These sites have the highest and lowest probabilities of finding juvenile haddock (*Melanogrammus aeglefinus*). Using state-of-the-art acoustic, imaging and sampling equipment, a field program is being conducted to determine the present day differences in seabed habitat, benthic communities, and fish communities at these six sites over different spatial scales. Some initial products and results will be presented. The new information being generated will be used to define important fish habitat and map its spatial extent in selected areas.

Theme 3 – Anthropogenic Effects

Effect of short-term flow fluctuations on the behaviour of Atlantic salmon parr in winter. **Robertson[1], M. J.**, C. J. Pennell[2], D. A. Scruton[2], G. J. Robertson[3] and J. A. Brown[1]. Cognitive and Behavioural Ecology Programme, Memorial University of Newfoundland, St. John's, NL, A1C 5S7; [2]Department of Fisheries and Oceans, Box 5667, St. John's, NL, A1C 5X1; [3]Canadian Wildlife Service, 6 Bruce Street, Mount Pearl, NL, A1N 4T3 (paper 3-1)

Abstract:

Radiotelemetry was used to determine the effect of short-term flow fluctuations on movement and microhabitat use of Atlantic salmon *Salmo salar* L. parr in winter. To simulate hydropeaking operations, flow was increased from a background level of 1.3 $m^3 s^{-1}$ to 5.2 $m^3 s^{-1}$ for 24-hour periods. Flow changes did not affect fish habitat use, consumption or displacement. Stranding rates were also very low (1 fish, 3%). However, flow did affect activity within diel periods in early and late winter. During high flow periods, fish in early winter increased daytime activity whereas fish in late winter reduced both daytime and nighttime activity.

A model of swimming costs in turbulent flow of juvenile Atlantic salmon (*Salmo salar*). **Enders, E.C.**[1], D. Boisclair[1], and A.G. Roy[2]. [1] Département de sciences biologiques, Université de Montréal, PQ (eva.enders@umontreal.ca); [2] Département de géographie, Université de Montréal, PQ (paper 3-2)

Abstract:

The costs of habitat utilization of salmonids are often modelled using swimming cost estimates derived from forced swimming experiments where fish swim against a unidirectional flow of constant velocity. However, juvenile Atlantic salmon (*Salmo salar*; JAS) live in rivers characterised by a highly turbulent flow. In these environments, flow turbulence is associated with a wide range of instantaneous flow velocities which may affect the energetic costs of habitat utilization of JAS. The complexity of the movements fish perform when swimming against a turbulent flow suggest that a new model may be needed to estimate the energetic cost of swimming of JAS in their turbulent environment. The purpose of our work was therefore to develop a swimming costs model for JAS in a turbulent environment. Instead of measuring the activity metabolism by having fish swim against a flow of constant velocity, we estimated the swimming costs of fish in a respirometer in which we produced five turbulent flow conditions each characterized by a mean and a standard deviation of flow. Respirometry experiments were conducted with three mean flow velocities (18, 23, 40$cm \cdot s^{-1}$) and three turbulence intensities (5, 8, 10$cm \cdot s^{-1}$) with fish ranging in size between 5 to 15g at three water temperatures of 10, 15 and 20°C. Our results confirm (1) that the cost of swimming in turbulent flow were up to five-fold higher than predicted by forced swimming models, and (2) that the cost of swimming increased with an increase of flow velocity, turbulence intensity, and body mass. However, the swimming costs did not vary significantly with an increase of water temperature.

Relative Activity of Brook Trout and Walleye in Response to Flow in a Regulated River. Murchie, K.M., and **K.E. Smokorowski**, Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, 1 Canal Drive, Sault Ste. Marie, ON (paper 3-3)

Abstract:

Coded electromyogram telemetry transmitters were used to examine the effects of varying flows on the relative activity of brook trout and walleye in a regulated river. Relative activity levels of two brook trout and two walleye were continuously monitored for a minimum of 24 hours, and measurements were compared to river flow values

logged at nearby gauging stations. Generally, fish relative activity levels mimicked patterns of flow change, with peaks in activity level corresponding to peaks in flow. Mean relative activity was generally greatest at extreme high (≥ 25 m^3/s) and low (< 15 m^3/s) flows. High flows may have elicited hyperactivity as fish may necessarily seek suitable refugia, increase activity to hold position in the water column, or increase feeding activity on increased levels of drifting invertebrates. Hyperactivity at low flows may have been caused by habitat loss or ease of movement at lower flow regimes. Physiological telemetry provides researchers with a method of quantifying immediate effects of flow changes on fish. Increasing our knowledge of the effects of river regulation on fish is essential to allow the development of more effective management strategies that balance ecology and economics.

Effects of Flow and Ramping Rate from a Hydroelectric Dam on Macroinvertebrate Abundance and Diversity Within the Magpie River, Wawa, Ontario. **Patterson, R.P.**[1], K.E. Smokorowski[2], and G. Mackie[1]. [1]Department of Zoology, Guelph University, Guelph, ON, N1G 2W1; [1]Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries & Oceans Canada, 1 Canal Drive, Sault Ste. Marie, ON, P6A 6W4 (paper 3-4)

Abstract:

Aquatic macroinvertebrates are frequently used to study anthropogenic, toxicological, and hydrological impacts on aquatic systems, including effects of hydroelectric power generation on downriver communities. Because of their range in sensitivity to various forms of impact, an assessment of invertebrate abundance and diversity can indicate the health of that ecosystem. Effects of the currently restricted ramping rate (the rate of change in flow over time) on the macroinvertebrate community is one issue of concern for the possible change in ramping rate for the Steephill Falls hydroelectric dam on the Magpie River, Wawa, Ontario. It is known that invertebrate drift abundance and diversity is affected by flow regimes of dam regulation, with typically decreased abundance and diversity with close proximity to the dam. To assess invertebrates, 3 drift nets were placed at 5 sites downstream of the dam, for 10 hours each of day and night collections per site, per trial. Two Surber net collections were also performed at each site to assess differences between benthic and drift taxa. Sampling was replicated on the unregulated Batchawana River as a reference. Both rivers were studied concurrently in spring and summer 2001, and spring 2002, with 3 trials per season. A single site above the dam was sampled as an alternative reference site, as well as each of the two main tributaries, Lena Creek and Catfish Creek, to assess their input to the Magpie River. Results will be presented to assess any relation of abundance and diversity with daily ramping rates, high flow and low flow conditions, attenuation of impacts with distance from dam, composition of non-drifting benthos found in drift, differences between night and day, trends found among seasons and years, all in relation to reference sites. Relationships between flow and ramping rate with invertebrate drift would provide predictive models for future quantitative assessments of the benefit of ramping rate restrictions when negotiating operational regimes of hydroelectric dams.

Critical swimming speed as a metric for estimating maximum allowable water velocities in fishways and culverts. **Peake, S.**. Canadian Rivers Institute and Department of Biology, University of New Brunswick, Fredericton, NB (paper 3-5)

Abstract:

Convention dictates that critical swimming speed is a measure of prolonged swimming capacity, an estimate of maximum sustained speed, and a useful parameter for calculating maximum allowable water velocities in fishways and culverts. However, several key assumptions are made when critical swimming speed is used to set fish passage guidelines, and the guidelines themselves are rarely evaluated quantitatively. Therefore, the objectives of this study were to (1) test the assumption that ground speeds attained by smallmouth bass (*Micropterus dolomieu*) during passage through culverts are low (i.e. slightly higher than the water velocity) and unpredictable, (2) test the assumption that ground speed decreases as fish face higher water velocities, and (3) evaluate fish passage guidelines based on critical swimming speed determinations using a 50 m experimental raceway. Results indicate that ground speeds chosen by smallmouth bass during ascents in the experimental raceway were predictable and much higher than expected. Maximum allowable flows based on critical speed determinations (in conjunction with the ground speed data) were found to be very conservative, indicating that critical swimming speed is a poor metric for use in fish passage models.

Fish Passage and Hydro Generation on the Exploits River: A Case Study. **Goosney, R. F.** Department of Fisheries and Oceans, St. John's NL A1C 5X1 (paper 3-6)

Abstract:

The control of the flow of water on river systems using structural dams can and do cause conflicts with the migration of anadromous and native fish species. In most cases this control of water has taken the shape of dams for

hydro generation, water storage and municipal water supplies. In order to address these conflicts, engineers and biologists have attempted to design fish passage systems that allow fish to migrate around man made structures in such a way as not to impact on their natural migration patterns. The goal of this presentation is to highlight some of the major problems that designers have to deal with in providing effective fish passage and some of the solutions that have been used to minimize the impact on migrating fish species. Since the early 1900's there have been concrete dams constructed the Exploits River that have been used for hydro generation and affect the migration of salmonids. In order to minimize the impact of these dams, a variety of fish passage techniques have been developed and constructed for specific site conditions to address migration issues on the Exploits River.

Do vertical slot fishways work? Preliminary results from two low-head sea lamprey barriers. O'Connor, L.M. and **T.C. Pratt**. Fisheries and Oceans Canada, 1 Canal Dr., Sault Ste Marie, ON (paper 3-7)

Abstract:

We examined the ability of vertical slot fishways to successfully attract, retain and pass upstream migrating fishes using passive integrated transponder (PIT) technology. We intercepted migrating fishes using seines and fyke nets, and implanted PIT tags in all individuals >100mm (n = 555 Cobourg Br. (L. Ontario), n = 519 Big Carp R. (L. Superior)). Three antennae were mounted at each site: one approximately 10m downstream of the barrier, one at the entrance of the fishway, and one in the upper compartment of the fishway. By determining at which time individual fish passed each antenna, we were able to estimate attraction, retention and passage efficiency. Preliminary results indicate that attraction efficiency was high at both sites, but that both fishways were unable to retain the substantial numbers of fishes that approached and entered the traps. Thus, passage efficiency was low (<5% Cobourg Br., <25% Big Carp R.). Species-specific patterns (sea lamprey, rainbow trout, white sucker, and rock bass) in approach behaviour and timing were evident.

Changes in the Fish Communities of the Kawartha Lakes, Ontario in Response to Anthropogenic Stressors. **Robillard, M.** and M.G. Fox.[1] Watershed Ecosystems Graduate Program, Trent University, Peterborough, ON. [1]Environmental and Resource Studies Program and Department of Biology, Trent University. (paper 3-8)

Abstract

Recently, a great deal of concern has been expressed by fishery managers and user groups on the perceived decline in fishing yields in some of the Kawartha Lakes (central Ontario), but it is not known whether such declines are system-wide, and whether or not they are symptomatic of historical changes in the fish assemblages in these lakes. The objectives of this research are to characterize the patterns in the fish community structure in these lakes, document the changes in the fish assemblages throughout the past 30 years, and to assess whether such changes are related to changes in nutrient concentrations and/or the productivity of lower trophic levels. Extensive data on the historical and current fish communities was collected through gillnetting and trapnetting conducted using standardized protocols since 1978. Outboard trawling and funnel trapping were conducted to provide current information on non-game fishes and the forage base available to the piscivores in the lakes. Chlorophyll *a*, total phosphorus, total nitrogen concentrations (TKN), secchi depth, and zooplankton were collected to identify productivity differences between the lakes. Preliminary analysis suggests that bottom-up factors regulate the productivity of the lower trophic levels in these lakes. Mean summer phosphorus concentrations (TP) have declined from 35.0 ugL^{-1} in the 1970's to
17.7 ugL^{-1} in 2002. This corresponds to a decline in the relative abundance of walleye in these lakes since 1978 and an observed collapse of the cyprinid populations.

Identifying "temperature sensitive streams" for forest management: An analysis of stream temperature variation and salmonid thermal requirements in the central interior of British Columbia. **Nelitz, M.A.**, E. A. MacIsaac, and R. M. Peterman . School of Resource and Environmental Management, Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6 (paper 3-9)

Abstract:

Forest harvesting is known to influence stream temperatures, which affect salmonids. In British Columbia, a new forest practices code calls for the designation of "temperature sensitive streams" yet there is no objective methodology for their identification. Typically an allowable stream temperature guideline is set near the optimum temperature for the most sensitive fish species and life history stage or within a range of unimpacted stream conditions. Our objective was to develop an approach to identify "temperature-sensitive streams" for forest management. We first compiled and analyzed data on a watershed's terrain, land-use history, and stream temperature as well as regional information on air temperature and hydrology to examine the factors controlling the spatial and temporal variability in stream temperature. We then used published temperature-dependent models to estimate the

influence of a thermal regime on several biological endpoints, specifically rainbow trout incubation, growth, disease related mortality, and temperature induced mortality during the summer. Our analysis suggests that forest managers need to explicitly consider: (1) the factors that control the spatial and temporal variability in stream temperature, and (2) the responses of more than the most sensitive species and life history stages. Failure to incorporate these considerations in decision making could result in the misidentification of "temperature sensitive streams" and lead to unwarranted restrictions to forest harvesting or undesirable impacts to fish populations. To help managers properly identify these streams, we propose a classification scheme to account for variability in stream temperatures and illustrate the tradeoffs among several salmonid endpoints in response to alternative temperature management thresholds.

Temporal and Spatial Variability of Stream Fish Populations in Two Undisturbed Streams of Eastern Canada. **Mitchell[1], S.C.**, D. A. Scruton[2], and R.A. Cunjak[1]. [1]Canadian Rivers Institute; University of New Brunswick, Fredericton, NB; [2]Department of Fisheries and Oceans, St. John's, NL (paper 3-10)

Abstract:

A vital aspect of determining anthropogenic impacts on fish species and communities is understanding the intrinsic variability exhibited by natural systems without perturbation. Understanding the magnitude of this natural variability is essential in order to partition human-induced change from that which occurs due to natural environmental variation. To evaluate natural variation, data on fish populations over long periods of time are required. Within eastern Canada, two long term time series (each 13 years) of fish populations in unimpacted systems exist – Catamaran Brook, New Brunswick, and Northeast Brook, Trepassey, Newfoundland. These two streams represent very different environmental settings (Acadian forest and continental climate for the former, largely barrens & stunted spruce/fir forest and maritime climate for the latter) and fish communities (16+ species in Catamaran Brook versus 4 species in Northeast Brook). Therefore, the results from these individual streams may be useful in assessing the between- and within-year variability of natural fish populations in very different systems. Atlantic salmon density for sites within Catamaran and Northeast brooks show a year to year fluctuation greater than $\pm$ 100% in 12% to 22% of samples and greater then $\pm$ 50% in roughly half the samples. Inter-annual variability exhibited by comparable widely separated sampling sites (i.e., riffles) within the same system are similar in most (~70%) years. The within-year (i.e., summer to autumn; Catamaran Brook only) variability is lower with autumn density exceeding summer density, on average, only 10% of the time. These large between- and within-year, and spatial, fluctuations in density occurring in natural streams suggest that using fish density as a measure may not be sufficiently sensitive to detect effects of human disturbance. Two alternative measures (production, in the sense of Ivlev (1945); and the formulation of Van Horne (1983)) for use in evaluating impacts will be explored.

Production Dynamics of Salmonids in Newfoundland: Investigating the Role and Linkages of Lacustrine and Fluvial Habitats from a Population Perspective. **Clarke, K. D.** and D. A. Scruton. Science, Oceans and Environment Branch, Department of Fisheries and Oceans, P.O. Box 5667 St. John's, NL A1C 5X1 (paper 3-11)

Abstract:

Salmonids extensively utilise both lacustrine and fluvial habitats for production within Newfoundland freshwater systems. The linkage between these habitats is poorly understood and we tend to manage them as separate entities, although they are often highly linked from a population viewpoint. The variety of functions provided by these habitats with respect to salmonid production was investigated by comparing habitat based production estimates and movement patterns within two very different Newfoundland freshwater systems. The first study system is a small headwater system located in western Newfoundland, which is inhabited by brook trout as its only fish species. The second system studied is located on the Avalon Peninsula with easy access to the marine environment. The latter has a diverse fish assemblage, by Newfoundland standards, with six species, brook trout, brown trout, Atlantic salmon, American eel, rainbow smelt, and three-spine stickleback, all with a variety of anadromous and non-anadromous life history strategies. Extensive movement between lakes and streams was observed in both systems with some movements being associated with changes in life history stage and others having a seasonal pattern. Production estimates are presented within each habitat or meso-habitat as appropriate and then 'scaled up' using information from the movement studies to estimate population production. This information will allow us to investigate the relative role each of these major habitat classes on the productive capacity of salmonids in Newfoundland, thus, improving our ability to mange these systems both from a habitat and fisheries management perspective.

Past and future water chemistry changes in Atlantic Salmon rivers of Nova Scotia affected by acidification: A dynamic modeling approach. **Clair, T.A.**[1], I. Dennis[1], P. G. Amiro[2], and B.J. Cosby[3]. [1]Environmental Conservation

Br, Environment Canada - Atlantic Region, PO Box 6227, Sackville, NB, E4L 1G6; [2]Science Branch, Fisheries and Oceans Canada, Bedford Institute of Oceanography, PO Box 1006, Dartmouth, NS, B2Y 4A2; [3] Department of Environmental Sciences, University of Virginia, Charlottesville, VA, 22903, USA (paper 3-12)

Abstract

Acid precipitation has been shown to be seriously deleterious to Atlantic Salmon populations in large parts of Nova Scotia. The area contains soils and geology which contain little acid buffering capacity, and receives acid deposition originating in central Canada, the eastern seaboard and Ohio Valley of the United States. Atlantic Salmon populations have been extirpated from a number of regularly monitored rivers, as measured acidity has increased. We applied the **M**odel of **A**cidification of **G**roundwater **i**n **C**atchments (**MAGIC**) to these rivers to estimate a) pre-industrial water chemistry conditions, and b) potential future changes in water chemistry under three future acid deposition scenarios for the region. Our results indicate that water chemistry in the streams remained relatively unchanged until the 1950's and then maximum acidification generally took effect from 1970 to the early 1980's. The main effects of acid deposition have been a decrease in pH and an increase in base cations to surface waters, as the ion exchange processes in soils released soil cations into surface waters. Forecasts of future changes were examined under three scenarios: a) no change in deposition from Year 2000 values, b) 10% and c) 20% sulfate reductions per decade. The forecasts indicate that recovery of water chemistry will not be a linear nor direct. We show that the more rapid the reduction in acid deposition, the faster recovery will be. We also show that although stream water acidity will recover within a few decades, in most streams, base cations will not recover to pre-industrial levels within the next 100 years.

Stepping up the scale: Taking a provincial model for Walleye (*Sander vitreus)* productivity to the national level. **Feduszczak, J.M.**[1], N.P Lester[2], C. Chu[1], C.K. Minns[1]. Great Lakes Laboratory for Fisheries and Aquatic Sciences, Department of Fisheries and Oceans, Canada Centre for Inland Waters, 867 Lakeshore Road, P.O. Box 5050, Burlington, ON, L7R 4A6 [2]Harkness Laboratory of Fisheries Research, Ontario Ministry of Natural Resources, 300 Water Street, Peterborough, ON, K9J 8M5 (paper 3-13)

Abstract:

The purpose of this project is to predict walleye (*Sander vitreus)* productivity in all Canadian lakes where they are likely to occur, using morphometric, water clarity and climate indices. Lester et al. (2002) developed a habitat supply model for walleye that predicted the potential yield in Ontario lakes. The model is simple to use, as its parameters are based on aspects of the physical environment which determine the availability of suitable temperature and light conditions for walleye. Experimentally-determined optimal ranges of both variables were combined to estimate "thermal optical habitat" for walleye. Within Ontario, this habitat model had high predictive success. Here, we investigate assembling the means to apply the model on a national scale. We also identify key parameters that become important when estimating walleye habitat supply across the broad range of climates, landscapes, geologic features and human impacts seen in Canadian freshwater lakes. The strengths and weaknesses of the process whereby a regional model is extrapolated to a larger scale are identified and the relevance of this work as a stepping stone to understanding large scale shifts in habitat use due to climate change is discussed.

Fish Species at Risk Assessment and Protection on the Sydenham River. **Poos, M.S.**, Mandrak, N.E.[2], and R.L. McLaughlin. [1] Department of Zoology, University of Guelph, Guelph, ON; [2] Department of Fisheries and Oceans, Great Lakes Laboratory for Fisheries and Aquatic Sciences (GLLFAS), Burlington, ON (paper 3-14)

Abstract:

Laboratory for Fisheries and Aquatic Sciences (GLLFAS), Burlington, Ontario.

The passage of the Species at Risk Act (Bill C-5) has created the need for improved scientific tools to assess and monitor species at risk (SAR), identify factors that limit their distribution and abundance, and identify their critical habitat requirements. We are using the Sydenham River as a test case to address these needs. The Sydenham is inhabited by 82 fish species, 8 with COSEWIC designations. Our objectives were to identify efficient methods for sampling fish SAR, and to determine the factors that limit their distribution. Fishes were sampled from one hundred sites throughout the watershed using a variety of gear types. Corresponding measures of water chemistry, geomorphology, and land use were also made. Backpack electrofishing and seine netting were more efficient at sampling fish SAR than backpack electrofishing alone, while passive methods such as Windermere traps were not effective. Five of the 8 COSEWIC-listed species were collected and three of these, (*Ammocrypta pellucida, Fundulus notatus, Etheostoma blennioides*), have extended their range. Canonical correspondence analysis was used to determine species-environmental relationships. Environmental characteristics, such as turbidity, water

temperature, and dissolved oxygen, showed varying and often contrasting effects on the presence of fish species at risk. As such, management of fish species at risk must be tempered with the consideration of multiple species outcomes utilizing multiple assessment and sampling methods in order for recovery actions to have the desired consequence/s.

Developing Sampling Protocols for Fish Species at Risk in the Great Lakes Basin. Mandrak, N.E., **J. Barnucz**, M. Poos, and H. Surette. Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, ON L7R 4A6. Department of Zoology, University of Guelph, Guelph, ON N1G 2W1 (paper 3-15)

Abstract:

There are 31 fish species at risk (SAR) present in the Great Lakes basin. They are found in a wide variety of habitats from small, headwater streams (e.g. redside dace, *Clinostomus elongatus*) to the hypolimnion of the Great Lakes proper (e.g. the deepwater ciscoes, *Coregonus* spp.). It is important to conduct ongoing assessments of the distribution and abundance of fish SAR to accurately determine conservation status, identify threats, and evaluate recovery actions. However, by their very nature, fish SAR are often difficult to capture and even more challenging to enumerate. We are currently developing species-specific sampling protocols for the ongoing, standardized monitoring of fish SAR. To determine the best methods for detecting a species, we are conducting sampling gear selectivity comparisons. Preliminary analyses indicate that a combination of active (backpack and boat electrofishing) and passive gears (hoop nets) used in a standardized manner allow for the best detection of many fish SAR in the Great Lakes basin. Future analyses will examine the amount of sampling effort required for detection, and for developing population estimates.

Ecological Integrity in Uncharted Waters: Historical Changes in the Fish Assemblages of Point Pelee National Park of Canada. **Surette, H.**,[1] N.E. Mandrak[2] and T.D. Nudds[1]; [1]Univiversity of Guelph, Guelph, ON; [2]Deptartment of Fisheries and Oceans, Burlington, ON (paper 3-16)

Abstract:

A goal for the management of protected areas, and particularly national parks, is to maintain and restore ecological integrity (EI). EI is defined, in part, as intact native species composition and abundance. To know whether this goal is met for protected areas requires a comparison between historic and present conditions over which native species composition and abundance has varied (i.e., the historical range of variability (HRV)). Without long-term records, it can be difficult to estimate the HRV for many protected areas, and thus to make decisions about management and restoration. Parks allow the study of the factors that influence distribution and abundance of fishes over time in an environment where many confounding factors (e.g. land use, exploitation) are controlled. Point Pelee National Park of Canada (PPNP) is a sand spit extending south into Western Lake Erie, and encompasses a 1113 hectare marsh. The fish assemblage in this marsh has been sampled periodically between 1940 and 1997. During the summers of 2002 and 2003, the ponds were sampled systematically to incorporate all wetland habitats, and to describe the current fish assemblage. Fishes were collected using a combination of passive and active gears. One hundred eleven sites were sampled across seven marsh ponds, yielding 36 fish species; including four fish species at risk (SAR). Ordination techniques, such as CCA and PCoA, will be used to determine associations between physical, chemical and biotic interactions affecting fish assemblages in the marsh complex. Examination of changes in the historical composition of fishes in PPNP, relative to present-day composition, will provide insight to whether, and to what extent, species composition has changed over time.

Use of Fish Populations in an Effects Based Assessment to Evaluate Non Point Stressors Associated with Agriculture. **Brasfield, S.**, M. Gray, K. Munkittrick. Canadian Rivers Institute, P.O. Box 5050, 100 Tucker Park Road, Department of Biology, University of New Brunswick, Saint John, NB E2L 4L5 (paper 3-17)

Abstract:

In most situations, discharges from non-point sources, such as agriculture, are complex mixtures, the concentrations of toxicants are difficult to characterize, and rates and timing of discharges are difficult to predict. Along the Little River watershed, located north of Grand Falls, New Brunswick, differing agricultural intensities at sites along the Little River reach provide a gradient to assess cumulative effects of agriculture. An effects-based approach was used to determine the role that various stressors play in the population-level impacts on survival and reproduction of slimy sculpin (*Cottus cognatus*). Previous studies have shown decreased gonad size, fecundity, nest size and density and young of the year densities downstream of agricultural practices. Although it is probable that sediment runoff is playing a role in the decreased performance of fish in the agricultural areas, there are also other factors involved with these events, including increases in temperature, nutrients, and pesticides. Seasonal changes in sediment and pesticide exposure profiles, temperature and nutrients may also be contributing factors. Heavy rainstorms in mid to

late summer coincide with heavier spraying as the potato vine grows and is more susceptible to peril. Summer storm events will be characterized in terms of sediment transport, pesticide transport, fish exposure and hydrological changes. Prior studies on this system documented year class failures in the agricultural areas, however YOY survival was not affected in a year of little rainfall or when summer heavy summer storms preceded pesticide use. Emerging information from summer studies indicates that there is a negative relationship between rainfall and YOY abundance in the agricultural areas. This research is significant because of several key aspects, including: the fish are exposed *in situ* in the wild; the sediment accumulation of chlorinated and non-chlorinated pesticides can be quantified; and developmental and endocrinological endpoints can be assessed.

Human Development and Environmental Monitoring: Assessing Fish Mobility and Performance Parameters. **Doherty, C. A.**, R.A. Curry and K.R. Munkittrick. Canadian Rivers Institute, University of New Brunswick, Fredericton, NB (paper 3-18)

Abstract:

Goals of the work presented were to assess the mobility and performance parameters of the Common White Sucker often used as a sentinel species in areas of human development in large rivers. We studied white sucker movements at sites in the Saint John River in reaches heavily influenced by human activities via telemetry (radio and acoustic) and stable isotope analysis. Limited seasonal movements < 0.1 km / day were observed outside of the spawning period. Fish maintained residency within a small river section most often consisting of stable deep water. Suckers travelled 10-25km to spawning areas in tributaries in the spring. In some cases fish returned to areas occupied previous to spawning. End points associated with growth and reproductive development was measured at multiple sites within this river section on three occasions. Repeatable patterns were observed, with fish size decreasing with downstream progression and significant differences in condition factor and liver size present. This correlated well with degree of human impact in this reach of the river.

The Effects of Municipal Nutrient Loading on Trophic Structure and Spatial Distribution of Fish in a Large River System. **Askey, P.J.**, L. Hogberg, J.R. Post, L.J. Jackson, M. Thompson and T. Rhodes. Department of Biological Sciences, University of Calgary (paper 3-19)

Abstract:

Understanding the effects of anthropogenic nutrient enrichment on aquatic communities is key for fisheries management and conservation. The effect of nutrient enrichment on trophic level structure was examined in a large river system. Abundance was estimated for three trophic levels; primary producers, consumers and predators. Estimates were obtained in the Bow River, Alberta above and below a point source nutrient influx due to city of Calgary waste water. Treated waste water additions led to a five fold increase in phosphorus concentrations and affected all trophic levels. Primary producer and consumer abundance increased with total phosphorus concentration. Counter intuitively, enrichment did not have a positive effect on the top trophic level (fish). This was due to opposing responses of the trout and whitefish. Trout abundance closely followed predicted phosphorus levels over 170km section of river, as would be expected by ideal free distribution theory. However, whitefish abundance decreased with increased productivity. Overall, municipal nutrient loading had a drastic impact on the Bow river aquatic community, and compositional change within trophic levels was important in assessing the response of trophic structure.

Effects of pulp mill effluent on fish communities. **Freedman, J.A.**, R. A. Curry, and K. R. Munkittrick. New Brunswick Cooperative Fish and Wildlife Research Unit, Canadian Rivers Institute, Department of Biology, University of New Brunswick, Fredericton NB (paper 3-20)

Abstract:

Fish community composition can be affected by human impacts on the environment. We assessed community structure in relation to pulp mill effluent in the headpond of Mactaquac Lake, New Brunswick. Twelve sites were sampled, located on both banks, upstream and downstream of the effluent discharge of a bleached kraft hardwood pulp mill. Species richness and catch-per-unit-effort were used to assess the fish community assemblages among sites. Length, weight and physical condition of fishes were also compared. The mill's effluent is treated and diffused, but still results in mild eutrophication in the receiving environment. This nutrient enrichment may account for differences in fish communities.

Oil Development on the Grand Banks of Newfoundland: A Perspective on Potential Impacts and Approaches to Monitoring. **Payne, J.F.,** Science Oceans and Environment Branch, Fisheries and Oceans, St. John's, NL, A1C 5X1 (paper 3-21)

Abstract:

Development is presently proceeding on one of the world's richest fishing grounds on the Grand Banks where the Terra Nova, Hibernia and Husky fields are located. What will be the scale and nature of any impacts? There is a substantial body of knowledge from field studies in the North Sea, the Gulf of Mexico and California, and more recently from the Grand Banks. There are companion laboratory studies including in areas funded by the Program on Energy Research and Development to gain more information on the chronic toxicity of drill cuttings and production waters. Overall, the majority of information available from field and laboratory studies suggest that offshore impacts should be minimal and pose little or no risk to fisheries and the environment. However there remains knowledge gaps with respect to chronic toxicity that need to be addressed for reasons of scientific uncertainty or public assurance. The "final" step in addressing uncertainty is to have rigorous monitoring programs that can provide early warning of potential problems. The Canada Newfoundland Offshore Petroleum Board is the regulatory authority for the Grand Banks and all three developments on the Banks are assessing potential impacts on fish health, fish product quality and sediment quality. These monitoring programs, together with selected further chronic toxicity studies, should provide early warning of any risks to fisheries and the environment. However, plankton may also have to be given consideration for incorporation into monitoring programs at some sites in the future. With respect to the broader question of potential for cumulative effects from various activities, science is also now revealing a potential for disconnect with the Fisheries Act. For instance while the drilling of an exploratory well over a period of 60 days may involve the alteration or disruption of 500 cubic meters of sediment habitat around a rig site, one small boat dredging for clams may alter three to four thousand cubic meters of habitat per day. (However common sense would dictate the difficulty of trawling, clamming, etc. without impacting habitat to a major degree in comparison with oil development activities.) With respect to seismic, avoidance behaviour by marine mammals or schooling fish has been studied fairly extensively. However, one important aspect that also needs attention is the question of exposure distance relationships for producing sub-lethal damage (e.g. serious pathologies, delayed mortality, reproductive effects, etc.) in representative fish and other organisms. There is virtually no information in this area and needs to be addressed for regulatory and public assurance.

Eelgrass Transplantation as Habitat Compensation for the White Rose Project. **Pinsent, D. L.[1],** Taylor, D.G.[2] and Dyer, K.[3], [1]Jacques Whitford Environment Limited 607 Torbay Road, St. John's, NLA1A 4Y6, [2]D.G. Taylor, Inc., 74 Swansea St, Conception Bay South NL A1W 4S5, [3]Husky Energy, Suite 801, Scotia Centre, 235 Water Street, St. John's, NL A1C 1B6 (paper 3-22)

Abstract:

As part of the habitat compensation required for the White Rose Development, Husky Energy has undertaken an eelgrass (*Zostera marina*) transplantation project. The primary transplant location was Rocky Barachois, Bonne Bay NL, at the site of a 38,000-litre diesel spill in 1999. An eelgrass bed at this site was gradually wiped out due to the effects of hydrocarbon contamination and sedimentation resulting from construction of a rock berm, built to contain the diesel. During the summer of 2003, Rocky Barachois was replanted with 180,000 eelgrass plants harvested by thinning a nearby eelgrass bed. The transplant method used was called TERFS™ or Transplant Eelgrass by Remote Frame System. The method has been used successfully in New England, but this is the first time the TERFS™ method has been tested in Atlantic Canada. This presentation will discuss: the results of surveys conducted around the island of Newfoundland to locate a suitable transplant location; methods used in harvesting and transplanting eelgrass by TERFS™; and a report on the survival of the transplanted eelgrass, 3 months post-transplant.

Mummichog (*Fundulus heteroclitus*) movement during the ice-free season in the Miramichi River Estuary. **Skinner, M.**[1,2], S. Courtenay[1,2], R.A. Curry[1], P. Riebel[3] and R. Parker[4]. [1]Canadian Rivers Institute, University of New Brunswick, Fredericton, NB; [2]Gulf Fisheries Centre, Fisheries and Oceans Canada, Moncton, NB; [3]UPM Kymmene, Miramichi, NB; [4]Environment Canada, Fredericton, NB (paper 3-23)

Abstract:

Range of movement of mummichogs (*Fundulus heteroclitus*) within the upper Miramichi estuary was investigated to validate the usage of this fish as a sentinel species in environmental effects monitoring (EEM) fish surveys in Atlantic Canada. During the ice- free season (May – end November) of 2002 mummichogs were captured by beach seine and minnow trap biweekly from four sites within the Miramichi estuary and 4051 fish were differentially marked using Visible Implant Elastomer (Northwest Marine Technology, Inc.). Recaptures were made during this period and again during the ice free season (end April – end November) of 2003. To date, 638 (15.7%) recaptured:

Chatham Head - 485 tagged and 49 recaptured; UPM Kymmene Bleached Kraft Mill Effluent – 741 tagged and 88 recaptured; Strawberry Marsh – 1844 tagged and 369 recaptured; and an area upstream of Flett Cove – 981 tagged and 132 recaptured. Preliminary results indicate the majority of marked fish displayed distinct site-fidelity, with 618 of 638 (96.9%) recaptured at original tagging sites. Of those 20 fish recaptured at non-tagging sites, time elapsed from marking to initial recapture ranged from 10-371 days (mean= 118 days) and the sex ratio was approximately 2:1 in favor of males. These findings support the assumption of previous EEM fish surveys by pulp and paper mills in the Canadian Maritimes that the mummichog is a relatively sedentary estuarine species and, at least in this regard, a suitable sentinel fish species.

The Impact of Barriers on the Upstream Habitat Use of Resident and Migrant Brook Trout (*Salvelinus fontinalis*). **Morinville, G.R.**[1] and J.B. Rasmussen[2]. [1]Department of Biology, McGill University, Montréal, PQ: [2]Department of Biology, University of Lethbridge, Lethbridge, AB (paper 3-24)

Abstract:

Barriers to fish movement including waterfalls, and man-made structures such as culverts, can affect fish by preventing them from travelling between feeding and/or spawning grounds. Fish found upstream of such barriers are thus limited in their movement and are considered residents. A road bordering the Ste-Marguerite River (SMR), Québec crosses many tributaries. Since the SMR system contains both anadromous Atlantic salmon (Salmo salar) and anadromous and resident brook trout (Salvelinus fontinalis), poorly constructed culverts could have an impact on the occurrence of migrants in its tributaries. Previous work has demonstrated that both juvenile anadromous trout and salmon have higher metabolic costs than resident trout, the consequence of using costly habitats (fast water). It is thus likely that a change in overall habitat use may occur if migrants are absent from a system. We investigated the impact of barriers on salmonids by examining changes in habitat utilisation due to the absence/presence of brook trout migrants in tributaries of the SMR. As predicted, the migrant form of brook trout is absent from tributaries containing barriers to upstream movement. Furthermore, when such migrants are absent, the overall range in water velocities employed by residents is reduced, with a shift to slower velocities. Our results suggest that barriers to fish movement not only impact the presence/absence of migrants but also impact the overall upstream habitat use.

Small Stream Habitat Use by Brook Trout, *Salvelinus fontinalis*, in Northwestern Ontario. **Lawrie, M.K.** and R.W. Mackereth. Department of Biology and Centre for Northern Forest Ecosystem Research (OMNR), Lakehead University, Thunder Bay, ON (paper 3-25)

Abstract:

Stream dwelling brook trout populations are widely distributed throughout the drainage systems they occupy in Northwestern Ontario, including small, tributary streams where they are often the only fish species present. At a watershed scale, brook trout are most often found in small streams that flow into larger streams or ponds. Our objectives were to compare the fish community, brook trout population characteristics and habitat characteristics in small (1 sq km catchment area) and large (>30 sq km catchment area) streams and to monitor brook trout movement within and between the two streams. Fish communities were sampled using backpack electrofishing in four small streams and the larger streams into which they flowed. Two-way weirs were installed at the mouths of the small streams to monitor movement into and out of these streams. Total sample size was 997 brook trout; 663 were caught in the electrofishing survey and 334 were captured in the weirs. 484 PIT tags were inserted and 300 brook trout were recaptured. Larger streams had slightly higher mean fish species richness (5.3) than small streams (3.75). Brook trout length ranged from 24-241 mm in large streams and 15-199 mm in small streams. Both young-of-the-year and adult brook trout were present in small streams; however, smaller fish were more abundant. Small streams were consistently colder and had more cover than the larger streams. Movement of brook trout through the weirs was more frequent in the spring and fall. Movement tended to be upstream in the spring and downstream in the fall and was associated with rainfall and stream flow increases. Distances moved by brook trout in small streams during the study period ranged from 0-600 m. Our results highlight the importance of small streams for brook trout populations.

Landscape Scale Characteristics Influencing the Presence and Relative Abundance of Brook Trout (*Salvelinus fontinalis*) in Beaver Ponds in Northwestern Ontario. **Parker, S.A.** and R.W. Mackereth. Department of Biology and Centre for Northern Forest Ecosystem Research (OMNR), Lakehead University, Thunder Bay, ON ((paper 3-26)

Abstract:

Beaver ponds may have a considerable influence on brook trout abundance and distribution in stream ecosystems. Brook trout are routinely found in beaver ponds which may act as refugia if stream conditions become adverse.

However, beaver dams are potential barriers to brook trout movement within the stream. The objective of this study was to examine characteristics of beaver ponds at both local and landscape scales and determine the characteristics associated with the presence and relative abundance of brook trout. Brook trout presence and relative abundance was based on catch-per-unit-effort (CPUE) from angling in ponds and by electrofishing surveys in streams associated with beaver activity. Preliminary results indicate mean brook trout size was greater in beaver ponds (mean = 197.6 +/- 40.9 mm, 98.01 +/- 65.7 g, n = 321) than in the adjacent streams (mean = 97.5 +/- 40.5 mm, 14.3 +/- 18.3 g, n = 620) in the study area. Ponds sampled in the study were stratified based on upstream catchment area which was positively correlated with CPUE and negatively correlated with mean brook trout size. In addition, individual pond characteristics, such as depth, temperature, position within the drainage network and size, also appear to influence CPUE. Reference ponds sampled at intervals throughout the study experienced greater CPUE during summer months than in the spring and fall. This research may allow us to use landscape scale characteristics to predict whether beaver ponds possess attributes that distinguish them as potential brook trout habitat enabling resource managers to protect these areas from possible land use impacts.

Alternative States in Brook Charr Fisheries: The Role of Spatial Refuges in Mediating Interspecific Competition. **Browne, D. R.**, and J. B. Rasmussen. Department of Biology, McGill University, Montreal, PQ (paper 3-27)

Abstract:

Spatial refuges such as distinct nursery versus adult habitats can reduce competition between fish species allowing for coexistence. Management experience with lakes in which brook charr and yellow perch co-occur has shown these systems to fall into two categories: either highly productive and resilient to over fishing or, prone to over fishing and providing low yields. We hypothesize that available nursery habitat is the main factor differentiating high versus low yield brook charr – yellow perch systems. We examined the landscape and food web patterns in a series of brook charr and yellow perch systems characterized as either high or low brook charr yield in order to test this hypothesis. Lakes were characterized by lake order, number of potential nursery streams, and number of streams used by young-of-the-year brook charr. The strength of the competitive interaction with yellow perch was characterized by comparing ontogenetic diet shifts, as determined by stable isotope analyses, and growth of brook charr. We show that in lakes characterized as high yield, brook charr diet remains a mixture of benthic and pelagic sources throughout ontogeny and growth parameters show no evidence of a competitive bottleneck. In contrast, in lakes characterized by low yield, brook charr exhibit a shift from pelagic to profundal resource use and a growth bottleneck at intermediate size classes. High yield lakes had a greater number of potential nursery streams and a greater number of streams with young-of-the-year present. We argue that the presence of a spatial refuge from competition with yellow perch allows brook charr to escape an otherwise strong competitive bottleneck. These results highlight the importance of taking into account landscape alterations that may affect nursery habitat in the management of brook charr fisheries.

Mercury Dynamics in Forage Fish Communities: A Growth Story. **Swanson, H.K.**[1], T.A. Johnston[2], D.W.Schindler[1], R.A. Bodaly[2], R.A. Cunjak[3], and D.M.Whittle[2]. [1]Dept. of Biological Sciences, University of Alberta, Edmonton, AB; [2]Dept. of Fisheries and Oceans, Burlington, ON and Winnipeg, MB; [3]Dept. of Biology, University of New Brunswick, Fredericton, NB (paper 3-28)

Abstract:

This study compared total mercury concentrations, stable C and N isotope ratios, and growth rates among rainbow smelt and five native forage fish species in 25 central Canadian lakes. Rainbow smelt is native in three of these lakes but is exotic in the others. There were significant differences among species in all of the variables examined. As in an earlier study, we found that rainbow smelt had a significantly higher trophic position (determined by stable N isotope ratios), but a lower mercury concentration, than most native forage species. Rainbow smelt growth rates were intermediate relative to the other species. Among species and within most species, the relationship between mercury concentration and trophic position was weak and negative. Growth rate and lake conductivity were much stronger predictors of forage fish mercury concentrations. Mercury concentrations were negatively related to growth rate both within and among species and a model that included growth rate, lake conductivity, and a species class variable explained 60% of the variation in forage fish total mercury concentrations. Our results indicate that although rainbow smelt may alter trophic structure in the lakes that they invade, they are unlikely to have higher mercury concentrations than native forage fish. Our results also indicate that general theories of biomagnification may only apply to fish communities with relatively large interspecific differences in trophic position.

The Potential Use of Rock Gunnel (*Pholis gunnellus*) as a Bioindicator Species in Saint John Harbour, New Brunswick, Canada. **Vallis, L.**, D. MacLatchy and K. Munkittrick. Department of Biology, UNBSJ, Saint John, NB (paper 3-29)

Abstract

The harbour at Saint John, New Brunswick (SJH) receives waste from both municipal and industrial sources. We were interested in determining whether rock gunnel (*Pholis gunnellus*) would be a suitable sentinel species for documenting contamination levels around SJH. The growth and reproductive development of rock gunnel were examined along three shores of SJH where past records indicate differing levels of contamination. There were no differences in steroid levels between sites, nor was there a difference in EROD activity levels between sites, but rock gunnel collected at sites with the highest contamination were larger, had higher condition factors and larger relative liver sizes. Liver size differences between sites were not evident in spring when fish returned from offshore spawning. There was also a decease in the number of juveniles present at the most contaminated site. Larger sizes could be an indication of eutrophication due to sewage inputs at the contaminated sites.

Theme 4 – Aquaculture

Studs or duds?: The influence of artificial selection on the spawning behaviour of male Atlantic salmon. **Weir, L.K.**, J.A. Hutchings, I.A. Fleming and S. Einum, Department of Biology, Dalhousie University, Halifax, NS, Canada; Hatfield Marine Science Center, Oregon State University, Newport, Oregon, USA; Norwegian Institute for Nature Research, Trondheim, Norway (paper 4-1)

Abstract:

During spawning, Atlantic salmon males establish dominance hierarchies, such that a few males control access to spawning females. Consequently, there should be a corresponding skew in aggression, courtship, and reproductive success among males. The aquaculture environment, through artificial and domestication selection, has been found to alter male spawning behaviour. To date, most studies have focused on overall differences between groups of farmed and wild males, rather than the relationships among individuals within groups. We examined the influence of artificial selection and the hatchery environment on individual male Atlantic salmon spawning behaviour in three different experiments. We observed behaviour of males of farmed and wild origin while they competed for spawning opportunities in either pure or mixed groups in a semi-natural environment. Farmed males were from a major Norwegian aquaculture strain, AquaGen, and wild males were derived from two different rivers: the River Namsen, the principal river from which the AquaGen strain was derived, and the River Imsa, a geographically distinct river. Mortality among farmed males in all years was higher than among wild males. Furthermore, wild males established stronger dominance relationships than farmed males, had more reliable behavioural correlates of spawning success, and were more effective spawners than farmed males. The extent to which these differences are genetic or environmental remains to be established.

Photomanipulation of Captive Atlantic Cod (*Gadus morhua*) Broodstock. **Lush, L.**[1], J. Wade[1], J. Brown[2], M. Burton[2], R. Penney[1]. [1] Department of Fisheries and Oceans, North West Atlantic Fisheries Centre St. John's, Newfoundland A1C 5X1; [2] Ocean Sciences Centre Memorial University of Newfoundland Logy Bay, NL A1C 5S7 (paper 4-2)

Abstract:

Proper broodstock management is critical to the successful aquaculture of a species. Photomanipulation with the goal to have broodstock spawn outside of the natural spawning season is an important aspect to any management strategy to maximize use of all resources. Atlantic cod (*Gadus morhua*) are being developed for aquaculture as an alternative finfish species in Newfoundland with great emphasis being placed on broodstock management through the ACRDP funded cod broodstock development program. Atlantic cod broodstock were placed on a photoperiod regime to promote spawning 4-months in advance of the normal spawning season of April-May. Photomanipulation began on June 24, 2002 and first manipulated spawning was observed on December 10, 2002. Egg and larval quality were excellent based on the measured parameters of fertilization, cell division abnormalities, survival and growth. Greater than 75 liters of high quality eggs were produced in 96 batches, more than doubling the production of these fish in the first year of captivity under ambient conditions. Abnormalities in cell divisions averaged 2.9%. Egg and larval survival were exceptional, and growth rates were on average with previous years. Egg quality parameters were comparable to the sister ambient group held at the same facility. Both ambient and advanced fish were reconditioned under the same light regimes, and data from the second year of photoadvancment may be available at time of presenting.

Growth and survival of Atlantic cod larvae from four latitudinally separated populations: implications for broodstock development. **Puvanendran, V.** and J.A.Brown. Ocean Sciences Centre, Memorial University of Newfoundland, St.John's, Newfoundland A1C 5S7. (paper 4-3)

Abstract:

Latitudinal differences in growth and survival of fish populations have been documented in several recent studies. In general northern population grow better than their southern counterparts. We carried out common garden experiments on larval cod from four regions in the North Atlantic, 3L (Bonavista Bay, NF. 49 N), 3PS (Placentia Bay, NF. 48° N; 54° W), 4T (Northumberland Strait, P.E.I. 46°N; 64° W) and 4X (Scotian Shelf, NS, 44° N) to determine if larvae from these populations would display different growth rates and survival. Experiments were carried out at two temperatures (7 and 11°C) and two prey concentrations (1500 and 4500 prey/L). Larvae were sampled from 1 to 43 days post-hatch for growth and larval survival was recorded at the end of the experiment. Our results showed significant effects of prey density, temperature and population on larval growth with the southern 4X larvae were significantly smaller than 4T and 3PS larvae. Likewise, both prey density and temperature affected survival among these populations, however, prey density had a more significant effect than temperature. Survival of 4T and 3PS larvae was influenced by prey density while survival of 4X larvae was affected by temperature. We discuss our results in the context of selecting appropriate broodstock for cod the aquaculture industry.

The nutritional benefits (lipids, amino acids) versus economic costs of providing live *Artemia* and commercial diets to first-feeding common wolffish, *Anarhichas lupus*. **Halfyard, L.C.**[1], C.C. Parrish[2], C.I. Hendry[3], B. Blanchard[4], M. Rommens[4] and K. Jauncey[5]. 1Marine Institute, Memorial University of Newfoundland, St. John's, NL A1C 5R3; [2]Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL A1C 5S7; [3]Department of Fisheries and Aquaculture, Government of Newfoundland and Labrador, Grand Falls-Windsor, NL A2A 2K2; [4]Scotian Halibut Ltd., Lower Woods Harbour, NS B0W 1E0; [5]Institute of Aquaculture, University of Stirling, Stirling, Scotland FK9 4LA (paper 4-4)

Abstract:

The culture of many marine finfish species often relies on the provision of both live *Artemia* and commercial diets to promote predatory feeding responses and to optimize nutritional profiles. However, the production costs versus the nutritional benefits of live food sources have often been questioned in aquaculture ventures. Species such as *Anarhichas lupus* (common wolffish), are being assessed as alternative white-fleshed aquaculture candidates. This study evaluated first-feeding strategies for the common wolffish and found that low feeding frequencies (3 times daily) adversely affected growth, while high frequencies (18 times daily) compromised water quality. The 9 times daily feeding frequency provided a good feeding regime for optimizing growth and survival. Co-feeding of a dry commercial and live *Artemia* diet at low feeding frequencies did not affect growth and survival, but did at higher frequencies. Biochemical tissue composition (lipids and amino acids) varied with the inclusion of enriched and / or unenriched *Artemia* diets, particularly triacylglycerol and phospholipid proportions. Economic modeling using wolffish growth and survival profiles compared the production costs versus the nutritional benefits of providing live *Artemia* and / or commercial diets.

A Whole-Lake Experiment to Assess the Impact of Cage Aquaculture on Freshwater Ecosystems. **Podemski, C.L.**[1], P.J. Blanchfield[1], K. Mills[1], L. Flavelle[1], M.J. Paterson[1], D. Findlay[1], K.A. Kidd[1], S. Chalanchuk[1], M.J. Turner[1], R. Rooney[2], C. Bristow[3], R Hesslein[1], S. Schiff[4], and L. Hendzel[1]. [1] Freshwater Institute, Department of Fisheries and Oceans, Winnipeg, MN; [2] Department of Entomology, University of Manitoba, Winnipeg, MN; [3] Department of Biology, University of Ottawa, Ottawa, ON; [4] Department of Earth Science, University of Waterloo, Waterloo, ON (paper 4-5)

Abstract:

Although aquaculture has been lauded as a potential savior for overexploited wild stocks, there is increasing controversy about the ecological costs associated with the controlled production of fishes. Although the impacts of aquaculture on the marine environment have been studied extensively, the impacts of aquaculture on freshwater ecosystems has received much less attention. Land-based facilities are the numerically dominant form of freshwater aquaculture, but a higher biomass of cultured fishes is produced in lake-based cage culture. The technology for collection of waste materials from cage farms is neither well-developed nor its use wide-spread. As a result, these facilities have the potential to impact the ecology of their receiving waters. Researchers at the Experimental Lakes Area, located in Northwestern Ontario, are conducting a whole-lake experiment to assess the impacts of cage aquaculture on a lake ecosystem. In June 2003, 10,000 all-female rainbow trout (*Oncorhynchus mykiss*) were added to a cage installed in Lake 375, a small oligotrophic boreal lake. The fish were reared in the cage using feeding schedules and advice provided by the Ontario Aquaculture Association. Impacts of the operation of this cage facility

on water quality, primary productivity, phytoplankton species composition, zooplankton secondary production and species composition, and changes in sediment characteristics and benthic invertebrate communities were monitored on a monthly basis. Depth-sensing acoustic telemetry was used to monitor the impacts of the cage farm on the spatial and pelagic distribution of native lake trout (*Salvelinus namaycush*) and white sucker (*Catostomus commersoni*). Changes in the spatial distribution of forage-fish species was assessed through the use of minnow traps. Trap-netting in spring and fall was used to document the abundance and condition of forage fish and the abundance, condition, and recruitment of lake trout and white sucker. Stable isotopic analysis of monthly collections of representative food web components was used to trace the distribution and utilization of aquaculture-associated materials through the aquatic food chain. Results from the first year of operation and plans for the second year of this study will be discussed.

Harmful Algae Detection at Newfoundland Aquaculture Sites – A Product Management and Marketing Issue. **McKenzie, C.H.**[1], Kenny, S.[1], Nicholls, T[1]., Mouland, D.[2] and Kennedy, K.[3] [1]Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre, St. John's, Newfoundland, [2]Department of Fisheries and Aquaculture, Grand Falls, Newfoundland, [3]Canadian Food Inspection Agency, St. John's, NL (paper 4-6)

Abstract:

The Newfoundland Aquaculture Industry Association, the Aquaculture Research Section of Fisheries and Oceans Canada, the Provincial Department of Fisheries and Aquaculture and the Canadian Food Inspection Agency have partnered in an ACRDP (Aquaculture Collaborative Research Development Program) funded project to determine the population dynamics of harmful marine phytoplankton at shellfish aquaculture sites. Information obtained from this research will establish a framework for assessing and managing the risk harmful algae may pose to the aquaculture industry in Newfoundland and Labrador. A harmful algae early warning system has been designed and implemented on 5 commercial mussel aquaculture sites in Newfoundland. Sampling has continued monthly from April to November 2002 and 2003. Phytoplankton samples and environmental data including nutrients, SEABIRD CTD casts and moored YSI Sonde profilers, were collected at each site. Microscopic analysis using a Zeiss Axiovert 35 inverted microscope and Hitachi S570 scanning electron microscope were conducted to determine the presence of known harmful algal species. When harmful algal species were detected at a site at concentrations that might affect site management, shellfish growers were immediately notified and additional sampling and testing was done. When suspect species were detected, the following procedures were followed: (a) additional plankton sampling was conducted; (b) mussels were provided to Canadian Food Inspection Agency for appropriate testing and (c) phytoplankton samples were concentrated for chemical analysis at NRC, Halifax. Sampling at selected sites also included the collection of epiphytic algae from the mussel sock or seed collector lines. The samples were examined to determine the presence of *Prorocentrum lima*, a known source of diarrhetic shellfish poisoning (DSP) toxins. Several species of harmful phytoplankton were detected, but abundance was not sufficient to pose a risk to shellfish production. These species included *Prorocentrum lima*, *Dinophysis norvegica*, *Alexandrium fundyense* and several species of *Pseudo-nitzschia*. Providing the shellfish growers with harmful algae information and the resulting husbandry practices that can be taken to ensure the safe transfer or harvest of their product from their site is important to developing a HACCP (Hazard Analysis Critical Control Point) industry standard in Newfoundland and is vital to product marketing and exportation.

The Effects of *Mytilus* spp. Farming on the Benthic Environment at Two Newfoundland Aquaculture Sites. **Ryan, J.**[1], R. J. Thompson[1], M. R. Anderson[2], R. B. Rivkin[1], and D. Deibel[1]. [1]Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL A1C 5S7; [2] Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre, PO Box 5667, St. John's, NL, A1C 5X1 (paper 4-7)

Abstract:

Suspension feeders such as *Mytilus* spp. filter particles from the water column. A portion of the ingested material is excreted as feces and pseudofeces in a process known as biodeposition. In areas of dense bivalve populations, such as mussel farms, biodeposition can result in a significant increase in the overall sedimentation of material to the benthos. This increased sedimentation and accumulation of biodeposits on the seabed has the potential to alter the biological and physico-chemical characteristics of the sediment.

The objective of this study was to examine the effect of biodeposition on the structure of the macrobenthic community and to determine the degree of organic enrichment at two aquaculture sites in northeastern Newfoundland. Depositional areas in coastal Newfoundland are typically dominated by organic-rich, fine-grained sediments. Sediments within both farms were hypoxic to anoxic. At these sites, biodeposition rates were measured and comparable to rates measured elsewhere in Newfoundland. Sediment samples taken to determine macrofaunal composition showed that stations within a farm are relatively similar to each other and also similar to those at nearby

reference stations. The two farms were however, very different from each other with one farm being dominated by species indicative of organic enrichment. The second farm, on the other hand, showed a very different taxonomic assemblage that indicates at a lesser degree of enrichment. These results suggest that environmental effects are site-specific and that modifications to organic deposition resulting from the presence of high density mussel culture may not alter benthic community structure in such depositional areas.

The effects of mussel (*Mytilus* sp.) farming on the zooplankton communities of Notre Dame Bay, Newfoundland. **Stacey, J.** and D. Deibel. Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL (paper 4-8)

Abstract:

The impact of mussel (*Mytilus* sp.) farming on the zooplankton communities of inlets on the northeast coast of Newfoundland, Canada, was investigated in a quarterly study (2001-2002). The size distributions, abundance, biomass and composition of the zooplankton communities of two farms in Notre Dame Bay were compared to their nearby reference sites. In general, the zooplankton communities in this area were dominated by a few small-bodied taxa, including *Acartia* sp., *Pseudocalanu*s sp., *Temora* sp. and *Oithona* sp. Most taxa exhibited peaks in abundance in mid to late summer. The total abundance of the zooplankton communities of the farmed inlets was generally not affected by mussel farming. However, the size structure and community composition of the farms differed from their reference sites in summer and fall. Specifically, the abundances of *Pseudocalanus* sp., *Acartia* sp., *Centropages* sp. and harpacticoid copepods were significantly higher at the farms than at the reference sites. The abundances of copepod nauplii, *Oithona* sp. and *Temora* sp. were significantly lower at the farms compared to the reference sites. We suggest that these differences may be related to direct ingestion of the eggs and nauplii of some groups by mussels, differences between the food available to zooplankton at farms and reference sites, or to competition for food with mussels.

Seabed Dispersal of Mussel Farm Debris. **N.D Hartstein**. Fisheries and Oceans Canada, Science, Oceans and Environment Branch, P.O. Box 5667, St. John's, NL A1C 5X1 (paper 4-9)

Abstract:

Significant expansion in mussel farming over recent years has increased interest and concern over their potential impact on the marine environment. Mussel farms produce large volumes of shell debris and faecal matter (faeces & pseudofaeces). Sediment trapping over an 18-month period indicates that a one-hectare farm produces between 250-400 tons of mussel debris per annum. At present little is known about the dispersal of these deposits in and around farm sites. Accordingly, the seabed distribution of mussel debris at three farm sites, in sheltered to exposed environments, was mapped using side-scan sonar. The resultant imagery was "ground truthed" with splash camera footage and over 160 sediment samples. In sheltered environments, side-scan sonar imagery shows high acoustic backscatter beneath farm sites and low scatter in areas immediately surrounding the farm. Both camera footage and sediment samples confirm large piles of shells smothered in places with fecal material debris beneath the mussel farms. At the high-energy site there appears to be no areas of high backscatter. Camera footage indicates the seabed is predominately clean with only the odd small clump of shells and no visible fecal material even though this site had the largest volume of debris per annum collected by sediment trapping.

Assessing Site Suitability for Suspended Mussel Aquaculture – A Modeling Approach. **Chamberlain, J.**[1], M.R. Anderson[2], D. Deibel[1], R. Rivkin[1] and R.J. Thompson[1]. [1]Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL A1C 5S7; [2]Environmental Sciences Section, Ocean Programs Division Science, Oceans and Environment Branch, Department of Fisheries and Oceans, St. John's, NL A1C 5X1 (paper 4-10)

Abstract:

The ecological effect of biodeposits from suspended mussel farms on the surrounding benthic environment has been the subject of numerous recent studies. Results indicate a variety of effects, ranging from significant impact such as extensive bacterial mats underneath the farms and changes in the benthic community composition to minimal effects and no observable changes. Key parameters affecting the spatial scale and degree of effects caused by the biodeposits on the seabed geochemistry and infaunal communities are the biomass of cultured stock, concentration of available food esource, dispersion characteristics of the surrounding area, and longevity of the site. During this study, the particle-tracking model DEPOMOD was used to examine the relative importance of each of these parameters in determining the benthic impact of biodeposits from suspended mussel farms. The model simulates the flux of biodeposits through the water column and predicts the accumulation of solids on the seabed and associated changes in benthic faunal communities. The results of extensive field programs at mussel farm sites in Newfoundland and Ireland were used to calibrate the model. The results suggest that slight differences in the

dispersion characteristics of the sites may explain marked differences in the observed sediment geochemistry and benthic community structure. However, in areas of high natural sedimentation, the additional effects resulting from mussel biodeposition are difficult to detect. We propose that such modeling techniques may be a useful tool during the planning phase of aquaculture developments to assess the appropriate sizes of farms.

Theme 5 – Genetic Variation versus Life History

Countergradient Variation in Growth and Associated Life-history Trade-offs in Brook Trout from Western Newfoundland. **McCairns[1], R.J.S.**, J.A. Hutchings[1] and T.W. Knight.[2] [1]Department of Biology, Dalhousie University, Halifax, NS; [2]Resource Conservation, Gros Morne National Park, Rocky Harbour, NL (paper 5-1)

Abstract:

Fishes represent ideal model systems for the study of adaptive plasticity. Given their capacity to trade-off somatic growth against reproductive investment, considerable variation in growth and maturation phenotypes may be evident within a single species. However, selective forces unique to specific environments may reduce such phenotypic variability. Furthermore, if the traits in question are to some degree heritable, then the phenotypes that remain after several generations of selection can be considered adaptations. By using a combination of field-based observations and controlled experimentation, we can interpret such phenotypic plasticity within an adaptive framework. We are investigating how allopatric populations of brook trout, putatively of common descent, have adapted to climatic differences along an altitudinal gradient. Work was conducted in western Newfoundland, using 6 populations from 3 separate watersheds: one highland-lowland population pair was located in each watershed. Gonad samples from 60 individuals in each population, and ageing structures from 200 individuals per population, were collected between August and October 2002. An additional 600 to 800 individuals were marked in each population in order to estimate survival probabilities in situ. We also selected brood-stock from 2 populations for a common-garden experiment: twenty-four full-sib families (12 highland and 12 lowland) were reared at 2 experimental temperatures simulating mean observed differences between field sites. Analyses of ageing structures, and size-at-age modeling, suggest no significant differences in mean size-at-age between environments. This is indicative of more rapid somatic growth in highland individuals. Results of the common-garden experiment demonstrate a potentially genetic basis underlying differences in observed growth rates. We will present evidence of correlated life-history trade-offs, and discuss the adaptive significance of our observations.

Genetic Determinants of Population Variation in Atlantic Cod Growth, Survival, and Phenotypic Plasticity. **Hutchings[1], J.A.**, Puvanendran[2], V., Swain[3], D.P., Brown[2], J.A. and W.R. Driedzic[2]. [1] Department of Biology, Dalhousie University, Halifax, NS B3H 4J1; [2] Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL A1C 5S7; [3] Dept. Fisheries & Oceans, Gulf Fisheries Centre, PO Box 5030, Moncton, NB E1C 9B6 (paper 5-2)

Abstract:

We undertook a common-garden experiment on Atlantic cod to disentangle the genetic and environmental contributions to population differences in larval growth, larval survival, and phenotypic plasticity for growth and survival. Adults were captured immediately prior to spawning from 4 spatially distinct regions of the Northwest Atlantic: Southwest Nova Scotia (Northwest Atlantic Fishery Organisation [NAFO] division 4X), Southern Gulf of St. Lawrence (NAFO division 4T), Placentia Bay, Newfoundland (NAFO division 3Ps), and Trinity Bay, Newfoundland (NAFO division 3L). Subsequent to their collection, groups of 40-70 adults were allowed to spawn undisturbed, producing egg batches that were transferred to a controlled environment prior to hatching. Offspring were reared at 2 levels of food (1500 and 4500 prey litre^{1}) and at 2 temperatures (7 and 11^{0}C). Size at, and survival to, 43 days post-hatch differed significantly among populations, with growth generally increasing with latitude, as predicted by the counter-gradient selection hypothesis. Reaction norms, which describe the way in which genotypes alter their phenotype along an environmental gradient, also differed among populations, providing evidence of a genetic basis to plasticity. Importantly, genetic differences in fitness-related traits were evident at spatial scales at which genetic variation at selectively neutral loci detected no population substructure. Genetic differences in traits directly linked to reproductive success are consistent with the hypothesis of adaptation to environmental conditions at comparatively small scales in Atlantic cod.

Genetic Differences in Body Shape Among Populations of Atlantic Cod (*Gadus morhua*). **Marcil, J.**, D. P. Swain, and J. A. Hutchings. Department of Biology, Dalhousie University, Halifax, NS (paper 5-3)

Abstract

Molecular genetic techniques often fail to detect genetic differences between groups of marine fish. Morphometric characters are subject to selection and therefore may reveal differentiation among populations that would not be evident when looking at neutral characters. However, genetic and environmental components of morphometric variation need to be disentangled in order to use these characters to examine genetic differentiation between populations. The goal of this study was to conduct a common garden experiment on Atlantic cod larvae (*Gadus morhua*) to examine inter-population differences in body shape when reared in common environment. We compared body shape differences of post-metamorphosis cod larvae from four stocks: the Southwest Scotian Shelf (NAFO Division 4X), the southern Gulf of St. Lawrence (4T), Placentia Bay (3Ps), and Bonavista Bay (3L). Mature cod from each stock were collected from the wild and allowed to spawn in laboratory tanks, and their offspring were reared as embryos and larvae in a common laboratory environment. Differences in shape among groups were examined using geometric morphometric techniques on 14 homologous landmarks located on the lateral outline of larvae. We found significant shape differences among populations. These differences suggest that genetic differentiation has occurred between these cod populations, likely reflecting adaptation to their local environments.

Inter-population differences in growth, food conversion efficiency and swimming performance of juvenile Atlantic cod (*Gadus morhua*). **Wijekoon, M.P.A.**, Puvanendran, V., Gamperl, A.K. and J. A. Brown. Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL (paper 5-4)

Abstract:

Latitudinally separated fish populations exhibit variations in growth at age, with larvae and juveniles in the south attaining a larger size at a given age. However, the Counter-Gradient Variation hypothesis predicts that northern populations will grow faster than their southern counterparts. The presence of such variation in growth suggests possible trade-offs with other physiologically important characteristics such as swimming performance and metabolism. We hypothesized that i) Atlantic cod juveniles will exhibit counter-gradient variation in growth and food conversion efficiency ii) Energy and growth maximization of northern populations would trade-off against swimming performance. We compared the specific growth rate, food conversion efficiency and critical swimming speeds (U*crit*) of juveniles from two cod stocks (NAFO Division 3Ps- Placentia Bay, NF. 48°N; 54° W and 4T- Northumberland Strait, P.E.I. 46° N; 64° W), at two temperatures (7^{o}C & 11^{o}C). We found no significant difference in growth, food conversion efficiency, U*crit* or metabolic rate (resting, active or scope) between these two populations. However, 3Ps juvenile showed a trend to grow faster than the southern counterpart (4T) at 11^{o}C (SGR - 1.34 + 0.03 and 1.23 + 0.02 % day^{-1}, respectively). Juveniles from both populations spent more energy on swimming at higher temperature with 4T juveniles having >20% higher metabolic scope for activity over 3Ps juveniles. Understanding the trade-off strategies of energy expenditure between growth and swimming in different populations could be important for fishery management. We will discuss the results based on our knowledge of the ecology of these two cod populations.

Variant Colourations of Atlantic Cod (*Gadus morhua*) in Newfoundland and Labrador Nearshore Waters. Gosse, K.R. and **Wroblewski, J.S.** Ocean Sciences Centre, Memorial University of NL (paper 5-5)

Abstract:

Adult cod (*Gadus morhua*) inhabiting continental shelf waters of the Northwest Atlantic typically display a countershaded colouration pattern: a dark back gradating to a light underbelly. The dorsal and lateral integuments have small, rounded brown spots. Some cod in Newfoundland and Labrador inshore waters have predominant brown or red pigmentation. Cod inhabiting Gilbert Bay in Labrador often have a golden-brown colouration of the fins, the sides and underbelly, and are known in the vernacular as the "golden cod of Labrador". To determine the stability of these variant colourations, we captured cod from Gilbert Bay, held them in a net-pen and fed them a piscivorous diet. Over the 10 week experimental period the variant coloured cod lost much of their red or brown pigmentation due to the reduction of carotenoids in their diet, and became countershaded. Brown or red colouration is expressed by cod foraging on a carotenoid-enriched diet of invertebrates. The brown, red and golden cod of Gilbert Bay are feeding near the base of the food web, as marine plants are the producers of carotenoids.

Life history strategies of Atlantic salmon in Newfoundland. **Gibson, R.J.** Department of Fisheries and Oceans, St. John's, NL A1C 5X1 (paper 5-6)

Abstract:

Atlantic salmon may have anadromous, adfluvial or potamodromous life history strategies. These all are illustrated in Newfoundland waters. Examples of these life history types will be shown, and related to environmental and genetic factors.

Bimodal Run Timing in Sockeye Salmon: Adaptive Life History or Accident of History? **Heath, D.D.** and E. Fillatre. Great Lakes Institute for Environmental Research & Department of Biological Sciences, University of Windsor, Windsor, ON (paper 5-7)

Abstract

Sockeye salmon (*Oncorhynchus nerka)* return to Klukshu River (Yukon) in two distinct runs; a small "early run" in the summer, and a larger "late run" in the fall. The return frequency distribution is significantly bimodal in all years for which data exists. Life history differences (fork length, age at maturity, fresh and saltwater residency times) were found between the early and late runs; however, inconsistent patterns suggest that environmental effects outweigh, or strongly interact with, genetic effects for the life history characters evaluated. Analysis of variation at eight microsatellite loci showed the early and late runs are genetically differentiated in all years examined (Exact test). F_{ST} estimates between runs within years were significantly greater than zero for all years except one. The genetic variance explained by early versus late runs (2.27%) was twice the variance among years (1.16%) based on AMOVA. Our Neighbor-Joining tree showed early and late runs generally clustering separately, indicating higher gene flow among the early or late run fish across years relative to between-run gene flow. An analysis of possible cryptic population structure in early and late runs indicated that at least a few fish strayed between the runs in each year, and the highest rate of mixing was in 1995 and 2000. Our data indicate that the runs are at least partially reproductively isolated due to temporal and/or spatial isolating mechanisms, although no consistent adult life history differences provide little evidence for an adaptive component. However, parentage assignment of yearling juvenile sockeye showed that offspring from early and late run parents utilize different parts of the nursery lake, indicating possible adaptive effects of run timing on juvenile habitat use.

Comparative Life History Variation in Anadromous and Non-anadromous Atlantic Salmon (*Salmo salar*) Populations of Newfoundland. **Adams, B. K.** and J.. A Hutchings. Department of Biology, Dalhousie University, Halifax, NS (paper 5-8)

Abstract:

Life history variation was quantified for anadromous and non-anadromous Atlantic salmon (*Salmo salar*) in the Indian Bay River (sympatric populations) and Northwest River Watersheds (historically allopatric populations, currently sympatric) of Newfoundland. Age at maturity, growth rate, reproductive effort, and mortality rate varied substantially between anadromous and non-anadromous individuals. Non-anadromous individuals matured earlier, had higher survival rates, slower growth rates and lower reproductive effort than anadromous individuals. Non-anadromous salmon abundance was an order of magnitude greater than the abundance of anadromous salmon and displayed significantly different sex ratios in the Indian Bay Watershed. Models of relative fitness suggest that non-anadromous life history strategies have a higher fitness than anadromous strategies under current environmental conditions. Relative productivity and mortality rates of marine and freshwater habitat may influence the relative fitness of anadromous and non-anadromous life history strategies.

Assessing the Reproductive Contributions of Sympatric Anadromous and Freshwater-Resident Brook Charr. **Curry, R.A.** New Brunswick Cooperative Fish and Wildlife Research Unit, Canadian Rivers Institute, Department of Biology, University of New Brunswick, Fredericton, NB (paper 5-9)

Abstract:

Stable isotope analysis of newly emerged alevins was used in the present study to determine if freshwater resident and anadromous contributions to production of age-0 abundance could be assessed in brook trout. The study demonstrates that newly emerged alevins can be useful indicators of origins and therefore contributions of females in mixed population, i.e., residents, anadromous, or immigrants from other streams. The window of opportunity is short because the isotopic signature of alevins changes rapidly. This preliminary assessment of reproductive contribution of females failed to support a predicted increase in alevin production with the presence of anadromous females. Continued research will be necessary to validate the present results toward better understanding their evolutionary significance of anadromy as a strategy in sympatric populations of salmonids.

Early Life Growth of Icelandic Capelin (*Mallotus villosus*). **Olafsdottir, A.**[1], and J. T. Anderson[2]. [1]Department of Biology, Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL, A1C 5S7; [2]Northwest Atlantic Fisheries Centre, Department of Fisheries and Oceans, P. O. Box 5667, St. John's, NL, A1C 5X1 (paper 5-10)

Abstract:

Capelin is a small pelagic fish with a circumpolar distribution in the northern hemisphere and is considered a key stone species in boreal marine ecosystems. The Icelandic capelin stock shows large variations in year-class size at spawning (age 3) which is determined during the first year of their life. Capelin grow quickly during their first summer of their life and the length of post-larvae in August is highly variable between years. Spawning time of Icelandic capelin is known to vary interannually but it is not known to what extent larger post-larvae sampled in August result from faster growth versus earlier spawning. We hypothesize that larger post-larval capelin result from higher growth rates and that this will result in higher survival. Capelin post-larvae were sampled on the Icelandic shelf in August 2001 and 2002. Micro-otolith analysis was used to estimate hatch date, age and growth rate. Capelin in 2001 spawned later and post-larvae in August 2001 were in better condition and growing faster than in 2002. We discuss these results in the context of early life history survival and year-class strength formation of capelin.

Quantifying Inter-individual Variability in Contribution to Year-class Strength in an Iteroparous Fish. **Johnston, T.A.** [1], P. J.v-C. de Groot [2], T. Herra [2], S. Casselman [2], W.C. Leggett [2], J.M. Casselman [3], P.T. Boag [2], and R.M. Montgomerie [2]. [1] Department of Fisheries and Oceans, Burlington, ON; [2] Department of Biology, Queen's University, Kingston, ON; [3] Ontario Ministry of Natural Resources, Glenora Fisheries Unit, Picton, ON (paper 5-11)

Abstract:

The mature portion of iteroparous fish stocks is often composed of a wide variety of age and size classes. Generally, the larger and older females produce more eggs. However, egg quality may also vary substantially among these age and size classes. Thus, the demographics of the adult stock may be as important as the biomass of spawners in determining recruitment. We conducted a controlled breeding experiment with walleye from the Bay of Quinte (Lake Ontario) to determine i) the variability among adults (males and females) in their contribution to cohort strength for a standard quantity of gametes, ii) how the relative contribution to cohort strength varied over time (from hatch to the juvenile period), and iii) how the relative contribution to cohort strength was related to characteristics of the adult fish. We collected 25 males and 25 females from a single spawning site and fertilized measured quantities of their gametes in three batches of unique 1x1 crosses. Adults were analyzed for age, length, growth history, lipid status, and various indices of gamete quality. Fertilized eggs were pooled and incubated in a hatchery jar system. Hatched larvae were stocked into culture ponds and allowed to grow for several months. Qualitative samples of offspring were collected at hatch and at several dates afterwards. The parentage of each offspring was determined by matching the allelic patterns at microsatellite loci with those observed in the adult fish. In this way we could determine the proportion of surviving offspring originating from each adult 1 x 1 cross and calculate the relative contribution of each adult to cohort strength. Analyses are ongoing.

Life in the 'Old Country': Changes in Life History and Growth of a North American Sunfish (*Lepomis gibbosus*) Introduced into Europe. **Fox, M.G.**, G.H. Copp[1] and C.H. May. Environmental & Resource Studies Program and Department of Biology, Trent University, Peterborough, ON; [1]Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Lowestoft, England (paper 5-12)

Abstract:

The pumpkinseed (*Lepomis gibbosus*) was introduced into European waters about 100 years ago. To assess changes in life history and growth in the non-native environment, we compared age and length at maturity, growth rate, and adult body size using new data collected for this study and available data for North American and European populations across their respective native and introduced ranges. Age-specific growth rates were generally lower in European than in North American populations, with populations in England exhibiting some of the slowest growth rates recorded anywhere. Maximum adult body size (as indicated by the von Bertalanffy L_∞) was significantly smaller in European populations. European pumpkinseeds also matured significantly earlier and at a smaller size than native North American populations, even when juvenile growth rates were taken into account. In European populations generally, somatic growth appears to be compromised in waterbodies with limited food resources, probably by strong intraspecific interactions. A dearth of potential predators may also be responsible for slow growth and early maturity of European pumpkinseeds.

Stable Isotope and Tagging Evidence for Resident and Migrant Types of Atlantic Cod (*Gadus morhua*). **Windle, M. J.**, G. D. Sherwood and G. A. Rose. Fisheries Conservation Chair, Marine Institute, Memorial University of Newfoundland, P.O. Box 4920, St. John's, NL A1C 5R3 (paper 5-13)

Abstract:

The movements and biological characteristics of spawning aggregations of cod have been observed since 1997 at the Bar Haven spawning ground in Placentia Bay, Newfoundland. Analysis of condition factor, stomach contents and

seasonal distribution of past spawning cohorts indicate a possible division of this population into "resident" and "migrant" components. To investigate potential residency behaviour in Placentia Bay, isotopic samples were taken from 48 spawning cod tagged in April 2002 as part of a biotelemetric study, and the results of individual fish movements were compared with their respective isotopic signatures. In fish, $\delta^{13}C$ signatures tend to correspond closely to those of their prey, and are typically higher in benthic vs. pelagic food sources. Post-spawning cod migrating to summer feeding grounds have access to a wider variety of prey items relative to resident cod, particularly pelagic species such as capelin. The pooled results of telemetric surveys and returns from the fishery for both 2002 and 2003 revealed that cod located at Bar Haven during the spawning season displayed a wide range of $\delta^{13}C$ values, characteristic of the entire range of benthic and pelagic food types found in Newfoundland waters. Following spawning, only those cod with signatures typical of benthic feeding were either relocated or recaptured in the general vicinity (within 15 km) of the spawning grounds. A genetic analysis of cod sampled in 2001 and 2002 from inshore and offshore locations in NAFO subdivision 3Ps revealed no significant differences between seven microsatellite loci either within Placentia Bay or offshore, suggesting a mixing between both types of cod within a single spawning population. Overall, the tagging results provide physical evidence of residency and migration as suggested by $\delta^{13}C$ analysis, and support the existence of different life-history strategies within the Placentia Bay cod population.

Resource use by salmonids in riverine and lacustrine environments: Evidence from stable isotope analysis. **Jardine, T.D.**[1], D. F. Cartwright[1], J. P. Dietrich[2], and R. A. Cunjak[1]. [1]Canadian Rivers Institute and Department of Biology, University of New Brunswick, Fredericton, NB; [2]Ontario Ministry of Natural Resources, Glenora Fisheries Station, Picton, ON (paper 5-14)

Abstract:

Stable isotope ratios ($^{13}C/^{12}C$ and $^{15}N/^{14}N$) of invertebrates, Atlantic salmon (*Salmo salar*) and brook trout (*Salvelinus fontinalis*) were measured in three distinct freshwater environments (headwater tributary, ultra-oligotrophic lake, and main-stem river) in the Western Brook system, Newfoundland, Canada. Large differences in the stable carbon signatures of invertebrates ($p < 0.001$) from each environment allowed the identification of nutrient assimilation by resident parr ($p < 0.001$) and migrating smolts ($p < 0.001$). Smolts migrating from the fiord lake (with lake stable carbon signatures) were significantly larger than those exiting a nursery stream and the main river in the same catchment ($p < 0.001$), indicating better potential growth opportunities in the lake environment. Brook trout captured in the nursery stream in June had carbon signatures characteristic of the stream, while those collected in August had enriched ^{13}C (maximum = -15.6‰) and ^{15}N (maximum = 12.8‰) values. These enriched carbon and nitrogen signatures were likely indicative of foraging in the ocean. Trout fork length was positively correlated with $\delta^{13}C$ ($r^2 = 0.20$, $p = 0.005$) and $\delta^{15}N$ ($r^2 = 0.52$, $p < 0.005$), demonstrating larger individuals had been feeding outside the stream. These results corroborate previous studies indicating increased growth potential for salmonids in lacustrine and marine environments, and further; indicate possible adaptive advantages for salmonid movement away from natal streams.

Atlantic salmon juvenile emigration strategies and characteristics and subsequent adult returns of Clearwater Brook. **Mathews, M.** and R. Cunjak. University of New Brunswick, Fredericton, NB (paper 5-15)

Abstract:

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

Theme 6 – Climate Change

Impact Of Climate Variation And Storm Dynamics On Capelin Beach Sedimentation, Eastern Newfoundland. **Catto, N.R.** Department of Geography, Memorial University, St. John's, NL (paer 6-1)

Abstract:

Capelin (*Mallotus villosus*) is one of the most important species, ecologically and economically, spawning on nearshore and beach zones in eastern Newfoundland. Along this coastline, the beaches utilized by capelin are marked by wave-dominated, exposed moderate-energy pebble and granule gravel shorelines. Spawning capelin tend to concentrate on well-sorted fine to medium pebble zones, areas of the beaches with gently concave or planar profiles, and seaward-imbricated pebbles. Previous investigations have concluded that higher capelin egg density is associated with beaches aligned towards maximum fetch. Minimal fetch beaches have lower modal energy conditions, are susceptible to terrestrial sediment input, and are less likely to develop gently concave profiles dominated by well-sorted medium and fine pebbles. Beaches marked by modally moderate energy and wave-dominated conditions are more suitable than those with modally higher energies and coarser gravel. Development of these beaches is greatly influenced by storm activity, which steepens beach fronts. Debris transported to the beach derived from terrestrial sources and preferential removal of granules and fine pebbles by storm erosion results in a coarser substrate, producing less favourable conditions for capelin spawning. Climate change predictions for coastal eastern Newfoundland suggest that increases in storm frequency and severity are likely. Increased hurricane frequency and severity would result in decreased spawning suitability. If spawning is delayed until the start of hurricane activity, the net result could be a loss of productivity due to modification of beach habitat. Winter sea ice cover and ice foot development both appear to assist preservation of suitable areas for spawning. In milder winters, when sea ice and ice foot protection is reduced or eliminated, winter storms rework spawning beaches, resulting in coarser, steeper profiles that are less suitable as spawning areas. Years with prolonged sea ice cover that also were marked by effective beach reworking by hurricanes produce conditions less suitable for capelin spawning. Conversely, years with minimal sea ice cover and minimal hurricane activity would produce suitable spawning conditions for capelin.

Impact and Adaptation - Two Sides of One Coin: From Fish Through Fisheries to Fishers. **Minns, C.K.** and Shuter, B.J. Bayfield Institute (GLLFAS), Burlington, Ontario and Ontario Ministry of Natural Resources, Toronto, ON (paper 6-2)

Abstract:

Climate variability has always affected fish, fisheries, and fishers, and human-induced climate change is also beginning to noticeably affect them. The cause-effect chain from climate to fishers has a number of steps each involving linked impacts and adaptations: climate, ecosystems, fish populations, fish communities, fisheries, and fishers. The pattern of responses varies spatially. Climate conditions vary regionally as do the affected ecosystems, fisheries and fishers. This all makes it difficult to develop generic scenarios of impacts and adaptations to guide future decision-making for Canada's aquatic and fishery resources. Major investments in atmospheric and oceanography sciences have progressively improved our national and regional assessment of cause-effect chains in the air and water climates. Meanwhile under-investment in fisheries science is inhibiting a full appreciation of the implications of climate change for Canada's fisheries and identification of management options. Lack of specific knowledge about fish impact-adaptation chains makes it difficult for Canada's fishers, individuals and corporations, to assess potential impacts on their markets and livelihoods, especially when already confronted with closure and reallocation issues. Assessing impact-adaptation scenarios for fisheries is more difficult than for sectors like transportation and built infrastructure because of poorly-known feedback mechanisms at work in nature. An agenda for addressing the current deficiencies is outlined.

Climate Impact and Adaptation Responses of Salmon and Water Managers on the Somass River to the 2002 Fall Drought in British Columbia. **Hyatt, K. D.,** J. Cleland and M. M. Stockwell. Fisheries and Oceans Canada and Canadian Climate Impacts and Adaptation Research Network, Pacific Biological Station, Hammond Bay Road, Nanaimo, BC V9R 5K6 (paper 6-3)

Abstract:

Salmon populations on the southern end of their range are considered to be highly vulnerable to climate warming impacts. Southern British Columbia experienced a severe fall drought in 2002. On Vancouver Island's Somass River, limited water supplies and high temperatures created multiple threats to fish and fisheries associated with natural and cultured populations of salmon. Water supplies and withdrawals are regulated at several locations in the Somass system to meet the needs of fish, industry (hydro, pulp mill, aquaculture facilities) and urban populations.

Review of impact and adaptation responses of fish, fisheries and water managers to the drought indicated the following. Fish experienced delayed migration, delayed spawning, shifts in habitat selection, and decreased survival. Managers responded through emergency retrieval of daily information on resource status and an order of magnitude increase in consultations with stakeholders. The 2002 drought confirmed the vulnerability of major assets in both natural and "built" environments on the Somass and other BC rivers to climate change. Future extremes may dictate negotiation of multiple-asset "tradeoffs" involving significant economic losses. Development of impact models and adaptation options including "standing order responses" to extreme climate events could reduce the magnitude of future water resource conflicts, fisheries management crises and costly litigation in Canada. However, the creation of integrated assessment models and overarching processes to increase our adaptive scope to` climate change outcomes in fisheries will require much greater levels of interdisciplinary and inter-sectoral co-operation than current institutional arrangements produce.

Thermal habitat use by northern lake trout: energetics, production and conservation under climate warming. **Mackenzie-Grieve, J**.[1], Post, J.R[1], Foos, A[2], and D. Toews[2]. [1]University of Calgary, Department of Biological Sciences, Calgary, AB [2]Yukon Government, Department of the Environment, Fisheries Section, Whitehorse, YT (paper 6-4)

Abstract:

Lake trout are among the cold-water species most likely to be affected by climate warming. Previous studies have reported a preferred thermal range of 8 to 12^{o}C within which growth and survival of lake trout are maximized. Other studies suggest a strong correlation between lake trout production and volume of preferred thermal habitat. This study identifies various Yukon lake trout populations at risk from climate warming by considering lake morphometry, current and predicted thermal properties, and proportional changes in fish production with climate warming. Population persistence in terms of lake trout energetics is considered under various temperature and consumption scenarios for our 2 main study lakes. Summer lake trout movement patterns in response to temperature changes within the two main study lakes are also considered.

From Small Scale to Large and Back: Working with Coastal Communities on Climate Change. **D. Schneider**[1] and R. Ommer[2]. [1]Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL A1B 3X7; [2]University of Victoria, Centre for Studies in Religion and Society, PO Box 1700, STN CSC, Sedgewick B110, Victoria, BC V8W 2Y2 (paper 6-5)

Abstract

The concept of scale developed rapidly in the last three decades of the 20th century. Conceptual scale diagrams show the space and time scales of phenomena; these can be extended to institutions and social systems. Instrumental diagrams show the space and time scales of knowledge gathering activity, such as surveys. Space time diagrams are a useful device in developing shared knowledge where both uncertainty and impact on people is high. As an example, we use diagrams to show the process of gathering local ecological knowledge of fisheries, assembling it, taking it back to communities, and then using it to address a management question, that of fish stock status. Coordinated movement of knowledge across scales can be an effective way of working with communities on the problem of climate change.

Linking climate change to fisheries impacts in the BC rainbow trout lakes. **Parkinson, E.** BC Ministry of Water Land and Air Protection, Protection, 2204 Main Mall, University of British Columbia, Vancouver, B.C. V6T 1Z4 (paper 6-6)

Abstract:

The effect of climate change on fisheries can be considered as a chain of events starting with changes in temperature and precipitation patterns which leads to a response in fish populations and a response by anglers to these changes. Considerable uncertainty remains in the first step in this chain: GCM predictions about temperature and precipitation. However, for some fisheries, such as monoculture rainbow trout in southern BC lakes, a combination of ecological, fisheries and mapping data can be used to identify the location and severity of impacts for a range of climate change options. Observations of steep temperature and precipitation clines (associated with elevation) provide empirical evidence for several clearly documented pathways that link ecology of this species to climate change. Rainbow trout are obligate stream spawners, which, combined with water withdrawal for agriculture, makes them especially vulnerable to changes in water supply. Stream requirements can be quantified by comparing the current viablility of population across a range of stream conditions. Current and future water demand can be quantified in terms of permitted water extraction, the location of agricultural land and urban development. Observations across elevation gradients suggest that two of the key effects of climate change on lakes will be

increased eutrophication and winterkill risk. A complete database of all lakes (from a digital watershed atlas) can be used to assess geographic patterns of the balance between increased fish production (eutrophication) versus losses (winterkill and reduced stream flows).

Influence of Climate Change on Patterns of Primary Production, Export and Sustainable Fisheries. **Rivkin, R.**[1], M.R. Anderson[2] and L. Legendre[3]. [1]Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL; [2]Environmental Sciences Section, Oceans Programs Division, Science, Oceans and Environment Branch, Fisheries and Oceans Canada, St. John's, NL; [3]Laboratoire d'Oceanographie de Villefranche, 06234 Villefranche-sur-Mer Cedex, FRANCE (paper 6-7)

Abstract:

Global climate is changing and there is a need to understand the temporal evolution, climate impact, and potential feedback for biogeochemical forcings that influence marine food webs. Climate models generally show that an increase in atmospheric greenhouse species such as CO_2 will lead to changes in atmospheric circulation, and both physico-chemical and biological characteristics of the ocean. The effects on marine food webs are mediated through changes in biogeochemical cycles, and food webs will change in response to alterations in the patterns of circulation, stratification and nutrient delivery. Primary production in the contemporary ocean is ~50 to 55 Pg C y^{-1}, and although this is predicted to increase by <10% in the future ocean, large changes are predicted in both the size distribution of phytoplankton and export of biogenic carbon from the upper ocean. This will alter the flow of nutrients and energy to upper trophic levels, including demersal and pelagic fisheries. Less than 10% of oceanic primary production is harvested (aquaculture and wild fisheries) providing 6% of the global human protein requirement. Climate mediated changes upper ocean biogeochemistry and the structure of lower food web could more than double the fraction of primary production (to 20-25%) being channelled into fisheries harvest. This restructuring of energy flow patterns would potentially have significant and sustained feedback effects on nutrient cycling and ocean biogeochemistry.

The effects of high water temperatures on the physiology and the social behaviour of juvenile Atlantic salmon (*Salmo salar*). **Breau, C.**, R.A. Cunjak and S.J. Peake. Department of Biology, University of New Brunswick, Fredericton, NB (paper 6-8)

Abstract:

During high heat events, rivers can reach temperatures (>26ºC) that are potentially lethal for salmonid fishes. In such thermally marginal habitat, fish can regulate body temperature behaviourally either by adjusting their activity rates or moving to cooler areas. Previous studies have indicated that behavioural thermoregulation is a means by which fishes cope with high temperatures. Preliminary work on juvenile Atlantic salmon in the Miramichi River (NB) has shown that parr abandon territorial behaviour to aggregate near available cool water sources (e.g. springs, cooler brooks) and hold position in the water column. There were also differences among age-classes at high temperatures: 2+ parr were the first fish aggregating, followed by 1+ parr. Interestingly, the 0+ fry did not aggregate at high temperatures. Given that these behaviours (aggregating and swimming in the water column) are observed during periods of high temperature stress, it is of particular interest because of the high energetic costs required to sustain them. We examined the physiological and behavioural mechanisms involved in fish aggregation under both field and laboratory conditions. Implications for fishes in the wild will be discussed.

Identifying and separating impacts of climate change and anthropogenic effects on the distribution and abundance of small, pelagic fish in British Columbia (BC), with a focus on herring and eulachons. **D.E. Hay**, P.B. McCarter and K. Daniel. Fisheries and Oceans Canada, Pacific Biological Station, 3190 Hammond Bay Road, Nanaimo, BC V9R 5K6 (paper 6-9)

Abstract

Pacific herring spawn in shallow (<10m) nearshore waters. Fisheries staff have collected detailed records of the timing, size and distribution of spawns in BC since 1930. During this time a major fishery for meal expanded, to over 250 kt/year, before stocks collapsed in the 1960's. Stocks recovered and a new, but more modest fishery for roe started in the early 1970's. In general, throughout these changes, the amount of spawning reflected stock abundance but many local and regional changes in the timing and distribution of spawn have occurred, including cessation of spawning in some areas. Such instances have alarmed local observers who attributed the local cessations of spawning to a serial depletion of local stocks in the roe fishery. We examined this issue by a detailed review of the locations and timing of fisheries relative to spawning areas – but found no evidence of serial depletion by fisheries – rather spawning has stopped in many areas without fisheries and continued (and increased!) in areas

with fisheries. There are, however, other plausible explanations for the changes. We show that, in general, herring spawn earlier, and in slightly more northern positions in warmer years than colder years. The effect of such change is that in some regions, such as the Strait of Georgia, herring spawn locations shift, so some changes in spawn distribution can be attributed to inter-annual or short-term climate change. The implications for longer-term change are not clear. Another major factor affecting herring distribution and abundance is predation by pinnepeds, and especially by harbour seals (*Phoca vitulina*), that have increased tenfold in the last 30 years. The coastal waters of BC now have the highest density of harbour seals in the world – with over 11 seals per linear km of coast. The total predation by seals on herring may be >10 kt/y, but this is small relative to total biomass (>100 kt) in 2003. On the other hand, herring consist mainly (>80% by biomass) of migratory stocks that mingle with non-migratory stocks, that usually spawn later and in different areas than migratory fish. Migratory herring reside in nearshore waters for < 5mo/y (about 4 months for over-wintering and spawning, so their vulnerability to seal predation is limited but the smaller resident stocks are vulnerable all year. Therefore resident herring could be subjected to a much higher predation rate by seals than migratory herring – with the consequence that in some areas, resident herring could be continuously grazed down – and this would explain both the apparent disappearance of some local herring stocks and the observed changes in spawn timing and distribution.

Adapting to Climate Variation and Change: Issues for Aquaculture, Fisheries And Fisheries Communities. **Johannes, M.**, Fisheries Sector: Canadian Climate Impacts and Adaptation Research Network, Pacific Biological Station, Fisheries and Oceans Canada, 3190 Hammond Bay Rd., Nanaimo, BC, V9T 6N7 (paper 6-10)

This presentation briefly summaries how the aquaculture and fisheries industry and coastal communities are impacted by climate change predictions of warming. To improve predictions of climate change "impacts" on future resource productivity and on communities will require more effort and greater refinement of prediction on climate variation and change and vulnerabilities to change experienced by industry and communities. As an immediate response, a second "adaptation" approach can be used to reduce risk and help capitalize on benefits to industry and fisheries communities by assuming and preparing for adverse effects of climate change; this approach defines vulnerability to climate change and develops anticipatory adaptation in industry expenditures, resource use and future expectation. Adaptation to climate variability and change can be used to adjust practices, processes, management and structures of systems based on projected changes in climate. Early adaptation to climate change can assist in adjusting human expectations to sustainable use and development of aquaculture fisheries resources.

Theme 7 – Marine Biodiversity

Genetic differentiation among inshore and offshore Atlantic cod (Gadus morhua) of Newfoundland and Labrador. **Ruzzante, D.E.**[1], Taggart, C.T.[2], and Cook, D.[1]. [(1)] Department of Biology, and [(2)] Department of Oceanography, Dalhousie University, Halifax, NS, B3H 4J1 (paper 7-1)

Abstract:

Studies conducted during the 1990s on the genetic composition of Atlantic cod (Gadus morhua) in the Northwest Atlantic contributed to a shift in the general perception of the extent and role of spatial structure and connectivity in marine organisms. It is now recognized that there is more spatial structure in the North West Atlantic cod complex than was thought before and during the fishery collapse in the early 1990s. We will present new evidence of genetic differentiation based on 7 microsatellite loci among 560 cod collected from 11 inshore and offshore locations in Newfoundland and Labrador, from Fortune Bay in the south to NAFO divisions 2J and 2G off Labrador. The mean F_{ST} estimate overall loci is 0.01 when all 11 locations are examined. Most of the differentiation appears to be caused by the offshore samples collected off Labrador (NAFO Divisions 2J and 2G) which also differ from each other. Although overall genetic differentiation is lower when offshore Labrador collections are excluded from the analysis, important genetic differences remain among Newfoundland inshore and offshore collections. These results will be discussed in light of known migration patterns and published genetic data for cod in this region.

Phylogeography and Population Structure of the Atlantic Wolffish, *Anarhichas lupus*. **McCusker, M.R.**, Schweitzer, A., McPherson, A., and P. Bentzen. Department of Biology, Dalhousie University, Halifax, NS (paper 7-2)

Abstract:

The Atlantic wolffish, *Anarhichas lupus*, has experienced population declines of more than 90% over the last 25 years, and is currently listed as “special concern” by COSEWIC. Though once targeted in commercial fisheries, this species is now mainly caught as by-catch. Like the other two species of wolffishes in the Atlantic Ocean, the

Atlantic wolffish is thought to have a relatively sedentary, demersal life history with low dispersal rates, leaving it vulnerable to bottom fishing and habitat degradation by trawl nets. Understanding the population structure of Atlantic wolffish would be an important first step in designing appropriate management and conservation strategies. Little is currently known about the species, although given its life history traits, relatively rich population structure is expected for a marine species. Here, we present preliminary findings on the phylogeography and population structure of the Atlantic wolffish using both mitochondrial and nuclear DNA markers.

Marine Sponge (Phylum: Porifera) Biogeography and Ecological Function in the Northwest Atlantic: An Overview. **Fuller, S.D.**, Department of Biology, Dalhousie University, Halifax, NS (paper 7-3)

Abstract

Marine sponges are among the most widely distributed sessile species in the marine environment. There has been relatively little scientific investigation of these animals in the Northwest Atlantic. Data from trawl surveys, observer records, video transects of the seafloor and interviews with fishermen are compiled to illustrate the biogeographical distribution of sponge "hotspots" in the Northwest Atlantic. The role of these organisms as ecosystem engineers is reviewed, through the compilation of existing literature and recent field work. Sponges contribute to the topographical complexity of the benthos and provide habitat and shelter from predation for many invertebrate and vertebrate species.
An increased level of monitoring and quantification of trawl survey collections of marine sponges would result in significant progress in sponge research in the Northwest Atlantic.

Multi-Decadal Changes in the Megabenthos of the Bay of Fundy. **Kenchington, E.**, Gonzalez, P., Kenchington, T. J., Henry, L.-A. and S. D. Fuller. Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth, NS (paper 7-4)

Abstract:

The invertebrate fauna collected in scallop dredges in the Bay of Fundy was first described by Caddy taken from tows in 1966 and 1967. Three decades later a comparable data set was prepared from a 1997 scallop survey using similar gear. We constructed a common data set of 35 long-lived megabenthic (i.e. > 10 mm) taxa that were recorded in both periods from an area off Digby, Nova Scotia. Species that were not recorded at all in either period were excluded. Mean number of species per tow was significantly higher in 1997. A Bray-Curtis similarity matrix was constructed and an Analysis of Similarity (ANOSIM), a nMDS ordination and an UPGMA cluster analysis were performed, all using presence/absence data. The cluster and ordinations showed a separation of the two time-periods. ANOSIM found this difference to be significant, explaining 38% of the variance in the data. Thirteen taxa contributed to 50% of the dissimilarity between periods. In 1966/67 only four taxa (the sabellid fan worm *Pseudopotamilla reniformis*, the bivalve jingle shell *Anomia* spp., the tunicate *Boltenia* ovifera and the boring sponge *Cliona* spp.) occurred in 75% or more of the tows, while the similarity among tows was 54.4%. In contrast, the similarity among the 1997 tows was 69% while 11 taxa each occurred in more than 75% of the tows, indicating that the distribution of the fauna has become more homogeneous. Whelks, crabs, starfish and brittlestars were the most ubiquitous. Dramatic changes in the distribution of some species were noted. Two bivalve *Astarte* spp., the crabs *Hyas* spp., ophiurid brittlestars, the whelk *Buccinum undatum* and the bivalve *Cyclocardia borealis* became more widespread over the decades, while *Boltenia ovifera*, *Modiolus modiolus* and *Pseudopotamilla reniformis* were much less frequent. The biological traits associated with these species and changes that might account for the differences are discussed.

Fishing disturbance and marine biodiversity: the role of habitat structure in simple soft-sediment systems. **Ellis, J.**, Thrush, S., Hewitt, J., Funnell, G., Cummings, V. and A. Norkko. National Institute of Water and Atmospheric Research, PO Box 11-115, Hamilton, New Zealand (paper 7-5)

Abstract:

Broad-scale anthropogenic disturbances such as trawling and dredging activities that reduce the density of epifauna and homogenise surficial sediments can have important consequences for seafloor biodiversity. We investigated both habitat structure and macrofaunal diversity of relatively simple soft-sediment habitats over a number of spatial scales (cm to km) to identify the role of habitat structure in influencing macrobenthic diversity and to assess the validity of using habitat structure as a surrogate for measuring biodiversity. We sampled 10 locations with differences in habitat structure using a sampling design that nested macrobenthic core samples within videoed transects of the seafloor. We characterised elements of habitat structure based on direct counts of surficial sediment characteristics and the presence of other immobile features, many of which were biogenic in origin. Using

multivariate techniques (relative multivariate dispersion, mean and range of Bray-curtis dissimilarity) we found a positive relationship between habitat structure and macrofaunal diversity. The results suggest that removal of habitat structure even in relatively low-structure soft-sediment systems will significantly decrease their biodiversity, and consequently that of the wider marine ecosystem.

Bentho-Pelagic Coupling: Does Quality, Quantity and Diversity of Food Supply Influence Infaunal Biodiversity? **Kelly, M.C.** and P.V.R. Snelgrove. Ocean Science Centre / Department of Biology. Memorial University of Newfoundland. St. John's,NL (paper 7-6)

Abstract:

Regulation of sedimentary biodiversity patterns is a topic of heated debate that has generated considerable theoretical discussion in the absence of much experimental data. Using an *in situ* experimental approach we are investigating the role of food supply in establishing infaunal patterns and maintaining biodiversity in sub-arctic sedimentary ecosystems. Food supply for most benthic communities is provided by sedimenting particles from the overlying water column. In temperate latitudes this supply varies temporally in amount and composition of sinking particles (e.g. spring bloom). Three facets of food supply were investigated: quality, diversity, and quantity. Natural sediment was enriched artificially *in situ* by divers at a depth of 20 m, creating patches containing no enrichment, enrichment with a monoculture of concentrated algae, or enrichment with an algal mixture. For quantity experiments, patches were created having a high, low and control treatment. The patches were sampled 1 week and 5 weeks after enrichment and sorted for macrofauna. We hypothesized that a mixed enrichment would affect a broader diversity of colonizers and that different enrichments would attract different colonizers. Preliminary analyses, using higher taxonomic groupings, reveal that enriched patches show no clear response when compared to (unenriched) control patches, and that different patch types did not attract different colonizers. Finer taxonomic resolution may alter this interpretation but it is possible that food limitation is not an issue in this seasonal, highly productive system.

Non-Coherence in Biodiversity Patterns in Ichthyoplankon and Zooplankton Assemblages. **Snelgrove, P.V.R**., Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL A1K 1A7 (paper 7-7)

Abstract:

Ichthyoplankton assemblages are highly variable in time and space, but the nature of this variability is not well understood. Analysis of seasonal ichthyoplankton and zooplankton surveys in a Newfoundland coastal embayment over multiple years indicates that although individual species patterns show some level of temporal and spatial repeatability, assemblages are extremely dynamic and do not appear to represent distinct communities. Biodiversity varied in space and in time, indicating that specific geographic areas did not provide biodiversity "hotspots". Comparisons with zooplankton communities indicated no clear relationship between zooplankton diversity and ichthyoplankton diversity either spatially or temporally, however, during periods when the bay was physically structured there was a significant relationship between zooplankton abundance and ichthyoplankton diversity. Although there is some spatial and temporal coherence between ichthyoplankton and zooplankton assemblages, the relationship is neither species specific nor consistent in terms of diversity pattern.

The Utility of Taxonomic Pooling in Experimental Studies of Marine Benthic Diversity . **Quijon, P.A.** and P.V.R. Snelgrove. Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL A1K 1A7 (paper 7-8)

Abstract:

Given the difficulty and time involved in species-level identifications, several authors have proposed the use of species groupings (e.g. Families) as surrogates in exploratory studies of marine benthic diversity. Their studies are supported by extensive surveys (~1000s m) showing that surrogate patterns correlate well with species- patterns without the lost of significant amounts of information. Despite the strength of these results, two questions arise: Are species- surrogate relationships verifiable at smaller spatial scales, particularly, at the scales typical of field experiments (~10-100s> m)? If so, is the use of surrogates applicable to analyses of processes structuring benthic communities? We address both questions by analyzing results of experiments testing for predator regulation on benthic communities of Bonne Bay, Western Newfoundland. We pooled species data into higher functional groups and taxonomic (family) categories and determined whether effects of predation that were evident at the species level were also evident with the use of surrogates. As expected, our results vary according to type of surrogate and experiment (inclusion or exclusion), with families and functional groups reflecting at different degrees the results gathered using species- level data, suggesting that use of high taxonomic groups involves advantages and problems. The three sets of results and their further interpretation are discussed in relation to surrogate utility.

The Atlantic Reference Centre: Resource for Canadian Atlantic Biodiversity Information. **Van Guelpen, L.V**., G. Pohle, A. Martin, and M. J. Costello. Atlantic Reference Centre, The Huntsman Marine Science Centre, 1 Lower Campus Road, St. Andrews, NB E5B 2L (paper 7-9)

Abstract:

The Atlantic Reference Centre (ARC) is a research museum of Canadian Atlantic marine biota and a provider of regional marine biodiversity information. Computerization of all catalogued material has been accomplished through museum catalogue database restructuring and various funding programs. Because of its value as an archive of marine biodiversity data, concurrent ARC goals have been to place the database on-line and to use it for developing a species information system, or SIS, for Canadian Atlantic marine biota. This system is an evolving entity of products, often collaborative, and funded by various biodiversity information initiatives. The ARC SIS is currently comprised of specimens and catalogues; on-line sites with querying, mapping and analysis capability for each museum taxon, or displaying images, information, and a distribution map for each Canadian Atlantic fish species; a comprehensive list of all species inhabiting the Bay of Fundy, supplemented with substantial species information; a list and classification of all fish species in Canadian Atlantic waters; an on-line site integrating the biodiversity databases of the ARC and other providers with DFO physical and biological databases, into a biodiversity atlas service; and funding to 1) place ARC fish records on Species Analyst Canada, 2) develop a comprehensive Canadian Atlantic marine biodiversity register, 3) develop a web site for the Bay of Fundy species information system, and 4) perform quality assurance and quality control of the ARC museum database, thus improving data quality in the SIS. Future plans include collaboration with LarvalBase and FishBase in 2003-04, and expansion of the Canadian Atlantic marine biodiversity register. The ARC SIS will aid students, educators, researchers and managers in studying, protecting, and promoting the sustainable use of Atlantic Canada's natural resources.

General Contributed Papers

Verification and refinement of an electrofishing catch-per-unit-effort (CPUE) method used to assess juvenile Atlantic salmon abundance. **Peterson[1], D.P.**, D. Moore[2], and R.A. Cunjak[1]. [1] Department of Biology, University of New Brunswick, Fredericton, NB; [2] Fisheries and Oceans Canada, P.O. Box 5030, Moncton, NB (paper G-1)

Abstract:

Electrofishing CPUE methods to assess juvenile Atlantic salmon abundance are commonly employed to more efficiently allocate effort so that sample size and spatial extent of surveys can be increased, thus providing a more reasonable picture of spawning success or potential smolt production than intensive sampling at a few locations. This method typically involves derivation of a CPUE versus abundance regression relationship (predictive model I regression) based on a few sites, which is then applied to many sites. Results based on this regression are often described as 'semi-quantitative', because error associated with the independent variable (abundance) and the predicted value are commonly ignored. A similar electrofishing CPUE method has been used for over a decade to monitor abundance of juvenile Atlantic salmon in the Miramichi River system (NB), but its performance as quantitative estimator relative to traditional depletion electrofishing sampling is unknown. Our goal was to evaluate the relative performance of the CPUE method versus depletion methods across habitat sizes (stream order 2-5), and determine how relative bias (if present) varies between fry and parr. In addition, we explored how including environmental covariates in the CPUE model influenced its predictions.

The Effects of Predatory Threat and Temperature on Energy Acquisition in Newly Hatched Ocean Pout (*Macrozoarces americanus*). **Killen, S.S.** and J. A. Brown. Memorial University of Newfoundland, Ocean Sciences Centre, St. John's NL A1C 5S7 (paper G-2)

Abstract:

Previous research has shown that larval fish will decrease foraging activities in exchange for predator avoidance behaviors while in the presence of a predatory threat. In most of these studies, however, larvae are exposed to acute pulses of predatory threat of short duration. As a result, there is little known about the long-term impacts of predatory threat on development in newly hatched fish. In the present study, newly hatched ocean pout (*Macrozoarces americanus*) were visually exposed to predatory juvenile Atlantic cod (*Gadus morhua*) for approximately 8 hrs per day during the feeding period. Pout that were exposed to predators during feeding displayed differences in space usage within the experimental aquaria, with a greater proportion of individuals moving away from the predatory threat and/or making use of provided cover. When reared at 3^{o}C, 7 week-old pout not exposed to predators were significantly larger, and had a higher hepatosomatic index than those that were exposed to predators. Pout exposed to predators also had lower levels of whole-body phospholipids and

triacylglycerol, as well as decreased levels of certain essential fatty acids. Interestingly, there were no differences in size, hepatosomatic index, or lipid content between the two treatments when the experiment was performed at 8°C, despite a decrease in foraging activity among the pout exposed to predators. These results suggest that frequent predatory threat can affect the development of newly hatched fish, and that temperature is an important factor when performing laboratory experiments examining threat-sensitive foraging.

Stomach Temperature Telemetry Reveals Temporal Patterns of Foraging Success in a Free-Ranging Marine Mammal. **Austin, D.**, W.D. Bowen[2], J.I. McMillan[2] and D.J. Boness[3]. [1]Department of Biology, Dalhousie University, Halifax NS, B2H 4J1; [2]Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmouth NS; [3]Smithsonian Institute, Washington DC (paper G-3)

Abstract:

Despite rapid growth in our knowledge of marine mammal diving behaviour and diet, we still know little about the frequency of successful feeding in these top predators. Yet, variation in temporal distribution of feeding can have significant implications for how predators perceive the patchiness of prey. We studied feeding success in free-ranging grey seals (*Halichoerus grypus*) using stomach temperature telemetry from 1999 to 2001. Given that body temperature of prey fish in the marine environment is colder than that of core temperature in endothermic predators; ingestion should result in a predictable drop in stomach temperature. Data were retrieved from 21 of 32 animals (12 males, 9 females) totalling 338 d, with individual record length varying from 2 to 46 d. Both the number of animals and the duration of sampling represent the first opportunity to use such data in a quantitative analysis of foraging. A total of 583 putative feeding events were identified and records averaged 15.1±2.3 [SE] d. Successful feeding events occurred in an average of 59.5±6.4% of days. The mean number of successful events per day was significantly greater in males (2.5±0.4) than females (1.1±0.2, P=0.02). Similarly, the average time associated with successful feeding per day was significantly greater for males (111±23 min) than females (52±10 min; t-test, P=0.05). The time between feeding events in males (483.4±54.58 min) was significantly less than females (932.8±115.27 min; P<0.001). Further, the amount of time associated with feeding throughout the day differed significantly between the sexes (Repeat Measure GLM, P=0.02), with females less likely to feed during early to mid-morning. The time between feeding events was positively skewed (P=0.001) indicating that successful feeding was highly clustered in both sexes. A significant temporal pattern of feeding was found in 54% of seals (Runs Test, P<0.001). These results provide new insight as to the basis of sex differences in foraging behaviour in this size dimorphic species. Given that temporal distribution of predation introduces heterogeneity in prey mortality, this may provide valuable insight into prey community dynamics.

Habitat Selection and Early Winter Movements by Juvenile Atlantic Cod (*Gadus Morhua* L.) in a Coastal Area of Newfoundland. **Cote, D.[1]**, D.A. Scruton[2], and R.S. McKinley[3]. [1]Terra Nova National Park of Canada, gen. del. Terra Nova National Park, Glovertown, NL, Canada, A0G 2L0, [2]Fisheries and Oceans Canada, P.O. Box 5667, St. John's NL, A1C 5X1, [3]Centre for Aquaculture and the Environment (CAE), 123-2357 Main Mall, University of British Columbia, Vancouver, BC V6T 1Z4 (paper G-4)

Abstract

Acoustic telemetry was used to monitor the movements and landscape scale habitat use of age 2-3 juvenile Atlantic cod in Newman Sound, a coastal fjord of Newfoundland, during late autumn and early winter (24 October, 1999 to 22 January, 2000). Substrate, bathymetric relief and depth use were studied to determine if it differed from the pattern expected given an absence of selectivity (habitat use proportional to habitat availability). Prior to winter migrations, most cod maintained small home ranges (0.5-33.4 ha, median = 2.1 ha) although a few individuals moved more widely. No relationship between body length and home range size was detected. In inner Newman Sound, cod occupied depths of 10-30 m more than expected given availability, while depths of 0-9 m and 40-59 m were underutilized. No significant relationship between depth and size of fish was detected. Areas of medium (5-10°) or high (> 10°) bathymetric relief and boulder or kelp habitats were used significantly more than expected given the availability of these habitats. Sand and eelgrass substrates were underutilized given availability, although many cod used sandy-bottomed areas to some degree. Flexibility in habitat use by study individuals suggests reduced predation risk relative to younger conspecifics. Winter migrations to deeper water beyond Newman Sound began in mid-November, coinciding with the disappearance of the thermocline, and continued until 21 December. Approximately 30% of monitored individuals did not migrate and maintained their home ranges into the winter season. No significant differences in length between migrating and resident groups were detected, however the condition of migrating fish was significantly higher than in resident fish. This finding supports a previous suggestion that feeding history plays a role in the decision to undertake migration.

Discrimination of Coregonid Fishes in Maritime Canada. **Hasselman, D.J.** and R.G. Bradford. Marine Gene Probe Lab, Biology Department, Dalhousie University, Halifax, NS (paper G-5)

Abstract:

The Atlantic whitefish (*Coregonus huntsmani*) is an endangered species endemic to Nova Scotia. Historically, Atlantic whitefish have been difficult to distinguish from the closely related lake whitefish (*C. clupeaformis*), despite claims that several morphological characters can be used to reliably discriminate between them. The distribution and genetic relationships of coregonid populations in the Maritimes is ambiguous, due to past stockings of Nova Scotia's lakes with coregonids of Great Lakes origin, diversions among water bodies, and incomplete surveys of lakes in the Maritime Provinces. A reliable classification method to assess the existence/non-existence of Atlantic whitefish and lake whitefish populations in the Maritimes is required. To this end, morphometric and meristic characters from archival and recently obtained Atlantic whitefish and lake whitefish specimens were used in discriminant function analysis to test the robustness of the Atlantic whitefish typological description, to identify diagnostic external characters between these species, and to explore the phenetic variability of lake whitefish populations in the Maritimes specifically. The Atlantic whitefish typological description partially discriminates, while three external characters (i.e. adipose fin base length, pectoral fin length, and nare diameter) completely separate archival Atlantic whitefish and lake whitefish specimens. However, lateral line scale counts should be used to differentiate these species because of the ease of evaluation, and reliability of this feature. Lake whitefish in the Maritime Provinces express much phenetic variability, some of which may reflect differing trophic status of various populations. Based on observations of Maritime lake whitefish phenetic variability, inferences can be made to explain the historically limited geographic distribution of Atlantic whitefish.

Predicting Life History Traits of Yellow Perch From Relationships With Environmental Variables. **Purchase[1], C.F.**, N.Collins[1], B. Shuter[2], and G. Morgan[3]. [1] Department of Zoology, University of Toronto at Mississauga; [2] OMNR & Department of Zoology, University of Toronto; [3] Co-operative Freshwater Ecology Unit, Department of Biology, Laurentian University (paper G-6)

Abstract:

Although the yellow perch (*Perca flavescens*) is widely studied, knowledge of factors affecting its life history is limited. I examined sex-specific life history variation among 72 populations of yellow perch from Ontario, Canada. All life history traits of yellow perch varied 2 – 3 fold among populations. The relationship between specific life history traits to environmental variation was generally the same for males and females. Early growth rate was positively related to lake surface area, while relative density was positively related to growing degree days and total dissolved solids. For both sexes, maximum body size was positively related to lake surface area, and negatively related to growing degree days. Additional variation was explained by a positive relationship with water hardness in females, but this was not significant for males. Relatively high numbers of large yellow perch are predicted to occur in medium to large size lakes in hard water areas with climates like those of north-central Ontario. Climates like those of southern Ontario are predicted to produce high numbers of yellow perch, but only large lakes in hard water areas have the potential to generate large fish.

Individual Movement of Passive Intregrated Transponder (PIT) Tagged Slimy Sculpin, *Cottus cognatus*, in Small, New Brunswick Streams. **Keeler, R.A.** and R. A. Cunjak, Department of Biology & Canadian Rivers Institute, University of New Brunswick, Fredericton, NB (paper G-7)

Abstract:

This study was conducted to investigate aspects of the mobility of the slimy sculpin, *Cottus cognatus*, a small benthic fish common to Eastern Canadian waters. 12 mm passive integrated transponder (PIT) tags were surgically implanted in a total of 245 adult sculpin (>60mm in length) in 6 second order tributaries of the Kennebecasis River, New Brunswick. Sculpin were tagged in June 2003 and were tracked repeatedly over the summer and fall with a portable PIT tag antenna to determine the location of individuals. The portable antenna was 76-97% effective in detecting sculpin within the site. The detection efficiency of the antenna was related to duration of tracking event, number of sweeps per site and habitat complexity. Approximately 70% of the sculpin at each site were detected at least once during the study period. Greater than 65% of the sculpin moved <5m throughout the summer months; similar site fidelity was noted in the fall. Therefore, adult slimy sculpin appear to display limited mobility during the summer and fall period. Effects of water temperature, sculpin density and habitat complexity will be discussed as they influenced movement patterns.

Graphical decision analysis: Applications to Porbeagle shark harvests and Atlantic cod interactions with harp seals. **Hatton, I.**, McCann, K, Umbanhowar, J. Department of Biology, McGill University, Montreal, PQ (paper G-8)

Abstract

The depletion of a great many conventional fish stocks is urgent testimony for fisheries management to evaluate risk and uncertainty in an interpretable manner. We propose a novel decision based approach to time-series analysis that explores the spectrum of alternative trajectories as conveyed throughout the surplus production state space. Each of the various trajectories can be formulated into hypotheses covering different important biological and economic states of the fishery, and rigorously evaluated. The approach is first applied to the porbeagle shark fishery in the Northwest Atlantic. We consider how the vulnerable life history traits of porbeagle may alter our assumptions about population productivity, having potentially severe implications for current Canadian harvesting. The approach is extended further into the ecological realm by considering how community interactions between Atlantic cod and harp seals can be represented in state space over the past two decades. Our results demonstrate that harvesting was likely the cause of the collapse of the fishery, and that this was detectable well before the cod moratorium in 1992. Further analyses suggest that seals are the more likely cause that cod has yet to recover.

Minimizing error in model estimates of consumption and activity for wild fish populations. **Rennie, M.D.**, Collins, N.C., Henderson, B., Shuter, B. Department of Zoology, University of Toronto, Toronto, ON (paper G-9)

Abstract:

Contaminant accumulation models are increasingly used to estimate bioenergetics of fish populations. Often, required inputs for these models – namely growth and contaminant accumulation in fish and their diet – are estimated rather than measured directly. Using a methylmercury (MeHg) accumulation model, I demonstrated that certain methods for estimating these inputs can result in significant error in estimates of consumption and activity. I identified three key components in minimizing this error: First, input estimates based on data collected late vs. mid-summer were less variable. Second, seasonal patterns in fish dietary MeHg were identified; thus, seasonal estimates of dietary MeHg were biased compared to annual estimates, which translated into biases around estimates of consumption and activity. Last, MeHg accumulation in fish estimated as the difference between adjacent cohorts from a single sample may not reflect actual Hg accumulation patterns over the course of a year.

An application of generalized linear model in production model and sequential population analysis. **Jiao, Y.**[1], Chen, Y.[2] and Wroblewski. J.[3] [1]Biology Department, Memorial University of Newfoundland, Newfoundland, Canada, A1B 3X9; [2]School of Marine Science, University of Maine, Orono, ME 04469, USA; [3]Ocean Science Center, Memorial University of Newfoundland, NL (paper G-10)

Abstract:

Errors in fitting production models and age-structured models are usually assumed to follow a lognormal or normal distribution without an error diagnostic analysis evaluating the assumption made on the error structure of the models. Generalized linear model, which can readily deal with different error structures, was applied to assessing the Atlantic cod (*Gadus morhua*) 2J3KL using a production model and a sequential population model. This study suggests that the quality of the parameter estimation in both the models can be influenced by the realism of error structure assumed in the estimation. This study identified lognormal and gamma distributions as appropriate model error structures for the production model and gamma and Poisson distributions for sequential population model in assessing the Atlantic cod 2J3KL stock. We recommend that the generalized linear model be used to identify the appropriate model error structures in quantifying fisheries population dynamics using production models and sequential population models.

Information Use In Commercial Co-Management: Surveys And Snow Crabs. **Gillis, D.M.**[1], E. Wade[2], and D. Swain[2]. [1] Department of Zoology, University of Manitoba, Winnipeg, MB, R3T 2N2. [2] Gulf Fisheries Center, Department of Fisheries and Oceans, Moncton, NB, E1C 9B6 (paper G-11)

Abstract:

Throughout the 1990's, the Gulf of St. Lawrence Snow Crab harvest provided an example of effective co-management in a developing fishery. The Department of Fisheries and Oceans, Canada (DFO) and the snow crab fleet (the fleet) shared information that coordinated management and exploitation throughout the season. Annually, the fishery progressed in stages: 1) Scientific Survey (DFO), 2) Analysis (DFO), 3) Distribution of results to the Snow Crab fleet, 4) In-season monitoring of harvest, and 5) local (10' square) in-season fishery closures corresponding to conservation concerns. Information was bi-directional in this fishery. The survey data allowed the fleet to see the most recent resource distribution prior to the fishery's opening. In-season data allowed managers to track spatial and temporal variation in crab availability. The level of detail provided by this system allows the test

and application of behavioral hypothesis, such as the ideal free distribution, as management and conservation tools. However, the full potential of this data is still being developed. In this paper, we examine information use through the relationship between fleet distributions and survey data throughout the 1990s and early 2000's. Geostatistical analysis of annual survey data is used to represent the resource information provided to the fleet at the beginning of the season. Commercial landings data localize fishing temporally and spatially. As the fishery progresses, gear is moved due to reductions in local abundance that result from harvest and possible crab movements. Based upon preliminary analysis, it appears that survey information is followed more closely in the early season when higher catch rates correspond to more aggregated fishing activities. However, this relationship breaks down as the season progresses. More random and even locally uniform distributions of fishing activities suggest a progression toward greater reliance on personal information and exploratory fishing. In such cases the ideal free distribution no longer applies; its assumption of 'perfect information' is severely violated. We develop methods that focus on using geostatistical and point-pattern spatial analyses to distinguish between periods when public and personal information dominate effort distributions.

Development of a trap to exclusively target Jonah crab (*Cancer borealis*) in near shore Gulf of Maine. **Reardon, K.**[1] and C. Wilson[2]. 1. School of Marine Science, University of Maine, Orono, Maine, USA; 2. Maine Department of Marine Resources, Boothbay Harbor, Maine, USA (paper G-12)

Abstract:

Jonah crab (*Cancer borealis*) has been a traditional and unregulated by-catch of the Maine lobster fishery over time. In recent years landings and value have rapidly increased. An increasing number of fishermen are targeting Jonah crabs with lobster traps in off-peak lobster seasons. In 2000, fishermen approached the Maine Department of Marine Resources (MEDMR) interested in exempting a trap, from current lobster fishery regulations, to exclusively target Jonah crab. An experiment is now in the second of three years to develop a federally exempted crab trap (from the Maine Lobster Trap Tag Program) to directly target the Jonah crab. Fishery-dependent information is being collected to estimate rates of by-catch in experimental traps and to begin to estimate key life history and fishery parameters that may help determine the suitability of a targeted fishery on Jonah crabs.

Lipid and non-esterified fatty acid profiles in the plasma of North Atlantic cod (*Gadus morhua*) from Newfoundland. **Alkanani[1], T.**, K.J. Rodnick[2], K. Gamperl[1], and C.C. Parrish[1]. [1]Ocean Sciences Centre, Memorial University; [2]Department of Biological Sciences, Idaho State University (paper G-13)

Abstract:

Mass production of cod requires an understanding of lipid nutritional requirements as well as their metabolism. We examined how food deprivation affects plasma lipid and non-esterified fatty acids (NEFA) levels/profiles in wild Atlantic cod (*Gadus morhua*) from Newfoundland. Plasma total lipid concentrations were significantly lower in cod deprived of food for 8-10 weeks at 10 ^{o}C, although the profile of lipid classes was more or less similar for both groups. The level of triacylglycerol (TAG) was, on average, reduced by 99% in food deprived cod compared to fed cod, and this change was greater than the 84% reduction in phospholipid levels observed between the two groups. However, the reduction in TAG levels did not lead to elevation in the levels of plasma free fatty acids in food deprived fish. The total NEFA in food deprived cod was 1/7 of those in fed cod, and the concentrations (mg L^{-1} of plasma) of identified fatty acids in food deprived cod were generally reduced by 2/3. Exceptions were 20:4ω6 and 22:6ω3, where the difference was less than 1/3. Further, the concentrations of 18:1ω5 and 20:3ω3 in fed cod were, respectively, 87 and 47 fold higher. The NEFA profile for fed cod was different to that of food deprived cod. In particular, 14:1, 15:1, 16:4ω1, 16:4ω3, 21:0, 22:1ω11, 22:0, 22:1ω9, 22:1ω7, 22:0 and 24:1 fatty acids were not detected in the food deprived cod. Furthermore, the proportion (as a percent of total identified fatty acid) of 18:1ω9, 22:6ω3, and 20:4ω6 were higher (between 2 and 4 fold) in food deprived cod, and the reverse was true for 20:3ω3 which was 6.5 times greater in fed cod. These differences in the profile of plasma NEFA may be related to differences in how fed and food deprived cod regulate fuel selection.

Posters

Changes in *C. opilio* Feeding Ecology in Bonne Bay, Newfoundland and Labrador (Canada) from 1990 to 2003. **Retzlaff, A**. and R. Hooper, Memorial University, St.John's, Newfoundland (poster P-1)

Abstract:

Snow crab (*Chionoecetes opilio*) is the most important commercial crab species fished in eastern Canada (Khadra et. al. 1998). As such, they have been subjected to vastly increased fishing pressure from landings of 10 000 tonnes in the late 1980's, to 38 007 tonnes in 1996, and further to 56 705 tonnes in 2001 (Dawe et. al. 2002). Despite this

fishing pressure, many *C. opilio* populations have actually increased (Sainte-Marie 1997) with CPUE changing from 12.9 in 1996 to 13.9 in 2001 (Dawe et. al. 2002). With such inflated populations, it was hypothesized that grazing of *C. opilio* may be affecting bottom invertebrate communities. In the area around Bonne Bay, NL landings increased from 833 tonnes to 1675 tonnes over the period from 1996 to 2001 while CPUE remained stable (Dawe et. al. 2001). Two hundred and eleven *C. opilio* were captured from this area, measured for morphometrics, eviscerated, and their stomach contents were analysed for the presence of eighteen different categories of food. It was found that the prevalence of seven of these eighteen categories had changed significantly since 1990. It is suggested that this represents the effects of overgrazing by *C. opilio* on preferred, possibly more nutritive food items.

Lipid Analysis in Juvenile Salmon: Examining the use of Lipid Analysis as an Indicator of Fish Habitat Condition in Large Rivers of central British Columbia. **Cleary[1], J.S.**, M.J. Bradford[1], D.M. Janz[2], and R.M. Peterman[1]. [1]School of Resource and Environmental Management, Simon Fraser University, Burnaby, BC. [2]Department of Veterinary Biomedical Sciences, University of Saskatchewan, Saskatoon, SK (poster P-2)

Abstract:

Lipid storage and dynamics are an important attribute of fish health and population dynamics. Lipids play an important role in overwinter survival, energy allocation strategies, and response to environmental stress. Triglycerides, the primary form of storage lipid in fish, are mobilized as energy when food availability is low (i.e. during starvation and in the winter). Identification of (1) seasonal lipid patterns in juvenile fish and (2) the relationship between fish lipid levels and fish habitat could provide managers with an effective tool for monitoring the condition of fish habitat in large rivers. This research examines whole body lipids and triglycerides in juvenile chinook salmon in large rivers of the Fraser River basin to determine the effectiveness of these biological macromolecules as indicators of fish habitat condition. Young-of-the-year chinook salmon were sampled over one year at 11 rivers at different latitudes to determine the seasonal and spatial variability of total lipids and triglycerides in unimpacted rivers, and provide a basis for comparison with impacted habitats in future studies. Our preliminary results show an increasing trend in total lipid and triglyceride levels from summer through fall, and a decreasing trend in these biological indices over the winter months. We also observed differences in total lipids and triglycerides among reaches at the same time period, where reaches differed by temperature and flow regime. Survival through the winter may thus depend on the individual's ability to accumulate enough triglycerides during summer and fall to sustain themselves until spring. Our study supports the recent focus to identify alternative approaches for monitoring fish habitat condition. Performance measures, such as lipids, are suggested to be more effective than population-based or physical parameters as monitoring tools because they provide better direct evidence of mechanisms that control populations.

Stable Isotope Analysis of Some Representative Fish and Invertebrates of the Newfoundland and Labrador Continental Shelf Food Web. **Sherwood, G.D.** and G.A. Rose. Fisheries Conservation Chair, Fisheries and Marine Institute of Memorial University of Newfoundland and Labrador, St. John's NL (poster P-3)

Abstract

We examined stable carbon and nitrogen isotopic signatures of 17 fish species and 16 invertebrate taxa common to the Newfoundland and Labrador continental shelf food web. Particular sampling emphasis was placed on Atlantic cod (*Gadus morhua*) and related prey species (e.g. shrimp, *Pandalus borealis*, and capelin, *Mallotus villosus*). We found highly significant ($P < 0.0001$) differences between near-shore (bays) and offshore (shelf edge) $\delta^{15}N$ signatures for cod, 'other fish' (pooled) and invertebrates (pooled). In contrast, there were only minor differences in $\delta^{13}C$ signatures of 'other fish' ($P < 0.05$) and no difference for cod and invertebrates among the two habitats. We sampled at two times of the year (January and June) and found a negligible effect of season on both $\delta^{13}C$ and $\delta^{15}N$ in cod, 'other fish' and invertebrates. We calculated trophic fractionation factors for cod from the entire shelf (mixed diet sources) and for cod from an offshore site where feeding is limited to one main prey species (shrimp); these values ranged between 3.1 – 3.9 ‰ for $\delta^{15}N$, and 0.3 – 1.4 ‰ for $\delta^{13}C$. We discuss potential mechanisms for near-shore versus offshore enrichment of $\delta^{15}N$ signatures, and demonstrate the implications of this spatial variation on $\delta^{15}N$-derived trophic position estimates.

Potential of Black Fly Larvae (Diptera: Simuliidae) as an Alternative Food Source for Hatchery Production of Lake Sturgeon *(Acipenser fulvescens).* **Klassen, C.N.** and S.J. Peake. Department of Biology, University of New Brunswick, Fredericton, NB (poster P-4)

Abstract:

Artificial propagation is believed to be an effective means to increase lake sturgeon (*Acipenser fulvescens*) populations, which have become depleted due to commercial exploitation, habitat degradation and blocked

migratory paths. Success of current rearing methods using a diet of brine shrimp (*Artemia sp*.) and frozen bloodworm (BW) (*Glycera sp*.) has been inconsistent. As such, we incorporated black fly larvae (Diptera: Simuliidae), a natural prey item, into the diet of lake sturgeon and monitored survival and growth in an attempt to find a rearing method that will more consistently produce healthy fish for the purpose of restocking. Live and frozen black fly larvae (BFL) were presented to groups of larval lake sturgeon exclusively or in combination with brine shrimp (BS) over an eight and seven week period in 2002 and 2003, respectfully. Survival and growth of fish exposed to these experimental diets were compared to those individuals reared using traditional methods. Lake sturgeon offered live BFL exclusively, or switched from BS to BFL <1, 1, 1.5, 2 and 3 weeks following exogenous feeding had survival rates of 33, 32, 40, 6, 40 and 45%, respectfully. The same diet switch after 4 weeks resulted in 70% survival. Lake sturgeon switched from BFL to BS after 1 and 3 weeks had 80% survival but only 40% survival when switched after 2 weeks of exogenous feeding. Fish reared on frozen BFL had 44% survival while those switched from BS to whole frozen BFL (13%) and chopped frozen BFL (12%) after 1.5 weeks experienced a greater number of mortalities. Attempts to rear fish using traditional methods were unsuccessful (0%). Growth was greater when BFL was included in diets as compared to juveniles fed BS exclusively or a BS/BW diet. Switching from BS to BFL produced fish approximately 2-2.5 times heavier than fish switched at the same time from BFL to BS. Use of frozen BFL resulted in weights comparable or slightly greater than fish fed live BFL. Rearing methods incorporating black fly larvae (live or frozen), particularly following the first month of exogenous feeding, has the potential of being more efficient and cost effective than traditional diets. Further research on the larval development of lake sturgeon and dietary requirements during the first weeks of exogenous feeding is needed to find a suitable starter diet that will lead to more successful rearing techniques.

Examining the life history response of yellow perch to mass removal. **Ng, R.Y**., D.R. Browne and J.B. Rasmussen. Department of Biology, McGill University, Montreal, PQ (poster P-5)

Abstract:

This study evaluates the life history response of yellow perch to mass removal and the potential for population recovery. We removed 60% of the perch from a 35 hectare oligotrophic lake in Algonquin Provincial Park, Ontario, as part of a study designed to enhance the recruitment success of brook trout. Several response variables are examined both before and after mass removal: 1) condition, which includes growth, diet and overall condition responses, 2) habitat use, and 3) reproduction, which includes age at maturity and fecundity. Results show that prior to the manipulation, the perch exhibit a narrow size distribution, high dietary overlap, and low condition factor, typifying a stunted population. The main perch habitat was restricted to an offshore knoll. We hypothesize that after mass removal, the perch population will exhibit increased growth rate for all age classes, ontogenetic diet shifts at smaller sizes, and increased condition. We also predict that the perch will shift habitat use to the littoral zone and will exhibit earlier age at maturity and increased fecundity. We examine the question of whether compensatory life history response in the yellow perch will overcome brook trout predation leading to a reestablishment of a high density perch population.

A Preliminary Study on the Performance of Non-salmonids in a New Experimental Fishway. **Reid, J.E.**, and S. Peake. Department of Biology, University of New Brunswick, Fredericton, NB, E3B 6E1 (poster P-6)

Abstract:

Fishway designs have primarily been based on the swimming performance of salmonids and may not include design features relevant to the behaviour and swimming performance of nonsalmonid species. Nonsalmonids tend to be less motivated swimmers and generally have poorer swimming abilities than salmonids. The purpose of this experiment was to design a new fishway baffle based on the swimming characteristics of nonsalmonids and to test it against two baffle types currently in use that were designed for salmonids (Denil and vertical slot). The number of attempts and completions made by pike (*Esox lucius*), smallmouth bass (*Micropterus dolomieu*), walleye (*Stizostedion vitreum)* and perch (*Perca flavescens*) was recorded by PIT (passive integrated transponder) tags as they ascended and descended the fishway. There was no significant difference in fish performance between individual species using different baffle types ($P>0.05$). However, there were significant differences in the number of attempts and completions made by the different species using the Denil, vertical slot and experimental baffle. Overall, smallmouth bass made more attempts and completions of each baffle type than the other species tested. Fish performance using the experimental baffle was similar to that of the Denil and vertical slot, and therefore, modifications should be made to this baffle to improve fish passage further. Future work will focus on evaluating fish passage using a full scale model as well as testing a wider range of species. The development of a fishway designed specifically for nonsalmonids will improve the passage of fish over migratory obstacles and reduce the effects of these barriers on fish populations.

The Effects of Acute Sedimentation Events on the Survival and Growth of Aquatic Organisms in an Experimental Flume: A Preliminary Study. **Walker, E.M.** and S. Peake Department of Biology University of New Brunswick, Fredericton, NB E3B 6E1 (poster P-7)

Abstract:

Mesocosms are controlled representation of an ecosystem containing representative organisms. These devices have been found to be a useful tool for studying the impacts of specific abiotic factors on various organisms within aquatic ecosystems. This preliminary study used an open system mesocosm to test how exposure to acute doses of suspended sediments impacted fish and benthic macroinvertebrate growth and survival. The accuracy with which the mesocosm represented the reference ecosystem, the Pinawa channel, Pinawa Manitoba, was also determined. We found that the mesocosm represented the reference ecosystem in relation to water quality, dissolved oxygen, pH, conductivity, and velocity, and benthic macroinvertebrate community. The information gained in this preliminary study, with regards to sediment doses and the structure of the fish community, will be further used to conduct research on the affects of acute sedimentation on fish and macroinvertebrates.

Effects of Managed Buffer Zones on Fauna and Habitat Associated With a Headwater Stream in the Indian Bay Watershed in Northeast Newfoundland. **Wells, J.M.**[1,2], D.A. Scruton[1], J.A. Brown[2], and K.D. Clarke[1]. [1]Department of Fisheries and Oceans, Science, Oceans and Environment, St. John's, NL, A1C 5X1; [2]Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL, A1C 5S7 (poster P-8)

Abstract:

Sedimentation significantly increased for the 20 m buffer with selective harvesting. Water temperature was slightly impacted within the optimum temperature class for brook trout (*Salvelinus fontinalis*) only with a significant decrease for the 30-50 m buffer with selective harvesting and the 20 m buffer with selective harvesting. The stress and lethal temperature classes were not significantly different between pre- and post-harvest observations. The water temperature significantly increased within the upper and lethal temperature classes for Atlantic salmon (*Salmo* salar) within the 30-50 m buffer with selective harvesting. The effects of selective harvesting on aquatic macroinvertebrates varied depending on the index and taxon. The number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) divided by the number of Diptera index was not significantly affected by site and year. However, the number of total EPT, Ephemeroptera, Plecoptera, Trichoptera, Diptera (excluding Chironomidae) and Chironomidae were all significantly affected by site and year. The most notable difference between pre- and post-harvest occurred within the 20 m buffer, where a large increase in *Oxythira* sp., an algal consumer, was observed. Brook trout and Atlantic salmon populations significantly increased for all three experimental sites except for brook trout within the 20 m buffer site. The biomass of brook trout significantly increased within the 20 m buffer with selective harvesting, while all other differences for brook trout and Atlantic salmon biomass were not significant. Young-of-the-year salmonid populations increased for all three experimental sites, with the exception of brook trout within the 20 m buffer. Young-of-the-year salmonid biomass was not significantly different for any of the experimental sites. For year 1+ and older Atlantic salmon populations, the 20 m buffer displayed the only significant increase between pre- and post-harvest. The brook trout population estimates were not significantly different for any of the experimental sites as compared to the no harvest site. The biomass of both salmonid species were not significantly different for any of the experimental sites. Overall, the reach with the 30-50 m buffer with selective harvesting appeared to be the least impacted, specifically in terms of sedimentation and invertebrate community changes. These results suggest that managed buffers in this area of Newfoundland should be 30-50 m.

Managing the exploitation of brook trout *Salvelinus fontinalis* (Mitchill) populations in Newfoundland lakes. **van Zyll de Jong, M. C.**[1] W. Norris[1], N. P. Lester [2]and R. M. Korver[1]. [1]Indian Bay Ecosystem Corporation, Indian Bay Center for Ecosystem Studies, General Delivery, Indian Bay NF, AOG 1RO; [2]Aquatic Ecosystem Science Section, Ontario Ministry of Natural Resources, P.O. Box 7000, 300 Water Street- 3rd Floor North, Peterborough, Ontario, K9J 8M5 (poster P-9)

Abstract:

In response to anglers' allegation of a declining fishery, a monitoring and research programme was initiated in Indian Bay Brook Newfoundland, Canada. Creel and index fishing data from lakes were used to construct a model for managing the exploitation of brook trout, *Salvelinus fontinalis* (Mitchill). The model describes the relationship between angling effort (angler-hr ha^{-1} yr^{-1}) and fishing yield (kg ha^{-1} yr^{-1}). Based on model predictions, current fishing effort is nearing the sustainable limits of the system (3 angler-hr ha^{-1} yr^{-1}) and maintenance of a quality fishery demand regulations that restrict fishing effort or reduce its impact. A dynamic simulation model (calibrated for the study population) was used to compare the effectiveness of various types of management regulations (e.g.

creel limits, size-based restrictions on harvest). Simulation results indicated that creel limits will not prevent over-fishing and that size-based management is needed to offer a sustainable high quality fishery. Management guidelines and further data requirements are discussed.

Mercury Concentrations in Freshwater Fishes of Labrador in Relation to Biological and Environmental Variables. **Robertson[1], M. J.**, D. A. Scruton[1], M. R. Anderson[1], and G. J. Robertson[2]. [1]Department of Fisheries and Oceans, Box 5667, St. John's, NL A1C 5X1; [2]Canadian Wildlife Service, 6 Bruce Street, Mount Pearl, NL A1N 4T3 (poster P-10)

Abstract:

Ninety-five lakes in Labrador were surveyed from 16 August to 20 October 1982 as part of the Department of Fisheries and Oceans' National Inventory Survey. The lakes surveyed were generally small headwater lakes [143 ± 20 ha (SE); range 5-1217 ha] at high altitude within their respective watersheds. Lakes were sampled for morphometry, water chemistry and fish. The purpose of the present study was to examine the relationship of lake morphometric and water chemistry variables to mercury concentration in lake trout (Salvelinus namaycush), northern pike (Esox lucius), brook trout (Salvelinus fontinalis), lake whitefish (Coregonus clupeaformis), longnose sucker (Catostomus catostomus) and white sucker (Catostomus commersoni). The lake variables used in the statistical analysis were chosen to represent the physical and chemical characteristics of the lakes and to minimize intercorrelations between variables. The final results of a stepwise multiple linear regression of log fish mercury concentration on fish fork length, fish age, pH, secchi depth, log lake area, log maximum depth, log drainage area and log shoreline development are presented. As expected, fish fork length explained most of the variation in fish mercury concentration. However, age in northern pike and brook trout explained more variation in mercury concentrations than fork length. In general, fish mercury concentrations were greater in lakes with lower pH, smaller surface areas and increased shoreline development.

Mapping spawning times and locations for ten commercially important fish species found on the Grand Banks of Newfoundland. **Ollerhead, L.M.N.**, M.J. Morgan, D.A. Scruton, and B. Marrie. Fisheries and Oceans Canada, Science, Oceans and Environment Branch, P.O. Box 5667, St. John's, NL A1C 5X1 (poster P-11)

Abstract

Traditionally, Newfoundland and Labrador has been known for its fishing industry, but in recent years oil and gas has become an increasingly important natural resource. Identifying potential conflicts between oil and gas exploration surveys and spawning areas is critical to effective management of these natural resources. A comprehensive information source mapping sensitive spawning areas on the Grand Banks should prove invaluable to operators and industry regulators alike. This reference could also be used to provide a foundation from which to discuss concerns respecting seismic survey operations. Using data collected on Department of Fisheries and Oceans (DFO) research vessel surveys, a Geographic Information System (GIS) was used to create maps that illustrated locations and timing of higher intensity spawning for 10 commercially important fish species found on the Grand Banks. The maps showed that within the coverage of the Grand Banks surveys, peak spawning occurred for many species in spring and early summer with the location of the spawning peak often varying from month-to-month. In addition to showing the seasonal spatial variability, historical versus recent spawning trends were mapped. These maps illustrated how the higher intensity spawning areas change over time, both in a seasonal and a historical context.

The Newfoundland Small Stream Buffer Study: Impacts of Current Forest Harvesting Practices on Stream Habitat and Biota. **Decker, R.C.**, D.A. Scruton, J.D. Meade, K.D. Clarke, and L.J. Cole. Fisheries and Oceans Canada, Science, Oceans and Environment Branch, 1 White Hills Road, P.O. Box 5667, St. John's, NF A1C 5X1 (poster P-12)

Abstract:

Intensive forest harvesting has been ongoing on the island of Newfoundland since the early 1900's. Three pulp and paper mills are currently operating on the island and placing an increased demand on forested areas. The method of forest removal has traditionally been clear-cutting which is the most invasive and destructive method. Clear-cutting has been proven to adversely affect the local and regional environment especially aquatic systems as small streams and ponds. Twelve stream reaches from 3 different watersheds subjected to forest harvesting were sampled during the summer of 2000. Salmonids studied were brook trout (*Salvelinus fontinalis*) and Atlantic salmon (*Salmo salar*). Other variables measured during this study included sedimentation rates, temperature regime, benthic invertebrate community composition, riparian buffer composition, stream habitat characteristics, and large woody debris. These

results were then analyzed and related to different forestry treatments; control stream (no cutting), treatment #1 (recent cutting, 20m riparian buffer), treatment #2 and treatment #3 (older cut areas, limited riparian buffer). In the control and treatment #1 stream reaches results from the sediment sampling, benthic invertebrate sampling, and temperature data were mixed. In one watershed forest harvesting did significantly increase the amount of sediment entering the treatment #1 reach while the other 2 watersheds did not yield any significant increase in sedimentation after a harvest event. Benthic invertebrates were significantly less abundant in treatment #1 reaches than in control stream reaches. Treatment #1 reach was significantly warmer than the control in one watershed while there was no significant difference in another watershed. Brook trout in treatment #1 reaches were larger than brook trout in the control reaches while brook trout in treatment #2 and treatment #3 streams were significantly smaller than those in the control and treatment #1 stream reaches. Atlantic salmon size relationships were opposite to brook trout; the smallest Atlantic salmon inhabiting control streams while the largest inhabited streams impacted by older harvest events (treatment #3).

Variation in the Effect of Sea Lamprey Barriers on Non-Target Fishes: the Influence of Sampling (Chance) on Effect Size. **Harford, W.J.** and R. L. McLaughlin. Department of Zoology, University of Guelph, Guelph, ON (poster P-13)

Abstract:

The effects that in-stream barriers used to control sea lamprey in the Laurentian Great Lakes basin have on the diversity of stream fishes is an important concern for fishery managers. Estimates of species loss for 24 barrier streams in the basin were highly variable. We developed a simulation model to test whether the observed variance in impact was greater than that expected from a null model of fish assemblage structure. The null model was designed to assign species randomly, based on their observed frequencies of occurrence, to locations above and below real barriers on barrier streams and locations above and below hypothetical barriers on corresponding reference streams. The modeling exercise supported two conclusions. First, a relatively large variance in effect size is to be expected for our field sampling design. Second, the observed variation in effect size is greater than expected based on sampling considerations alone. Future work will examine environmental predictors of effect size at multiple spatial scales in an effort to assist managers with the selection of streams for new barriers.

Evaluation of Acute and Chronic Toxicity Aspects of the Aliphatic Hydrocarbon Based Drilling Fluid Being Used on the Grand Banks Of Newfoundland. Payne, J.F.[1], **C. Andrews[1]**, L. Fancey[1], J. Wells[1], B. French[2], and F. Power[3]. [1]Science Oceans and Environment Branch, Fisheries and Oceans, St. John's, NL; [2]Oceans Ltd., St. John's, NL; and [3]Petro Canada, St. John's, NL (poster P-14)

Abstract:

Oil or synthetic based drilling fluids have technical advantages over water based fluids for reduction or elimination of borehole problems and attendant risks, particularly where hole stability is a concern. Microtox®, amphipod and polychaete bioassays are commonly used in sediment monitoring programs and are presently being used on the Grand Banks. Dose response relationships were derived for these monitoring surrogates in studies with Hibernia source cuttings containing an aliphatic hydrocarbon based synthetic fluid. This particular fluid is also being used at the Terra Nova site and slated for use at the Husky site. The cuttings demonstrated a very low acute toxicity potential in all three sediment bioassays. Extrapolations carried out with respect to number of wells drilled and concentrations of hydrocarbon found at the Hibernia site after 2 years of development, indicate little or no risk to sediment biota as close as 500 m or less from the site over the projected life of the project. Acute toxicity tests carried out with capelin larvae, copepods and ctenophores also demonstrated the very low acute toxicity potential of the neat base oil for various pelagic species including fish larvae. Although chronic toxicity is much more difficult to assess, a number of detailed experiments carried out with flounder (and more recently snowcrab) over a 3 year period, also indicate that the aliphatic hydrocarbon based drilling fluid being used on the Grand Banks should pose little or no risk to marine biota. Also the monitoring programs in place on the Grand Banks for assessing effects on benthic communities and fish health will provide extra assurance as well as early warning of any potential problems.

Effectiveness of Re-Watering and Enhancement of a Flood Overflow Channel as Compensation for Habitat Lost Due to Hydroelectric Development. **Scruton, D.A.** and K.D. Clarke. Fisheries and Oceans Canada, Science, Oceans and Environment Branch, P.O. Box 5667, St. John's, NL A1C 5X1 (poster P-15)

Abstract:

Development of the Rose Blanche River for hydroelectricity resulted in destruction of fluvial habitat (flooding) and habitat compensation was required to offset habitat loss according to the 'no net loss' provisions of Fisheries and Oceans' Habitat Policy. The modification of a natural high flow, flood bypass channel, which was watered only

during peak flow snow melt events, was selected as the preferred compensation alternative. The channel consisting of 99 habitat units (100 m^2) was modified, with hydraulic control structures, to ensure a constant and regulated flow to the channel year round. Physical enhancement of the channel included addition of smaller substrate material, including spawning gravels, provision of bank stabilization and protection dykes from the main river, and installation of low head barriers to create pools. A three year study, involving electrofishing twice annually and marking of fish, was undertaken to assess re-population of the compensatory channel (fish density and biomass); age, growth, and survival of fish utilizing the channel; and the dispersal and recruitment of fish from the compensatory channel to the main stem of the river. Study results indicated that the channel is being predominately utilized by brook trout, with a mix of size/age classes, indicating the compensatory channel is providing habitat for all life stages. Young of the year production was particularly strong for both brook trout and Atlantic salmon within the 2001 year class. Year class strength was not as apparent in the main stem indicating differential (improved) survival in the compensatory habitat. Tag returns confirmed extensive movement within the channel and lesser movement between the main stem and the channel.

Microbial Pollution: A Key Factor to Consider in the Management of Municipal Wastewater Effluents From the "Smallest" of Sewage Outfalls. J.F. Payne[1], L.L. Fancey[1], **L. Park**[1], C. Andrews[1], S. Whiteway[2] and B. French[3]. [1]Department of Fisheries and Oceans, St. John's, NL; [2]Jacques Whitford Environment Ltd., St. John's, NL; [3]Oceans Ltd., St. John's, NL (poster P-16)

Abstract:

High volume municipal effluents may come under stringent regulations in the near future while small sewage outfalls dot the Newfoundland coastline. It has been established that sewage outfalls receiving effluents from populations as small as 50 people or less, have the potential to contaminate near shore intertidal and sub-tidal sediments to a considerable degree with various bacteria including *Clostridium*, total coliforms, fecal coliforms and *E. coli*. Studies were carried out at a number of sites including Harbour Grace, Harbour Breton and Carbonear Bay. Sediments from some small outfalls contained levels of Clostridium comparable to levels reported from a site in the United States receiving sewage from a population numbering in the hundreds of thousands. Studies in Harbour Grace and Carbonear Bay also indicated that sediments in deeper waters can act as reservoirs for high levels of Clostridium loading. Microbes (bacteria and viruses) in sewage may pose risks to the health of fish and marine mammals as well as human consumers of fish products. These results raise questions about the potential for cumulative impacts of clusters of small sewage outfalls versus single larger outfalls such as those in St. John's Harbour and Halifax Harbour. Studies have also been initiated in this regard on the health of fish around sewage outfalls.

Phytoplankton Community Dynamics, Environmental Conditions, and Mytilus Spp. Growth at Two Mussel Aquaculture Sites in Newfoundland. **DuRand, M. D.**[1], McKenzie, C. H.[2], Parrish, C.C.[1], and Thompson, R.J.[1]. [1]Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL A1C 5S7; [2]Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre, St. John's, NL, A1C 5X1 (poster P-17)

Abstract:

Two commercial mussel (Mytilus spp.) aquaculture sites in Notre Dame Bay, Newfoundland (Charles Arm and Fortune Harbour) were sampled approximately monthly when accessible (free from ice) for three years (2000-2002) to investigate the relationships among mussel growth, physical and chemical properties of the water column, and the phytoplankton community composition. Water column properties (temperature, salinity, and fluorescence) were determined. Discrete measurements were made of chlorophyll, particulate organic carbon, and nutrients at 4 meters depth, near the middle of the mussel sock. Mussel shell size and tissue wet weight were also measured. Net tows and whole water samples were collected to determine phytoplankton species composition. At each farm site, a more exposed and a more sheltered station were studied and the implications for mussel farm location selection are presented. Phytoplankton species composition and biovolume data are compared to those at the Charles Arm site from 11 years earlier, four years after the mussel farm was first established.

Potiential For Habitat Modification in Hypoxic and Anoxic Sediments Under Longline Mussel Farms. **Anderson, M. R.**[1], Stirling C.[1] Roy, A.[1] Ryan, J.[2] Strang , T. J. and Thompson R. J[2]. [1]Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre, PO Box 5667, St. John's NL A1C 5X1; [2]Memorial University of Newfoundland, Ocean Sciences Centre, St. John's NL A1C 5S7 (poster P-18)

Abstract:

During the course of a multi-year study into the environmental requirements for sustainable shellfish aquaculture in Newfoundland, we examined the potential for mussel farms to alter the benthic habitat under the farms. Most mussel

farms in Newfoundland Region are situated over bedrock and cobble in erosional areas or fine organic-rich silt in depositional areas. Accumulation of shell debris and attraction of macrobenthos was observed by video survey at the erosional sites studied. However such visual survey techniques proved of little value for the depositional areas. Nor did standard measures of organic enrichment such as redox and sulfides show any significant changes under the mussel farms situated over hypoxic or anoxic sediments. Infauna in the soft sediments under the farms were also similar to nearby reference sites. Farm sediments did however release significantly more nutrients than the reference sites. Thus changes are occurring at such sites but they are not easily observed by the usual sampling protocols. At the invitation of the mussel farm operator, the Canadian Hydrographic Service carried out an EM 3000 multibeam acoustic survey of one study site. Backscatter images of the farm clearly showed lines of shell debris in the soft bottom sediments throughout the site. These shell "windrows lie under the surface of the sediments as they are not visible in video surveys of the area and they appear to persist for a number of years. They were still clearly visible in the backscatter image of a portion of the farm that had been fallow for a number of years prior to the multibeam survey. Such acoustic surveys may thus offer a means of assessing and monitoring the environmental consequences of mussel farms in depositional areas.

Rates of protein synthesis are similar in juvenile cod despite differences in population, feeding level, and small temperature change. **Park, K.** and W.R.Driedzic. Ocean Sciences Centre, Memorial University, NL (poster P-19)

Abstract:

Protein accretion, which is a hallmark of growth, is the net of protein synthesis and protein degradation. Protein synthesis was determined in two geographically separated Atlantic cod (*Gadus morhua*) populations that were reared in identical conditions, at two different temperatures and feed levels. Rates of protein synthesis were determined by injecting isotopically labeled amino acid into the animals and tracking accumulation of amino acid into protein pools 5 hours later. Protein synthesis was greatest in liver, followed by heart, and then white muscle. Rates of protein synthesis were remarkably similar in that rates did not differ between populations nor was there an impact of either temperature or feed level on this parameter. However, juveniles reared in higher temperatures and higher feed levels had significantly larger liver, heart and body mass implying that rates of protein degradation are key in determining tissue growth. At low temperatures the ingested protein is sufficient to meet the lowered energy demands at both feed levels; however, at the high temperature condition the low feed group did not ingest sufficient protein to meet energy requirements. In an aquaculture setting care must be taken to ensure adequate protein in provided in excess of energy requirements to ensure accelerated growth.

Specific methylation of plasma non-esterified fatty acids: Assessment of selectivity. **Alkanani[1], T.**, Parrish[1], C.C., Rodnick[2], K.J., and Gamperl[1], K. [1]Ocean Sciences Centre, Memorial University; [2]Department of Biological Sciences, Idaho State University (poster P-20)

Abstract:

Plasma non-esterified fatty acids (NEFA) are the most labile form of lipid in the blood of vertebrates. Several methods have been adopted to measure plasma NEFA in aquatic animals. The common denominator for these methods is that, with the exception of free fatty acids, all other neutral lipids would not be esterified during the methylation procedure. However, preliminary analyses on lipid methylation in our laboratory suggest otherwise. Thus we carried out selectivity analyses of NEFA determination in two major neutral lipid classes, namely triacylglycerol (TAG) and free fatty acid (FFA). These two lipid classes were the obvious choice because they represent a major energy responsive component of fatty acids in marine animals and the level of FFA increases as the hydrolysis of TAG increases. Two lipid compounds were used to represent these two lipid classes, namely tripalmitin and palmitic acid. According to a published NEFA extraction method we expected that, for an effective methylation, 100% of the applied FFA should be in the form of methyl ester (ME) and that 100% of the applied TAG would be intact, if the method was highly selective. The calculated recovery of ME from the methylated FFA ranged between 102 and 114% with a mean value of 106±4%. This indicates that a high percentage of FFA was transformed to ME, and thus that the published method for NEFA extraction can be considered effective for the methylation of FFA. However, significant degradation of the TAG standard occurred with the published NEFA extraction method. Only between 57 and 75% of the initial concentration of TAG was recovered, and this degradation was not attributed to the prolonged atmospheric exposure during Iatroscan analysis. Analysis by short column gas chromatography confirmed the degradation of TAG by the presence of ME and DG peaks in the methylated TAG standard. These observations illustrate the risks of determining plasma NEFA without taking into account the amount of methyl esters originating from TAG. Without such adjustments/corrections, there is a potential to significantly overestimate the amount of non-esterified fatty acids in the sample.

Role of fatty acids in cultured *Mytilus edulis* grown in Notre Dame Bay, Newfoundland. **Alkanani[1], T.**, Parrish[1], C.C., McKenzie[1,2], C.H., and Thompson[1], R.J. [1]Ocean Sciences Centre, Memorial University; [2]Department of Fisheries and Oceans, St. John's, NL (poster P-21)

Abstract:

Fluctuations in mussel (*Mytilus edulis*) growth have been attributed to large-scale fluctuations in temperature, fluctuations in salinity and the abundance of plankton. This study examined the effect of fatty acids on the growth of cultured mussels during 2000-2002 in Notre Dame Bay, Newfoundland. Mussels were socked in June of 2000 and harvested in October of 2001. The mussels grew at variable rates (10.73±6.86, in 2000 and 10.09±8.91 mg d^{-1} in 2001) with the highest growth rate in September of each year. The growth, however, did not show localized differences. The proportion of polar lipid was much higher in mussel samples (71.1±4.8% total lipid) than the plankton (44.3±21.2%), and the opposite was observed for the neutral lipid (30.2±4.4% in mussels; 45.3±11.7% in plankton). The fatty acid profiles of plankton and mussels were, in general, the same except that 18:5ω3 was not detected in mussels, and no C_{22} non-methylene interrupted dienes (NMIDs) were detected in plankton. However, 22:2NMIDs in mussels were relatively abundant (range 2.5-3.5% of total fatty acids) particularly in 2000. The most abundant fatty acids in the plankton and mussels were 22:6ω3, 20:5ω3, 16:0, 14:0, and 16:1ω7. Of these fatty acids, 20:5ω3 was the only fatty acid in both plankton and mussels that showed a significant positive correlation with growth while correlations with other fatty acids varied in magnitude or direction (positive or negative) depending on whether the acid was in plankton or mussels. Neither 22:6ω3 nor 20:4ω6 was significantly correlated with growth but when their levels were combined with 20:5ω3 to give total essential fatty acids in plankton or mussels, the result was a significant positive correlation with growth. Moreover, the coefficients of correlation for the other physiologically important acids in bivalves, namely the 20:2NMIDs were by far the most significant but only with the mussel NMIDs, and their correlation with the growth was negative. Approximately 138 variables from mussels and plankton were tested in order to construct a model to predict the growth of mussels. Of these variables, ten were found to be significant, and they include the following: 20:2NMID, 16:1ω7, 18:2ω6+18:3ω3, ΣSFA, 18:4ω3, 22:4ω6, 22:2NMID, 17:0*i*, plankton 20:4ω3, and plankton 16:1/16:0.

Nutrient Regeneration Under Mussel Farms: The Environmental Effects of Mussel Aquaculture in Coastal Bays. **Strang, T.J.** and Anderson, M. R.[1] [1]Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre, PO Box 5667, St. John's NL A1C 5X1 (poster P-22)

Abstract:

Mussel farming can have varying effects on the surrounding environment depending on the type of environment that is initially present. Impacts have been documented on oxic substrates, however very little information exists for impacts of mussel farms that are established in naturally depositional hypoxic and anoxic areas. Two mussel farms in Newfoundland, situated in depositional areas with hypoxic and anoxic sediments were studied. The effects of mussel farming operations in such areas cannot be determined by redox but is seen from changes in sediment composition and nutrient regeneration rates. Total nitrogen, total phosphorus and total carbon present in the sediments were significantly elevated over nearby reference sites. Phosphorus was released from sediments under one farm but not the other farm nor at the reference sites. Sediments from both farm sites released significantly more ammonium than the reference sites. The higher release of ammonium at the mussel farm site may influence the water column productivity of the system if it is nitrogen limited. This may represent a biologically mediated feedback loop where mussels benefit from the increase in primary productivity.

Covariates of Migratory Phenotype and Life Histories in Anadromous Fish. **Bradbury, I.R.**, and P. Bentzen, Department of Biology, Dalhousie University, Halifax, NS (poster P-23)

Abstract:

We examined life history correlates with realized migratory phenotype in anadromous fish and present evidence consistent with the co-evolution of migration and life history strategies. Realized migration phenotype was defined for 19 species of anadromous fish from the published literature using migration distance, mean Fst between samples, and slope and intercept of the isolation by distance (IBD) regression). Clustering of life history parameters (i.e. fecundity, egg size, age at maturity) revealed species assemblages indicative of phylogenic associations, whereas clustering based on migration parameters suggest dispersal affiliations consistent with migration distances. Assemblages based on migration phenotype, and significant correlations between IBD parameters and migration distance, support inverse linkages between migration distance and gene flow. Migration phenotype was consistently correlated with many life history characters such as fecundity, egg size, and age at maturity; however the removal of size effects eliminated significant life history correlations. Principle Component Analysis (PCA) of all variables examined (life history traits and migration phenotype) consistently associated the components of migratory

phenotype with size, even after the effect of maximum size was removed. Surprisingly, the removal of size in the PCA revealed a linkage between fecundity and average genetic differentiation (F_{st}). We concluded that (1) linkages between realized migratory phenotype and life history seem to be made through the interaction of migration phenotype and body size; (2) linkages between the components of migration phenotype suggest a relationship between migration distance and gene flow possibly through homing ability. The evidence for the co-evolution of life history and migration phenotypes suggests spatial processes play a critical role in the evolution of life history strategies.

Assessing the status of a Newfoundland species: Fundulus diaphanus, the banded killifish. **Chippett, J.D.** Indian Bay Ecosystem Corporation, Indian Bay Center for Ecosystem Studies, General Delivery, Indian Bay NF, AOG 1RO (poster P-24)

Abstract:

The banded killifish, *Fundulus diaphanus*, belongs to the family Fundulidae. One of two fundulids in Newfoundland (the other is the brackish water dweller, the mummichog, *F. heteroclitus*), the banded killifish inhabits freshwater habitats. Located in only 7 known localities across insular Newfoundland, most coastal in nature, the distribution of *F. diaphanus* is scattered and disjunct. The Indian Bay population record, the most interior occurrence, is an eastern range extension from the previous such record at Freshwater Pond on the Burin Peninsula and is the only north east record of the species. While suitable habitat, generally described as the sandy or muddy shallows of freshwater lakes with abundant submerged aquatic vegetation, is fairly common, interior lakes may be unreachable due to steep river gradients. Preliminary enzymatic electrophoretic analysis indicated very little variation between the Newfoundland populations and a mainland population near the type locality (Saratoga Lake, New York). Classic morphometric analysis illustrated slight variations between populations but few consistent trends in variation. However, all three Newfoundland populations examined were significantly longer (total and standard length) than the mainland population. Previously designated as vulnerable (special concern) in 1989 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), this project culminated with a re-designation of the special concern status in May 2003, after a review of the first status report compiled solely on the Newfoundland populations of the species. While the current analysis provided little evidence to treat the Newfoundland populations as a separate species or subspecies, the disjointed distribution and few confirmed localities where they occur are causes for concern and were contributors to the species being designated as of special concern in Newfoundland.

Fourier Analysis of Brook Trout (*Salvelinus fontinalis*) Otoliths for Stock and Population Discrimination. **Pritchett, R.** and R. Allen Curry, New Brunswick Cooperative Fish and Wildlife Research Unit, Biology Department, University of New Brunswick, Fredericton, NB. E3B 6E1 (poster P-25)

Abstract:

Stock identification is important for fisheries managers when attempting to implement effective strategies in the development of a fisheries resource. Analysis has shown stocks may differ in fundamental characteristics such as growth rate, survival, recruitment, and reproductive rates. Many methods of stock identification have been used with varying degrees of success. One method uses otolith shape as an indicator of stock identity. Otolith shape has genetic and environmental influences but appears to be closely linked with growth rate. This study addresses the degree to which brook trout stocks and populations can be distinguished on a lake specific basis within a watershed using otolith shape. The relationship between otolith shape and growth rate is also addressed. Otolith shape was quantified using Fourier analysis, a method that uses the additive properties of cosine waves to determine the two-dimensional shape of the otolith. This method is advantageous because of its ability to detect small-scale differences in two-dimensional shapes.

Microgeographic population structure of brook char, *Salvelinus fontinalis* L.; a comparison of microsatellite and mark-recapture data. **Adams, B. K.** and J.. A Hutchings. Department of Biology, Dalhousie University, Halifax, NS (poster P-26)

Abstract:

Polymorphism at five microsatellite genetic markers (N-genotyped = 496) and mark-recapture tagging data (N-tagged = 9813) were used to define the population structure of brook char, *Salvelinus fontinalis* L., from the Indian Bay Watershed, Newfoundland, Canada. Despite the absence of physical barriers to migration among lakes, both genetic and tagging data suggest that char in each lake represent reproductively isolated populations. Exact tests comparing allele frequencies, θ (global value = 0.063), Rst (global value = 0.052), individual assignment tests, and Nei's genetic distance provided congruent estimates of population subdivision in agreement with the tagging data (only 2.2% of recaptures were lake-to-lake). The genetic structure of the char populations corresponded with the

geographic structure of the drainage basin on a qualitative level, although linear distance over water was not significantly correlated with the tagging data or the genetic distance measures. Being one of the few studies to combine tagging and microsatellite genetic data in an analysis of fine-scale fish population structure, the agreement between the tagging data and the genetic data suggest that microsatellite markers can be useful tools for defining real biological units. The results also suggest that brook char exhibit microgeographic population structure at the watershed scale, and that this is the scale at which conservation and management of this salmonid might best be implemented.

Optimal Foraging and Growth of Walleye (*Sander vitreus*). **Kaufman, S.,** J. Gunn and G. Morgan. Cooperative Freshwater Ecology Unit, Luarentian University, Sudbury, ON (poster P-27)

Abstract:

Optimal foraging theory predicts that growth rates will be higher when the ratio of energy gained from the prey to the energy costs of search and seizure is maximized. To test this theory, four walleye (*Sander vitreus*) lakes containing lake herring (*Coregonis artedi*) and yellow perch (*Perca flavescens*) (herring lake) and four additional walleye lakes containing yellow perch only (perch lake) in Sudbury, Ontario were chosen for intensive sampling. Lake herring grow to larger sizes than yellow perch and therefore should provide more opportunities for larger walleye to forage optimally. Detailed seasonal diets of walleye were assessed in two lakes (one perch lake, one herring lake) from the late spring to fall. This was done by gastric lavage of walleye caught by short set gillnets (~1-2 hours) at dusk in May and June, and around-the-clock netting (24 sets·day^{-1}, 2 hour sets) in June and September to determine early summer and early fall diet. Forage community structure of each lake was determined using the Nordic multi mesh netting method during July and August. Each walleye population was assessed using Fall Walleye Index Netting during September and October. Walleye stomachs were collected during the Nordic and Fall Walleye Index Netting surveys to determine diet composition. Somatic tissues were collected to estimate consumption rates comparing mercury levels in predator and prey. Anaerobic activity will be estimated by determining lactate dehydrogenase levels for walleye, perch and herring. It is hypothesized that walleye in perch lakes will have higher consumption rates, higher activity and more, smaller items in the diet than walleye in herring lakes. The larger range of prey sizes and subsequent difference in energetics should allow higher growth rates and greater asymptotic lengths in walleye in lakes with herring. Around the clock netting suggests that walleye activity (mean catch per unit effort, CPUE) in perch lakes increased following a peak in perch activity at dawn and dusk, with walleye remaining active throughout the night. In contrast, walleye activity in herring lakes increased following increased herring activity at dawn and dusk, but was low during the day and night. This suggests that walleye in perch lakes must forage longer to reach satiation, while walleye in herring lakes expend less time and perhaps energy foraging to meet their needs.

Growth of the sympatric rainbow smelt (*Osmerus mordax*) complex of Lake Utopia, New Brunswick . **Shaw, J.**, R. A. Curry[1] and S. L. Currie[2]. [1]New Brunswick Cooperative Fish and Wildlife Research Unit, Canadian Rivers Institute, Department of Biology, University of New Brunswick, Fredericton, NB, [2]New Brunswick Department of Natural Resources, Region 3, Islandview, NB (poster P-28)

Abstract:

Lake Utopia has three distinct and sympatric morphotypes of rainbow smelt. The early giant form spawns first, followed by the later spawning normal form and the latest spawning dwarf form that overlaps in spawning with the normal form. The dwarf morphotype has been listed as a threatened species in Canada. The objective of this study is to compare the growth rates of the three different forms of smelt in the lake. Adults of the three morphotypes were collected by dip-netting during spawning in April and May. Young-of-the-year smelt were collected at night by trawling at the surface of the lake with a 1 x 2 m Newston net from June to November. The otoliths of the adult and juvenile fish were removed, dried, mounted, sectioned or polished, and growth increments measured. Back-calculations were performed to determine age and growth rates. The preliminary results of this work will be presented and discussed.

Genetics and Life History of Landlocked Atlantic Cod (*Gadus morhua*) Populations from Coastal Arctic Lakes at the Extreme of the Species' Range. **Hardie, D.C.** and Hutchings, J.A. Department of Biology, Dalhousie University, Halifax, NS (poster P-29)

Abstract:

This study concerns unique Atlantic cod (*Gadus morhua*) populations from saline meromictic coastal lakes in Canada's high Arctic. These populations persist well to the north of the current distribution of Atlantic cod in Canadian marine waters, at the very extreme of the species' range. They are highly cannibalistic, and generally

mature at a later age and larger size than marine stocks, although growth rates are highly variable. Remarkably low allelic variation at eight polymorphic microsatellite loci provided evidence that these populations are small, and are probably isolated relicts from a period of warmer ocean temperatures in the Canadian Arctic. F_{st} values for these populations were two orders of magnitude higher than have previously been reported for this species. These remarkable genetic features are discussed, and the relationships among cannibalism rates and life history features such as growth rate and age and size at maturity are compared among lakes and to data from marine stocks.

Cheeseman (poster P-30)

Meristic and enzymatic responses of peri-metamorphic Atlantic cod (*Gadus morhus*) larvae to diets of enriched *Artemia*. **O'Brien-MacDonald, K.** and J.A. Brown. Ocean Sciences Centre, Memorial University of Newfoundland, Canada. A1C 5S7 (poster P-31)

Cod have what is referred to as an "altricial" digestive system, which means they lack a fully developed gut at hatch, but one that matures into a fully functional digestive system over the first three months of life. Cod larvae undergo rapid growth and tissue deposition and initiate successful prey capturing behaviours shortly after transition to exogenous feeding. One crucial physiological change that cod larvae experience is variation in digestive enzyme activity as the diet changes and the digestive organs become more functional. This experiment was designed to examine the period from 45-60 days post hatching in cod larvae after changing from a rotifer to an *Artemia* live prey diet. During this 15 day period, pre-metamorphic cod were fed *Artemia franciscana* that were either unenriched, enriched with AlgaMac 3050, krill protein, or were on a three day rotation of all these diets. Measures for survival, growth, and digestive enzyme activity were taken. Results show that the larvae fed a high-lipid AlgaMac-enriched *Artemia* treatment showed the greatest growth and survival. Digestive enzyme activity assayed before and after feeding showed that the high-lipid and high-protein enrichments induced higher activity in lipid and protein digesting enzymes, respectively. Evidence suggests that dietary quality not only plays a role in growth and survival of cod larvae, but also in the enzymatic ability of the digestive tract to respond to prey of differing nutritional quality.

Improving Survival in Larval Cod, *Gadus morhua:* An Investigation of Three Different Light Rearing Regimes. **Monk, J.**, J.A. Brown, and V and Puvanendran. Ocean Sciences Centre, Memorial University of Newfoundland, St. John's, NL A1C 5S7 (poster P-32)

Abstract

In recent years Atlantic cod (*Gadus morhua)* has been identified as a species that has much potential for commercial production. Currently one of the major problems encountered with intensive cod production is inconsistent survival and growth rates from hatch through to 'metamorphosis'. The limited success of intensive cod rearing to date is due in part to a poor understanding of the optimal culture conditions required for large scale commercial production. Studies to date have indicated that cod larvae reared under high light intensities perform better than larvae reared under low light intensities up to 28 days post hatch. It has been proposed that
a lower light intensity may be ideal during the later larval stages. This study will address the growth, survival and foraging behavior of Atlantic cod larvae reared under varying light conditions in the later larval stages and an ideal lighting regime will be suggested to obtain maximal growth and improve survival of larvae from day zero post hatch to day 60 post hatch. Results indicate that the larvae are slightly longer and heavier and have increased survival rates when light intensity is decreased at 28 days rather than at a later point during development.

Using Stable Isotopes of Carbon and Nitrogen to Investigate Bi-Dimensional Food Web Structure as Determinant of Mercury Levels in Fish from Labrador Lakes Exploited by Innu Fishers. **Roux, M-J.**[1] Anderson, .R.[2] Wadleigh, M. [1], Robertson, M.J. [1] and Planas, D.[3]. [1]Memorial University of Newfoundland, St. John's, NL. A1C 5S7; [2]Department of Fisheries and Oceans, box 5667, St-John's, NL. A1C 5X1; [3]Universite du Quebec a Montreal, C.P.8888, Montreal, QC. H3P 1B1 (poster P-33)

Abstract:

Aquatic community structure plays an intrinsic role in modulating mercury pathways in lentic environments. Recent evidence also argues for the importance of littoral/benthic processes to overall lake metabolism and suggests an active transfer of methylmercury via periphytic communities. Herein, we propose a two-fold research scheme addressing vertical and horizontal food web ecology in Labrador lakes selected and exploited by Innu communities, as this may define mercury cycling and so the extent of mercury bioaccumulation in fish. Our approach is founded on a dual stable isotope technique using stable carbon and nitrogen isotopes ratios ($\delta^{13}C$ and $\delta^{15}N$) as energy

sources/fluxes tracers and trophic indicators, respectively. Four inland Labrador study sites located between the 52nd and 55th parallels were sampled for particulates, periphyton, littoral and pelagic size fractionated (53, 100, 200 and 500μm) seston, and seven different fish species. Primary producers/consumers samples and fish specimens selected according to size/maturity stages will be subjected to stable carbon and nitrogen isotopes analysis as well as total (Hg) and methyl (MeHg) mercury determination, in order to (i) delineate how food provenance of either pelagic or littoral/benthic origin relates to mercury bioaccumulation in aquatic biota; (ii) clarify the role of littoral/benthic production in the active transfer of MeHg to aquatic food webs of the boreal forest; and (iii) describe how ecosystem-specific contrasts in trophic food web structure and dynamics may affect Hg levels in Labrador fish. This research project is part of the pan-Canadian COMERN (Collaborative Mercury Research Network) initiative, aimed to elucidate causes of mercury contamination in Canada, and assess and prevent related impacts on human health by means of an integrated ecosystem approach.

Fisheries Research Projects. **Dennis, B.**, Newfoundland Dept. of Tourism, Culture and Recreation, Science Division, Box 2007 Corner Brook, NL A2H 7S1 (poster P-34

Abstract

This poster will outline the three major fisheries program areas conducted by the Science Division. Our FLIN (FYKE Littoral Index Netting) program consists of lake studies which investigate the relative abundance and species community composition in various regions of insular Newfoundland. The Fishery Effort and Harvest surveys assess the angler effort and catch on lakes throughout insular Newfoundland. The discovery of previously unreported populations of *Fundulus diaphanus* (Banded Killifish) has led to future investigations into the distribution of the species, currently listed as a Species of Special Concern by COSEWIC.

General Information for the Society of Canadian Limnologists (SCL) Annual Meeting:

Program Themes and Theme Leaders:

(1) **Evidence and Impacts of Aquatic Regime Shifts** (CCFFR/SCL)
Chair - Bob Gregory

(2) **Northern Lakes Research: Where do we go from here**? (SCL)
Chair - Rolf Vinebrooke. The primary objective of this session is to examine how short-term and long-term variations in northern aquatic ecosystems are related to changes in climate, land-use, and other human stressors. Presentations are invited that use experimental, paleolimnological, modeling, or survey-based approaches to develop or test hypotheses regarding the effects of global change on alpine, arctic, or boreal aquatic ecosystems. Presenters should consider how their findings can help set future directions of Canadian research into coldwater lakes, ponds, or streams.

(3) **Multiple Stressors In Aquatic Systems** (SCL/CCFFR)
Chair - Shelley Arnott

Abstracts

Allaway*, C., and F.R. Pick.
Department of Biology, University of Ottawa
(email: calla470@science.uottawa.ca).

FACTORS CONTROLLING NITROGEN REMOVAL IN A RIVERINE NETWORK

River mass balance studies generally show that nitrogen input to a system is larger than the output, indicating that nitrogen is retained within the system. The total nitrogen (TN) and nitrate mass balance of thirty-two river reaches of various sizes (headwaters to outflow) was estimated to examine which factors influence nitrogen retention and where most retention occurs. Previous models based on databases and meta-analysis show that nitrogen removal rates decrease with increasing depth or stream order. This research intends to test these model predictions through field sampling. The study area was the South Nation River and its tributaries, which drain most of eastern Ontario. The watershed is 3900 sq. Km., flat and land use is roughly 57% agricultural. Individual Reaches ranged in size from <30cm deep to roughly 3.5m and from 2 L/s to 29 530 L/s in discharge. Water samples were collected and discharge measured at upstream and downstream locations with particular care to avoid tributaries. Preliminary analysis shows that shallow reaches (<30cm) displayed the highest retention and highest loading rates (previous studies do not show nitrogen loading for any given depth or order). TN retention decreased with increasing depths and discharge. Nitrate displayed a wider range in retention and loading compared to TN. Concentrations of TN and nitrate ranged from 0.59 - 3.58 mg/L and from below detection - 2.14 mg/L, respectively.

Barnard*, C. and J-J. Frenette
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ST. LAWRENCE ESTUARINE TRANSITION ZONE (ETZ) INVADERS: ZEBRA MUSSEL VELIGERS AND THEIR FEEDING HABITS IN THE ETZ

The estuarine transition zone (ETZ) of the St. Lawrence River is a productive ecosystem supporting a larval fish nursery. Since 1994, *Dreissena polymorpha* larval veligers have become the dominant zooplankton (up to 260 individuals•L^{-1}). Their dominance has led to much concern about their potential impacts on the microbial community and available food resources to other ETZ plankton. *Dreissena* veligers are filter feeders which consume photosynthetic picoplankton, bacteria, flagellates and detritus in the size range between 1 and 10 µm. Stations with high veliger densities were associated with high concentrations of chlorophyll *a* and photosynthetic picoplankton (0.2-2 µm), suggesting the veligers have no severe negative impacts on the ETZ plankton community and are restricted to favourable conditions for their survival in the upstream, low salinity region of the ETZ. This region may therefore be productive enough to support high veliger densities and/or the veligers use alternative ways of feeding in the turbid waters of the ETZ. In order to investigate this, we tested the capacity of veligers to assimilate dissolved organic carbon (DOC). In addition, the stable isotopic signatures (δ13C and δ15N) of their potential prey items (DOC, bacteria, phytoplankton and 0-10, 10-20 µm seston size fractions) were obtained in the upstream portion of the ETZ and directly in the ETZ. These results will be compared with the isotopic signatures (δ13C and δ15N) of veligers established in a previous study. Results indicate the veligers' capacity to assimilate dissolved organic carbon (DOC), suggesting that these filter feeders have a complementary way of meeting their energy requirements. This mode of feeding may have important implications for their survival in turbid environments where inorganic matter and sediments are the major constituents of the seston. The results from the stable isotopic analysis of their potential prey items will be discussed in terms of the potential consumer role played by veligers in the ETZ food web.

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EFFECT OF DAMMING ON NUTRIENT AND SEDIMENT BALANCE: THE CASE OF IRON GATE 1 RESERVOIR

Constructed in 1972, the Iron Gate 1 Reservoir is the largest impoundment on the Danube River. The previous nutrient balance studies applied to the Danube River show large differences between estimated loads to the surface water of the Danube Basin and the measured loads that enter the Danube Delta and the Black Sea. The measurements of the dissolved silica concentrations in the coastal Black Sea in the vicinity of the Danube show a 60

% reduction since 1972. In addition, sediment transport measurements revealed an enormous reduction in the amount of sediment reaching the Danube Delta in the mid 1970s. The construction of Iron Gate 1 Dam has been hypothesised as a possible cause of the nutrient and sediment retention. To provide a scientific assessment of the role of the Iron Gate 1 Reservoir as a sink for nutrients and sediments, as well as to understand the hydrodynamics of the reservoir (what is responsible for the possible retention of sediments and nutrients), a hydrodynamic and water quality model CE-QUAL-W2 was applied to Iron Gate 1. Additionally, a sediment balance analysis was performed on the Lower Reach of the Iron Gate 1 Reservoir. The main findings of this study are that (i) the morphological and hydrodynamic flow features of the reservoir play a crucial role in the sedimentation process; (ii) two significant zones of sedimentation have been identified, Orsova Bay and Submerged Island (former Bahna island). Both of them did not exist prior to the construction of the reservoir; (iii) as much as 1,200,000 tonnes of suspended solids are trapped annually; and (iv) the possible annual retention of suspended solids-related nutrients may be as high as 2,000 tonnes of phosphorus, 29,000 tonnes of nitrogen and 270,000 tonnes of silica. The new hypothesis has been hypothesised that the governing process of nutrient retention is not the increased primary production but (i) the increased sedimentation rate of suspended and bed-load particles due to newly emerged sediment sinks from the construction of the reservoir; and (ii) active decomposition of the bottom organic matter (mineralization, denitrification and methanogenesis) that might contribute to the nutrient retention and removal.

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EFFECT OF CLIMATE CHANGE ON THE LONG-TERM PATTERN OF PHYSICAL, CHEMICAL AND BIOLOGICAL PROPERTIES IN JACKFISH LAKE, SASKATCHEWAN

Evaporation rates of water from interior plains lakes and their watersheds are increasing as mean annual air temperatures rise. Increased rates of evaporation have the potential to alter physical, chemical and biological properties of lakes. We investigated the potential effect of climate change on Jackfish Lake, near North Battleford, Saskatchewan. Jackfish Lake is a shallow (Z_{max} ~4.5m) and large (area ~62km^2), making it succeptible to climate change. A rise in mean minimum air temperature from –4.8^{o}C to –3.7^{o}C was found between 1894 and 1999. In addition, mean annual August water levels have declined in Jackfish Lake over the past 27 years (~85cm). Total dissolved solid concentrations have risen from 1172 mg L^{-1} to 2894 mg L^{-1}, from 1938-2002. Likewise, conductivity has risen from 1600 □S cm^{-1} to 3310 □S cm^{-1} in the last 33 years, changing Jackfish from a freshwater system to a weakly saline one. Total phosphorus concentration (TP) has also risen from 0.05mg L^{-1} to 0.085mg L^{-1} between 1971-2002. Despite increases in TP, algal biomass has not responded. In fact, the chlorophyll *a* concentration appears not to have changed over the past 24 years.

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FRESHWATER DIATOM BIOGEOGRAPHY OF THE CANADIAN ARCTIC ARCHIPELAGO

Modern diatom assemblages and limnological characteristics were examined in 62 freshwater lakes across the Canadian Arctic Archipelago. The study lakes span a north-south transect from the Boothia Peninsula to northern Ellesmere Island, including sites on Victoria Island to the west. Lakes are neutral to basic with DOC values ranging from 0.06 to 13.5 mg/L, TKN from 0.01 to 1.10 mg/L and SO_4 from 0.03 to 395.0 mg/L. Sediment samples were measured by volume, weighed, and processed using strong acid digestion and concentrations estimated using serial dilution. A minimum of 600 valves was counted from each lake and identified using current taxonomic nomenclature. Species were identified under a light microscope and taxonomic verification of many species, particularly problematic taxa, was done using a Scanning Electron Microscope. A total of 326 species (including variations) were found. The spatial distribution of diatom genera and various species across the study area was mapped using a Geographical Information System (GIS). Many lakes were dominated by a species that was otherwise rare, such as *Stauroneis koeltzii*, *Cymbella delicatula*, and *Chamaepinnularia krookii*. Taxa occurring in highest concentrations, such as *Staurosirella pinnata* var. *pinnata*, *Staurosira construens* f. *venter*, *Amphora inariensis*, *Achnanthidium minutissimum* and *Hygropetra balfouriana*, were widely distributed throughout the study area. Maps of total diatom concentration (valves/cm^3 sediment) and species richness show no clear relationship

between concentration or richness with latitude. This is a reflection, at least partly, of the complex climate patterns of the Canadian Arctic, which are not simply a function of latitude.

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LACUSTRINE VARIABILITY AND THE DEVELOPMENT OF PALEOLIMNOLOGICAL TRANSFER FUNCTIONS

Paleolimnological research includes computing calibration sets between modern limnological variables and sediment organism assemblages. Collections typically consist of taking one point sample of water chemistry at one point in time. Does this water sample truly characterize the actual lake environment? Physical, chemical and biological measurements were collected from 17 lakes in the southwest Yukon Territory and northern British Columbia, Canada several times between May and August 1996 through 2003. Each of the 17 lakes were sampled once a year for 4 years. One lake in particular was twice sampled at multiple locations at one point in time, and again 12 times over the course of a season. Our preliminary analysis of the data suggests that, as expected, the seasonal variability is greater than the within-lake, or spatial, variability for total phosphorus (TP), total nitrogen (TKN), chlorophyll *a* (chla), temperature, specific conductance, and pH. It is difficult to distinguish the spatial variability within a lake from the sampling error.

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COULD INCREASED BOAT TRAFFIC IN WESTERN BROOK POND AFFECT THE SPATIAL DISTRIBUTION OF ZOOPLANKTON?

Western Brook Pond, a scenic ultraoligotrophic fjord lake (summer chla 0.11 to 0.75 µg/l) in Gros Morne National Park, Newfoundland and Labrador, receives over 20,000 tourists each summer. Boat traffic is restricted to 2 tour boats, with a 3rd boat proposed to meet tourism demands. Potential impacts of increased boat traffic on plankton populations and lake ecology is unclear. Zooplankton were sampled at 7 sites on 6 different dates, using 5 m vertical tows. Cladocerans Eubosmina longispina and Holopedium gibberum, copepods Leptodiaptomus minutus, Epischura lacustris and Tropocyclops prasinus, and rotifers Asplanchna sp., Kellicotia sp., and Conochilus sp. were found in the lake. Zooplankton populations exhibited significant patchiness (Green's coefficient of patchiness, C_x); however patch locations were not constant throughout the sample dates. Hence, there were no apparent zones of high zooplankton productivity to be avoided by boat traffic. Such traffic marginally increased local turbidity but not to the extent of adversely affecting zooplankton populations. Predictions concerning impacts of increased tourism are hampered by a lack of studies on the lake.

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TRANSFER OF MERCURY AND OTHER METALS IN EASTERN LAKE ERIE: HOW DOES THE ROUND GOBY FIT IN?

The round goby *Neogobius melanostomus*, along with *Dreissena* spp, has altered the food web dynamics of the lower Great Lakes, particularly by competing for benthic resources with native fish species. It is hypothesized that in this changing food web, the round goby may now serve as a conduit for contaminants and nutrients from *Dreissena* and other benthos to the upper trophic fish such as smallmouth bass *Micropterus dolomieui* in the eastern basin of Lake Erie. In the summer of 2002 and 2003, we collected fish (including smallmouth bass, rock bass, white bass, yellow perch, alewife, gizzard shad) and benthic invertebrates from the Port Dover area in eastern Lake Erie. The trophic relationships of these fish and benthic invertebrates were assessed using $\delta^{13}C$ and $\delta^{15}N$. The

importance of round goby in connecting benthic production and trophic transfer of mercury and other metals to important fish species is assessed. A computerized parameter search was developed to use mean isotopic ratios of prey and predators to assess dietary importance of each item, and it was indicated that large round goby (>9 cm) is an isotopically important prey item to smallmouth bass (approx. 20-50% of diet). Mercury concentrations are significantly correlated with trophic position, as indicated by $\delta^{15}N$, reaching concentrations above 1000 ng/g in top trophic fish. Rubidium, a rarely-studied alkaline metal, was shown to exhibit biomagnification properties, and may be an emerging metal for future research. Trophodynamics of other elements analyzed via ICP-MS are also assessed. Round goby and small mouth bass stable isotope values and contaminant burdens are significantly correlated, indicating that a significant portion of the diets of top trophic predator species consists of round goby.

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CONSIDERATIONS IN ASSESSING IMPACTS OF SHORELINE DEVELOPMENT ON THE NUTRIENT STATUS OF ONTARIO LAKES

Guidelines for managing impacts of shoreline development on lake water quality are commonly based on phosphorus criteria. For example, Canadian guidelines recommended by the National Guidelines and Standards Office are based on a tiered approach, whereby phosphorus concentrations should not increase more than 50% over background levels. Furthermore, phosphorus concentrations should remain below trigger ranges, based on a reference trophic status for a given region. Since small changes over a narrow range in concentrations are addressed by such objectives, it is important to precisely measure the nutrient status of lakes to help evaluate the model outputs. This will require the consideration of measured data within the context of sample contamination, precision, and length of record. In addition, uncertainties remain with respect to the effect of development on nutrient loads to lakes; and in particular more comprehensive information is required regarding the factors that influence the retention of phosphorus in septic systems. Finally, in Ontario, there is evidence that the nutrient status of lakes may be changing in response to factors other than human activity within the watershed. The impact of these effects on the application of a steady state model should be examined. Together, these considerations will require a conservative approach to setting lake development capacities.

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INTERACTIONS AMONG TIME, DEPTH AND DISSOLVED ORGANIC MATTER ON UVR-ATTENUATION AND ALGAL BIOMASS IN WATER FROM ENCLOSURES.

Experiments were conducted in enclosures to assess the interaction among depth and dissolved organic matter on the biomass of phytoplankton and the UV transparency of water over ten weeks in summer at the Experimental Lakes Area (northwestern Ontario). Two sets of six 1 m^2 enclosures spanning a depth gradient from 0.5 to 2.3 meters installed in Lake 239. One set of enclosures was filled with lake water (DOC 10 mg/L), the other set was filled with stream water (DOC 28 mg/L). Phytoplankton biomass was generally higher for the streamwater treatments. Response of phytoplankton was consistent with photoinhibition at low DOC concentration and shallowest depth, and with light limitation at highest DOC concentration and greatest depth. UVR attenuation decreased in all enclosures over time. Loss rates for UVR attenuation from the stream water set were about eight times that of the lake water set. Further, loss rates depended directly on depth. Thus, climatic change resulting in decreases in DOM loading and decreases in depth interact positively to increase the exposure of aquatic organisms to UVR.

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REMOVAL OF SURFACE WATER CONTAMINANTS USING PHYTO-REMEDIATION

The usefulness of phytoplankton to remove surface water contaminants was investigated. Nine large mesocosms (90 m^3) were suspended in decommissioned DJX uranium pit at Cluff Lake, SK. Mesocosms were filled with contaminated mine water and amended with nutrients weekly for five weeks to encourage and sustain algal growth. Algal growth was rapid in fertilized mesocosms (as demonstrated by algal fluorescence). Nutrient amended mesocosms showed reductions in surface water contaminants from 0-79 %. Zn, and Cu showed the greatest reductions (>50 %). Co, As, Ni, U, and Mn had intermediate reductions (≤50 % to >12 %). Meanwhile, Ra and Mo showed little or no response to the 5 week treatment (≤12 %). When reductions occurred, contaminant concentrations in surface waters were inversely proportional to the amount of nutrient added to each mesocosm. Sediment trap (placed at the bottom of each mesocosm) contaminant concentrations corroborated changes in surface water concentrations. Our results indicate that phyto-remediation (in mesocosms) in DJX pit increased phytoplankton biomass, and via sedimentation, decreased many surface water contaminants.

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RESISTANCE OF THE PREY TO PREDATOR RATIO TO ENVIRONMENTAL GRADIENTS AND TO BIOMANIPULATIONS

Species and their abundances change along environmental gradients, and populations of some species are decimated by introductions of foreign species. We show that the prey to predator species ratio is resistant to change. We determined that ratios were about 3/1 for fifty lakes with diversity ranging from 5 to 58 taxa, and with a total combined fauna of 140 insects, crustaceans, and fish. Ratios were not related to chemical, thermal or physical characteristics of lakes. Ratios were generally the same for fishless lakes, those with one or two introduced predators (salmonids), and for lakes with more complex communities with up to 14 predators including five fish species. For the simplest model, this suggests that when a fish species is introduced and becomes established in a lake there is a fundamental ecological compensatory adjustment with either a three species increase in the diversity of prey or the loss of a predator (but no change in diversity). However, we show more complex prey-predator ratio changes occur because certain keystone species regulated community structure and prey diversity. When the keystone fish (a predatory salmonid) was removed from 5 lakes, the penultimate littoral predator (lake chub) occupied both the pelagic and littoral zones. Consequently, amphipod density decreased, chironomid density increased, and total zooplankton and benthic diversity increased by 31% or 7.8 taxa per lake on average. The mean prey/predator ratio for these five lakes increased significantly from 2.32/1 to 4.16/1. These community based prey/predator ratios were established by single keystone species from their influence on prey, other predators, and community structure.

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USING STABLE ISOTOPES TO DETERMINE P/R RATIOS IN LAKES

The relative importance of primary production over community respiration in both marine and freshwater ecosystems has been a highly debated subject for many years. If aquatic systems are net heterotrophic they are net sources of CO_2, whereas if photosynthesis exceeds respiration aquatic systems can act as sinks for carbon dioxide. Growing concern about global climate change necessitates an improved understanding of carbon cycling in aquatic ecosystems. In an attempt to quantify carbon cycling in aquatic ecosystems we have employed stable isotopes of dissolved inorganic carbon and dissolved oxygen to determine the metabolic balance of lakes. Twenty-one lakes with varying physiochemical properties were examined on a monthly basis and the metabolic balance determined.

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THE ROLE OF EUTROPHICATION IN STRUCTURING ZOOPLANKTON COMMUNITIES

Most ecologists are interested in understanding how organisms respond to changes in their environments. Zooplankton communities have been shown to have a wide range of responses to increased eutrophication, for example. These responses can be, for example, changes in energy allocation, size structure, feeding behavior and a whole set of other physiological responses, as well as changes in the phenotypes or even genotypes of these communities. This high variability in the response of zooplankton to eutrophication has triggered some heated debates about the relative importance of each of these changes (i.e, physiology, reproduction, phenotypic plasticity etc…) in the ecology and evolution of zooplankton. Based on a series of experimental studies conducted at different scales in time and space a model will be presented to explain the relative important of some of these changes in structuring zooplankton communities in lakes.

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CAN WE ACCURATELY AND RAPIDLY ESTIMATE PHYTOPLANKTON COMMUNITY STRUCTURE IN AQUATIC SYSTEMS USING NEW *IN SITU* TECHNOLOGIES?
Measurement of algal biomass is widely used in limnology and oceanography. The common methods are based on chlorophyll estimation and involve several analytical procedures. The typical delay between sampling the water and obtaining the final estimates of chlorophyll biomass can be at least few days. These delays preclude the use of those conventional methods for large measurements tasks such as spatial and temporal sampling at a fine resolution necessary for understanding the distribution of phytoplankton communities. We evaluated a new in situ technology (fluoroprobe) designed to estimate total algal biomass and determine the relative biomass of 4 algal classes based on the fluorescence of their characteristic photosynthetic pigments (Bluegreens, Greens, Diatoms, and Cryptophytes). The fluorprobe was deployed in different lakes with a wide range of chromophoric dissolved organic carbon to evaluate it interference of chlorophyll fluorescence. We also compared the chlorophyll estimates of the fluoroprobe with conventional spectrophotometric methods and cell counts. The results of the validation and their implication for limnological and oceanographical studies are discussed.

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TRACKING ACIDIFICATION TRENDS IN NOVA SCOTIA USING PALEOECOLOGICAL TECHNIQUES.
Acidification of surface waters due to atmospheric inputs of strong acids has been repeatedly cited as a major threat to aquatic ecosystems in eastern Canada and especially in Nova Scotia, where shallow glacial derived soils and non-weathering bedrock increase the sensitivity of lakes to acidic deposition. While LRTAP studies have monitored surface water chemistry in 72 lakes since 1983, due to the absence of pre-impact data, it is not known whether acid deposition have caused these lakes to acidify, when or by how much, and what role DOC has had as either a natural acidification agent or as a buffer. In this study (part of a 5-year, multi-disciplinary, NSERC Strategic Grant assessing water quality in Nova Scotia and Southern New Brunswick), 6 LRTAP lakes have been sampled from the Yarmouth, Bridgewater, and Kejimkujik National Park study areas. Using diatoms as paleoecological indicators, assemblages have been studied for both current and pre-impact (pre-1850) periods and assessed for changes related to acidification and the role of DOC.

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CONCORDANCE BETWEEN ABIOTIC AND PHYTOPLANKTON RECOVERY TRAJECTORIES OF ACIDIFIED BOREAL LAKES OVER A 20-YEAR PERIOD

Lower trophic levels are considered to be the earliest indicators of ecosystem recovery from stress because of their expected wide dispersal potential and rapid growth. However, several lines of evidence suggest that certain microbial assemblages, such as phytoplankton, show unexpectedly slow recovery rates (i.e. poor resilience) and long delay responses to chemical improvements in acidified boreal lakes. To quantify the recovery of phytoplankton in recovering acidified boreal lakes, we resurveyed 25 lakes in the Sudbury area in 2002 using the same sampling protocol of an earlier survey conducted by Ken Nicholls and others in 1981. Gradient analyses using taxonomic and select limnological variables were performed to determine recovery trajectories within these lakes. Lack of concordance between abiotic and biotic recovery trajectories show that phytoplankton assemblages may not be closely tracking chemical improvements in these lakes because of the confounding effects of complex interactions between acidification, climate change, and stratospheric ozone depletion and increased ultraviolet-B radiation.

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WHAT HAPPENS TO MERCURY, ONCE TRAPPED BY EPIPHYTIC BIOFILM?

In aquatic environment, mercury (Hg) accumulated in the biota is mainly under its organic form, methylmercury (MeHg). As mercury arrives to aquatic systems principally under its inorganic form, questions remain about: 1) sites other than anaerobic sediments where Hg is methylated, and 2) what are the transfer paths from methylators sites to fishes. Here, we will try to answer to the first question considering the epiphytic biofilms as potential methylation sites. Epiphytes are at the base of the food web and they have the potential to play an important role in mercury transfer. The specific objectives of the project were to verify epiphytes contribution to mercury accumulation and methylation. The study was carried out in the wetlands of the Baie St-François, St-Lawrence River. We sampled epiphytes to analyse: 1) their importance in relation to the host (emergent and submerged macrophytes); 2) their concentrations of Hg and MeHg; 3) their methylation rates. The inorganic Hg methylation was mesured by incubating epiphytes with the stable isotope ^{199}Hg. Our preliminary results showed that: i) Algal biomass ranged from 35.28 to 209.30 µg of chlorophyll-a/gDW and that epiphytes were more abundant on submerged macrophytes than on emergent ones. ii) Epiphytes attached to floating macroalgae had higher MeHg concentrations (23.34 ng/gDW) than epiphytes attached to submerged or emergent macrophytes (4.84 to 6.81 ng/gDW). iii) Epiphytes methylation rates ranged from 0.23 to 3.44 %. iv) Net methylation seems to follow a diurnal cycle.

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DOES GRAZING PRESSURE DIFFER BETWEEN STRESSED AND RECOVERED BOREAL LAKE ECOSYSTEMS?

Several ecosystem processes, such as grazing, are assumed to decline as a consequence of environmental stress, and thereafter, increase as the stress is removed. For example, previous studies have concluded that the decline in filamentous green algae in recovering acidified lakes is the result of increased grazing pressure. However, it is possible that this conclusion is not valid, and perhaps grazing pressure remains constant during recovery owing to a size-shift from numerous small acid-tolerant to fewer larger acid-sensitive species (i.e., functional compensation). This hypothesis was experimentally tested in mesocosms that excluded different size categories of grazers (e.g., invertebrates, tadpoles, minnows) from periphyton in three acidified and three chemically recovered lakes located in Killarney Provincial Park, Ontario. Grazer impacts on periphyton were assessed at the community- and species-levels over a 90-d period. The preliminary results do not support our hypothesis because they show that total grazing pressure does differ between acidified and recovered boreal lakes. Specifically, the compensatory effect of abundant acid-tolerant grazing chironomids in the acidified lakes is negated because of increased predation by other acid-tolerant insects, such as odonates and corixids. These findings suggest that grazing pressure does decline in boreal lakes during acidification, and that the re-establishment of a dominant life form (i.e., fish) is required to increase grazing during ecosystem recovery.

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DOES ENVIRONMENTAL WARMING INCREASE INVASION OF COLDWATER ZOOPLANKTON ASSEMBLAGES?

Higher trophic levels in northern freshwater ecosystems are expected to be the most sensitive to the impacts of climate warming. Therefore, we hypothesized that zooplankton assemblages in fishless alpine lakes are suppressed by environmental warming, thereby opening them to invasion if species can disperse from lower montane sites. Ordination analyses of crustacean zooplankton data from 379 mountain lakes and ponds in the Canadian Rocky Mountains identified species-poor alpine assemblages as consisting primarily of the calanoid copepod *Hesperodiaptomus arcticus* and the cladoceran *Daphnia middendorffiana*. We conducted a 3-factor (warming x native species present x colonization potential) experiment to determine if an increase of 7°C in water temperature and species dispersal would facilitate invasion of these coldwater specialists by montane species collected from five montane lakes in the Bow Valley. Preliminary results from our 28-day growth chamber experiment reveal that the interactive effects of warming and colonization involve suppression of *H. arcticus* and increased population growth by both alpine and montane daphnids. Our findings suggests that climate warming may shift zooplankton community structure in coldwater ecosystems towards daphnid-dominated assemblages, which could have pronounced impacts on related ecosystem processes, such as grazing and trophic energy transfer to higher trophic levels (e.g., fish).

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EFFECTS OF CONSUMERS ON NUTRIENT KINETICS IN PLANKTONIC FOODS WEBS

Several hypotheses have been developed to describe the direct and indirect effects of consumers on planktonic food web function (nutrient cycling). These hypotheses were tested with a diverse set of lakes (n >47) that had different fish assemblages (including fishless lakes). Oligotrophic, mesotrophic and eutrophic lakes were included. Food web structure conformed to the predictions of the trophic cascade hypothesis, except in lakes from the Experimental Lakes Area. The prediction that top-down effects on food web structure would be greatest in oligotrophic lakes was not supported (top-down bottom-up hypothesis). Kinetic results did not support existing hypotheses. For example, the turnover rate of phosphorus in pelagic food webs was unaffected by the presence or absence of various fish assemblages. Similarly, the degree of nutrient limitation remained unaffected by the presence or absence of fish assemblages

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IMPORTANCE OF PROTOZOA TO THE PELAGIC FOOD WEB OF LAKE VICTORIA, EAST AFRICA

In recent decades the importance of the microbial food web and how it interplays with the classical food chain has gained considerable attention. Intermediate trophic levels, such as flagellates and ciliates, can be an important link for carbon flux from the pico and nanoplankton size fractions to zooplankton and planktivores. Studies have shown that protozoa can increase the nutritional value of poor quality food for higher trophic levels in systems where inedible and/or poor quality algal cells dominate the phytoplankton community. Both heterotrophic flagellates and ciliates are also important grazers on bacteria. In oligotrophic lakes and oceans heterotrophic flagellates tend to be the dominant grazers; in contrast, ciliates have been observed as the principal grazers of the bacterial community in eutrophic lakes.

Depth profiles and grazing experiments were performed in Lake Victoria, East Africa, from May to July, 2002 to examine the interactions among the components of the microbial food web. Previous studies have found bactivorous ciliates to dominate the ciliate community in lakes with high bacterial densities. Average bacterial densities in Napoleon Gulf ranged from 6.9±0.2 to 12.3±0.6 cells x $10^6 ml^{-1}$ (SE) between May and July, indicating that ciliates could be important predators of the bacterial community. Size fraction experiments indicate a shift in grazing pressure on the bacterioplankton from large ciliates (> 40 μm) and small zooplankton in June to flagellates in July. Consistent with the shift in grazing pressure, flagellate abundance was significantly higher in July compared to June ($P=0.019$). Heterotrophic flagellates and cryptophytes were the most abundant flagellates throughout the sampling season, with oligotrichs, scuticociliates and peritrichs dominating the ciliate community. Average ciliate abundance was similar in May and June (52±1.9, 52±0.7 cells·ml^{-1} SE), with significantly higher densities occurring in July

(75±0.1 cells·ml^{-1} SE). These results are comparable to ranges found in tropical lakes of the same trophy, yet higher than those reported from oligotrophic Lake Malawi. With the plankton of Lake Victoria dominated by colonial cyanobacteria and raptorial zooplankton, protozoa could be an important component of this pelagic food web.

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BOTTOM-UP MEETS TOP-DOWN : RESULTS OF A LONG-TERM FERTILIZATION STUDY
PART 1: RESPONSE OF THE PLANKTON AND BENTHOS

This study examines the food web response to long-term fertilization of a small, shallow (25.7 ha, 1.3 m mean depth) oligotrophic Newfoundland lake. Summer fertilization was initiated in 1991 to increase annual N and P loading by 5-10 fold in the first two years with a subsequent tripling of the dosage during 1993-96. There was a relatively modest less than two-fold increase in planktonic primary production and chlorophyll relative to a control lake in the early years followed by a declining response in later years. There was little discernable effect on the zooplankton. In contrast, there was a marked 5-100 fold benthic community response to fertilization particularly among groups at lower trophic levels with short life cycles such as fingernail clams, chironomids and snails all of which demonstrated a step response to the increased fertilizer dosage. The chironomids began declining in the sixth year of fertilization, possibly due to the top-down effect of stickleback predation. Longer life cycle invertebrates such as the mayflies, dragonflies, damselflies and caddis flies exhibited a slower, more gradual numerical response. Increased benthic invertebrate abundance leads to the expectation of enhanced fish populations which consisted of brook trout, juvenile Atlantic salmon and threespine stickleback. This response is documented in Part 2.

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BOTTOM-UP MEETS TOP-DOWN : RESULTS OF A LONG-TERM FERTILIZATION STUDY
PART 2: RESPONSE OF THE FISH COMMUNITY AND AVIAN PISCIVORES

This study examines the food web response to long-term fertilization of a small, shallow (25.7 ha, 1.3 m mean depth) oligotrophic Newfoundland lake. Part 1 documented that benthic invertebrates responded most to the fertilization. A massive increase in chironomid abundance was reflected in their increased proportion in threespine stickleback diet in the experimental lake versus two control lakes. Experimental lake sticklebacks had a higher ration than the controls, exhibited an increase in relative condition, and subsequently had 30% higher fecundity which lead to their increased abundance in fyke net catches. Catch rates declined in later years, possibly due to increased parasite loads. Increased gastropod abundance in the fertilized lake was reflected by their increased importance in brook trout diet relative to the controls. Brook trout abundance increased dramatically in the fertilized lake in the fourth year but then unexpectedly began to decline coincident with observations of fish with fresh wounds likely attributable to loon attacks. Juvenile Atlantic salmon abundance showed a similar pattern. Loons began nesting on the experimental lake in the second year and they successfully raised a chick for five years running as compared to none for the control lakes. A marking study in year six confirmed that trout mortality was much higher in the experimental lake, especially for the larger fish which would be preferred prey. Loon forage requirement data indicate that a nesting pair with one chick could consume the entire salmonid standing stock if they confined their feeding only to the experimental lake. It thus appears that increased salmonid biomass triggered a behavioural response by the loons; the frequency of wounded fish subsequently declined as salmonid biomass decreased back towards control levels.

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REDUCED ECOSYSTEM PREDICTABILITY ARISING FROM POLLUTION: FOSSIL AND HISTORICAL RECORDS OF LAKE RESPONSE TO SEWAGE, ITS DIVERSION AND CONTINUED LAND USE

Ecological theory predicts that fertilized ecosystems should first resist community change by increasing the abundance of native taxa. However, with continued eutrophication, ecosystem predictability should decrease, as more variable species invade the original community. Unfortunately, little is known of whether nutrient diversion returns lakes to their original state (resilience) or whether variability remains high because of persistent alterations of food-web structure initiated by fertilization. These hypotheses were tested using a combination of historical records of plankton abundance (1949-2002), near-annual fossil records (algal pigments, Cladocera, stable isotopes of C and N) and dynamic linear models (DLM) to quantify the response of Lake Washington to inputs of urban sewage (ca. 1900-1968) and persistent land-use change (1851-present). Lake Washington is a 87.6 km^2 monomictic lake (hydraulic residence ~2.4 yr) located in urban Seattle, Washington, USA (watershed population ~1.4 million). Deforestation of the watershed began with urbanization ca. 1850, while water levels were reduced 3.3 m in 1916 when lake outflow was diverted to an artificial channel that also allowed entry of anadromous fishes (*Oncorhynchus nerka, O. tshawytscha*). Minimally-processed effluent from up to 11 wastewater plants was received by the lake until 1968, leading to blooms of *Oscillatoria* 1955-1975 and three-fold increases in total algal biomass. Complete diversion of effluent to the Pacific Ocean by 1968 reduced algal abundance and increased transparency within 5 years; however, longfin smelt (*Spirinchus thaleichthys*) populations also expanded, eliminated predatory *Neomysis mercedis* and allowed *Daphnia* spp. to further increase transparency after 1976. Comparison of fossil and historical records revealed that sediments recorded all major changes in plankton community composition, but that despite declines in lake production to near-baseline levels, N cycling is still disrupted due to intense urbanization. Consistent with these changes, modest but increasingly frequent blooms of cyanobacteria (*Aphanizomenon flos-aquae, Microcystis aeruginosa*) have been recorded since 1988, demonstrating that ecosystem variability remains high despite elimination of sewage-derived nutrients.

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CARBON AND NITROGEN STABLE ISOTOPE IN ZOOPLANKTON: WHAT'S UP IN RESERVOIRS ?
Flooding of a large surface area during the creation of reservoirs is generally followed by a large increase in organic matter and nutrients in the water. Such drastic change in water quality may be more pronounced in young reservoirs where recently flooded material is being decomposed. Thus, reservoirs are particularly relevant ecosystems to evaluate the impact allochthonous versus autochthonous carbon and effect of changes in productivity within the food web.
This presentation focuses on zooplankton community and its dynamic in Northern Quebec reservoirs. A series of 6 large reservoirs and 15 lakes were sampled to obtain carbon and nitrogen stable isotope signatures of zooplankton. Organisms were sorted according to taxonomic groups and/or main genus since their signature may vary according to food source.

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RELATIVE IMPORTANCE OF CLIMATE, LAKE ONTOGENY AND LAKE-SPECIFIC PROCESSES IN REGULATING LAKE PRIMARY PRODUCTION AND COMMUNITY STRUCTURE IN TWO ARCTIC LAKES.
In the closed-basin lakes around Søndre Strømfjord (West Greenland), lake-water salinity is primarily determined by the balance between evaporation (E) and precipitation (P). Diatom-based sediment core reconstructions from these lakes show that there have been centennial- and millennial-scale shifts in lake-water conductivity (and therefore P:E balance), with an overall trend of increasing conductivity throughout the Holocene. We used Holocene sediment records from two such climate-sensitive lakes to assess the relative importance of climate (diatom-inferred conductivity), lake development (ontogeny) and lake-specific processes in determining primary producer abundance and community structure (inferred from sedimentary pigments). Variance partitioning analyses showed that the effects of lake ontogeny were most evident in the first ~1000 years of lake development, when filamentous cyanophytes were abundant. Conductivity was positively correlated with algal abundance on millennial timescales, likely caused by the increased colonisation of benthic habitats when lake levels lowered. However, lake biota responded differently to conductivity shifts as lakes aged, indicating a substantial interactive effect of lake ontogeny and conductivity. As lakes aged, periods of meromixis became more frequent (after ~1000 years BP), signifying a

state change in biotic response to conductivity fluctuations once a threshold conductivity level had been exceeded. After this time, communities oscillated on centennial timescales between one composed of siliceous algae, cryptophytes and purple sulphur bacteria (indicating meromixis), and another composed of filamentous cyanophytes. Synchrony analyses suggested that photoautotrophs responded similarly among lakes ($r< 0.75$) on longer timescales (10^3 years). However, lakes became asynchronous during periods of intense climate forcing and on shorter (10^2 year) timescales, when individualistic lake responses became more apparent. Together, these analyses suggest that although biotic response to climate may be predictable over millennia, predictions on timescales relevant to humans may be undermined by abrupt changes in ecosystem state and individualistic lake response during periods of intense climate forcing.

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ASSESSING LAKE TURNOVER USING THREE DIMENSIONAL EXCITATION EMISSION FLUORESCENCE SPECTROSCOPY

Autumn lake turnover is known to dramatically alter the chemical and biological dynamics established within a once stratified water body. Among the altered dynamics is the composition of natural organic matter throughout the water column. In this study, three dimensional excitation emission (3D-EEM) fluorescence spectroscopy was used to evaluate changes to the structure of organic matter in the water column during autumn lake turnover. Fluorescent signatures were distinguished by conducting component analysis on the fluorescence matrix. Changes in the fluorescent signature of organic matter were compared to water quality parameters in order to determine if physico-chemical conditions of lake water are related to the composition of organic matter. 3D-EEM fluorescence spectroscopy was conducted on profiles from three Precambrian shield lakes in the south-central region of Ontario before, during and after turnover.

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SPATIAL TRENDS AND HISTORICAL INPUTS OF MERCURY AND LEAD IN EASTERN AND NORTHERN CANADA INFERRED FROM LAKE SEDIMENT CORES (P)

Mercury (Hg) has emerged as the top priority contaminant in the Arctic and in inland lakes of central and eastern Canada in the light of evidence for widespread elevated levels in fish, and increasing concentrations over time in biota and in lake sediments. However, there is limited information on current or past deposition over Pan-Northern Canada. To address this gap we examined the deposition and historical temporal trends of mercury, as well as lead (Pb), over a broad geographic area from southwestern NWT to Labrador and from the US northeast to Northern Ellesmere Island using dated sediment cores from 36 remote lakes. Possible post-depositional movement of Hg was examined using manganese (Mn) and iron (Fe) geochemical markers as well as organic carbon. Mercury concentrations in surface slices of each core varied from 0.017 to 0.283 ug/g (dry wt) and Pb from 2.8 to 41.5 ug/g (dry wt). No geographic trend of Hg or Pb was evident based on concentrations or on fluxes (ug m^{-2} yr^{-1}). Highest anthropogenic enrichment factors (EFs) of Hg and Pb were found in cores from lakes in Québec and Labrador while lowest EFs were generally in the cores from NWT. There was a weak but statistically significant negative relationship between Hg EF and longitude ($P =0.02$) indicating higher anthropogenic enrichment in cores from Eastern Canada and the high Arctic compared to NWT. EFs for Pb in sub-Arctic cores were also significantly negatively correlated with longitude ($P <0.01$) and Pb EFs declined exponentially with latitude ($P<0.001$). Mercury deposition appeared to have peaked in the 1980's and was on the decline in the 1990s in about half of the cores analysed and in all cores with high temporal resolution. "Reactive" Fe and Mn were correlated with Hg in a about 25% of the cores mainly in lakes with very low sedimentation rates, i.e. < 50 g m^{-2} yr^{-1}. The results for Hg and Pb are consistent with the greater density of Hg sources in Eastern North America such as coal burning power plants and, in the case of Pb, with proximity to former emission areas for alkyl lead.

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WHY ARE PCBS AND TOXAPHENE HIGHER IN LAKE TROUT FROM LAKE SUPERIOR THAN IN NEARBY SMALL LAKES?

Atmospheric deposition is the principal route of input of persistent organochlorine compounds (OCs) such as PCBs and toxaphene to Lake Superior as well as to other isolated lakes in northwestern Ontario. Although comparative data are limited, both toxaphene and PCBs, as well as other OCs are higher in lake trout (*Salvelinus namaycush)* from Lake Superior than in lake trout from nearby inland lakes despite similar atmospheric inputs. To examine this issue in more detail we sampled the food webs of western Lake Superior and Siskiwit Lake (Isle Royale) in 1998 and four nearby lakes in northwestern Ontario in 1999-2000. Samples were analysed using congener specific analysis of PCBs and toxaphene and stable isotope ratios of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) were used to characterize food webs. Microplankton size spectrum, speciation, and nutritional status were determined in all lakes except Siskiwit. Toxaphene concentrations in lake trout from Lake Superior (N=95) averaged (∀SD) 889∀896 ng/g wet wt compared with means of 15 – 149 ng/g in Siskiwit, Eva, Paguchi, Sandy Beach and Thunder lakes. Total PCB concentrations in the Lake Superior lake trout averaged 556∀411 ng/g wet wt compared with means of 89 – 133 ng/g in the smaller lakes. Average lipid content of the lake trout ranged from 4.6% in Siskiwit Lake, to 12% in Lake Superior, and to 16% in Eva Lake and did not explain lake to lake variation. Mean $\delta^{13}C$ for lake trout ranged from (-25 to -29 ‰) while mean $\delta^{15}N$ values ranged from 10 to 12 ‰ and were highest in samples from Paguchi and Sandy Beach Lakes. Trophic magnification factors derived from regressions of PCB 153 concentrations (lipid wt) versus $\delta^{15}N$ ranged from 1.39 in Eva Lake to 1.54 in Lake Superior and did not differ significantly among lakes indicating similar rates of accumulation of recalcitrant OCs in pelagic food webs. Concentrations of total PCBs and toxaphene in lake trout werepositively related to proportions of the algae Peridineae which was 3x higher in Superior than in the other lakes. The results suggest that phytoplankton composition may be a significant factor for explaining differences in levels of OCs between Superior and other nearby lakes.

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PATTERNS AND CONTROLS OF PRAIRIE LAKE SYNCHRONY DURING THE 20th CENTURY: EVIDENCE FROM FOSSIL PIGMENTS.

Climatic variability is expected to increase the temporal coherence of lake ecosystems, yet little evidence exists of such synchrony over multiple decades. Here we assessed ecosystem synchrony by quantifying changes in the concentrations of 12 algal pigments in sediments of seven prairie lakes from 1860 to1994. At the community level, lakes exhibited significant coherence (intra-class correlation coefficient=30%, p ~0.05), although the synchrony of individual algal groups varied greatly among sites and biomarker compounds. Seven pigments showed consistently high synchrony among all pairs of lakes, arising either because of degradation of labile compounds (Chl *a*, fucoxanthin), or because of climatic controls of the abundance of colonial cyanobacteria (oscillaxanthin, myxoxanthophyll, lutein-zeaxanthin), diatoms (diatoxanthin), and cryptophytes (alloxanthin). In contrast, historical changes in total algae (as ß-carotene, pheophytin *a*), Nostocales cyanobacteria (canthaxanthin) and photo-protective compounds (UVR-absorbing pigments) were asynchronous , suggesting that their variability was regulated by lake-specific factors. Only total cyanobacteria (echineone) exhibited landscape patterns of synchrony, with higher coherence among adjacent sites. Exploratory analyses demonstrated that relationships between fossil pigment concentrations and climatic indices were noisy but suggested that preservation of synchronous pigments varied as a function of the Pacific Decadal Oscillation or the Northern Atlantic Oscillation. Together, these patterns demonstrate that climatic variability during the 20th century resulted in substantial synchrony of shallow prairie lakes.

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EFFECTS OF FLOW AND RAMPING RATE FROM A HYDROELECTRIC DAM ON MACROINVERTEBRATE ABUNDANCE AND DIVERSITY WITHIN THE MAGPIE RIVER, WAWA ONTARIO

Aquatic macroinvertebrates are frequently used to study anthropogenic, toxicological, and hydrological impacts on aquatic systems, including effects of hydroelectric power generation on downriver communities. Because of their range in sensitivity to various forms of impact, an assessment of invertebrate abundance and diversity can indicate the health of that ecosystem. Effects of the currently restricted ramping rate (the rate of change in flow over time) on the macroinvertebrate community is one issue of concern for the possible change in ramping rate for the Steephill Falls hydroelectric dam on the Magpie River, Wawa, Ontario. It is known that invertebrate drift abundance and diversity is affected by flow regimes of dam regulation, with typically decreased abundance and diversity with close proximity to the dam. To assess invertebrates, 3 drift nets were placed at 5 sites downstream of the dam, for 10 hours each of day and night collections per site, per trial. Two Surber net collections were also performed at each site to assess differences between benthic and drift taxa. Sampling was replicated on the unregulated Batchawana River as a reference. Both rivers were studied concurrently in spring and summer 2001, and spring 2002, with 3 trials per season. A single site above the dam was sampled as an alternative reference site, as well as each of the two main tributaries, Lena Creek and Catfish Creek, to assess their input to the Magpie River. Results will be presented to assess any relation of abundance and diversity with daily ramping rates, high flow and low flow conditions, attenuation of impacts with distance from dam, composition of non-drifting benthos found in drift, differences between night and day, trends found among seasons and years, all in relation to reference sites. Relationships between flow and ramping rate with invertebrate drift would provide predictive models for future quantitative assessments of the benefit of ramping rate restrictions when negotiating operational regimes of hydroelectric dams.

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SPATIAL HETEROGENEITY IN LAKE METABOLISM

Using a continuous-flow aqueous infrared gas analyzer, we mapped surface pCO_2 of a small embayment of L. Memphremagog over a diel cycle to estimate ecosystem night-time respiration and how it is spatially distributed. We found large differences in the diel amplitude of the production/respiration balance between the shallow and deep areas suggesting that the usual bottle measurements collected at the deepest point can seriously bias estimates of whole ecosystem metabolic balance.

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THE EFFECT OF DISSOLVED ORGANIC CARBON (DOC) AND INORGANIC NUTRIENTS ON PHYTOPLANKTON AND BACTERIOPLANKTON BIOMASS AND PRODUCTIVITY

Systems having high dissolved organic carbon (DOC) concentration (an operational measure of dissolved organic matter) are often dystrophic, a trophic state where productivity is less than that predicted from apparent nutrient availability. Mechanisms hypothesized to cause dystrophy include attenuation of photosynthetically active radiation by DOC, and direct or indirect control of nutrient availability by dissolved organic matter. The effects of inorganic nutrient enrichment on the DOC dependence of phytoplankton and bacterioplankton biomass and productivity was the objective of this study. Experiments were conducted in Lake 224 at the Experimental Lakes Area, northwestern Ontario. A DOC concentration gradient was established in two sets of six enclosures using water from Lakes 224 and 225. One set of enclosures was enriched with inorganic nitrogen and phosphorus.

Phytoplankton biomass increased significantly with increasing DOC concentration in the reference enclosures but primary productivity was independent of DOC concentration. Nutrient enrichment significantly increased phytoplankton biomass but biomass was no longer dependent on DOC concentration. Primary productivity in the nutrient enriched enclosures reached a maximum at a DOC concentration range of 5.8 mg L^{-1} to 6.2 mg L^{-1} but low DOC and high DOC concentrations inhibited and limited productivity, respectively. Bacterioplankton abundance and productivity in the reference enclosures increased significantly with increasing DOC concentration but bacterioplankton turnover was low. Bacterioplankton abundance in the nutrient enriched enclosures was independent of all measured parameters. Bacterioplankton productivity and turnover in the nutrient enriched enclosures depended on DOC concentration. Increased phytoplankton biomass due to nutrient enrichment affected bacterioplankton abundance and productivity indirectly. These results suggest that the phytoplankton and bacterioplankton directly depended on DOC concentration in the reference enclosures. In the nutrient enriched

enclosures, inorganic nutrients regulated phytoplankton and inorganic nutrients and phytoplankton regulated bacterioplankton.

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ZOOPLANKTIVORY IN LAKES: HAVE WE NABBED THE WRONG SUSPECT?
The early work of Brooks & Dodson established two paradigms in freshwater ecology: (1) Planktivorous fish are the major determinants of zooplankton community structure, and (2) fish consume large zooplankton while invertebrates eat only small ones. These two paradigms form the basis of a third – the trophic cascade hypothesis. In clear, shallow lakes (e.g., montane ponds), strong effects of fish on zooplankton biomass and species composition have been demonstrated many times, but deep, stratified lakes are a different story. Surveys of deep lakes lakes show no clear relationship between the biomass of zooplankton and fish. Neither do fluctuations in the biomass of fish strongly affect zooplankton biomass. Introductions of large, invertebrate planktivores ("macroinvertebrates") on the other hand, typically have devastating impacts on both zooplankton biomass and species composition. Using data collected from published studies, I use two approaches to comparing the effects of fish and macroinvertebrate planktivores. In before/after analyses, I studied the effects on zooplankton of fluctuations in the biomass of fish and macroinvertebrates. The median impact on zooplankton biomass was much higher for macroinvertebrates than for fish. In another type of analysis, I compared the percentage of prey production consumed by fish and macroinvertebrate predators, and again found that macroinvertebrates had much strong effects. Another important finding was that the size range of prey affected by fish and macroinvertebrates was the same. Fish and large invertebrate predators do not have the zooplankton resource partitioned, as the cascade model suggests. Instead, they are competitors which has very different implications for the functioning of lake food webs.

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THE EFFECT OF LARGE-SCALE WOOD REMOVAL ON PERIPHYTON AND INVERTEBRATES ON SUBMERGED WOOD IN LAKES.
The addition of wood to aquatic systems has long been considered beneficial by fisheries resource managers. The structural complexity supplied by submerged coarse woody material (CWM) can provide protection from predation, decrease intraspecific competition through visual isolation, and provide a surface for periphyton and invertebrate production. We conducted a whole-lake wood removal experiment to determine the effects of nearshore habitat perturbation on the fish communities in a suite of small (<25 ha) lakes. Hypotheses related to primary and secondary productivity were developed to test the mechanisms behind any observed fish response. We hypothesized that the removal of nearshore CWM would result in increased productivity of periphyton and invertebrates on the remaining colonization surfaces (wood and artificial substrate) as a compensatory response to reduced competition for available nutrients. To test this hypothesis, wood of varying decay classes was sampled from three treated and one control lake, both before and after the wood removal. The wood samples were processed to determine chlorophyll *a* concentration of the periphyton and diversity and density of the invertebrates. Water column primary productivity was also monitored. On average, the density of invertebrates on wood was approximately 10 times greater than that on undisturbed sediment. Preliminary results suggest that significant biomass of wood-associated periphyton and invertebrates were removed from the lakes through the wood removal, though no compensatory response in primary or secondary productivity on the wood remaining in the system has been detected.

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ARCTIC LAKES AND PONDS: A PALEOECOLGOGICAL PRESPECTIVE OF LONG-TERM ENVIRONMENTAL CHANGE
The persisting general impression of arctic lakes and ponds is that they are somewhat uninteresting and relatively homogenous in their characteristics, simply reflecting the extreme climate of the region, and are usually considered "pristine" and unaffected by local human impacts. Although these generalizations are undoubtedly true to some

extent, after over 20 years of conducting research on arctic lakes and ponds, our view is that arctic sites have limnological characteristics that are at least as diverse as those observed in almost every other lake region on the planet. Furthermore, as a result of global transport of pollutants and the effects of climate warming, both of which are magnified in polar regions, these lakes and ponds deserve much more attention, as they are critical bellwethers of environmental change. Although lakes and ponds characterize most Arctic regions (about 18% of Canada's surface waters are north of 60°N), and are important sentinels of environmental change, very little long-term data are available, and so indirect proxy methods must be used in lieu of these missing data sets. We have been applying both present-day limnological techniques as well as paleolimnological approaches to study long-term environmental change in arctic regions. Our data show that lakes in different settings follow different ecosystem trajectories, dependent on local and regional factors. However, it is now becoming increasingly clear that marked limnological changes have been occurring in many arctic lakes and ponds over the last ca. 150 years that appear to be related to climatic warming. Paleolimnological and archeological data also show that some lakes have been affected by human disturbances at much longer time scales, such as nutrient inputs from Thule Inuit whaling camps abandoned centuries ago.

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CO_2 FLUXES FROM NATURAL LAKES AND HYDROELECTRIC RESERVOIRS IN NEWFOUNDLAND
Actually, there is a debate world wide, concerning the role of the reservoirs in the greenhouse gases (GHG) fluxes and their contribution in the increase of GHG in the atmosphere. Increasing the number of measurements will reduce significantly the uncertainties around a representative mean flux from natural systems as well as from reservoirs. Using an inexpensive floating chamber with a NDIR instrument (Non-Dispersive Infrared) Hydro-Quebec, in collaboration with Newfoundland-Labrador Hydro have measured gross fluxes of CO_2 from several reservoirs and natural lakes. Our results showed a strong similitude between lakes and reservoirs with mean gross CO_2 fluxes ranging from 500 to 2500 mg CO_2-m^{-2}-day^{-1} for natural lakes and from 700 to 3200 mg CO_2-m^{-2}-day^{-1} for reservoirs. These values are similar to those observed in Québec, Manitoba and British-Columbia as well as those from Finland.

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PROGRESS IN THE LONG-TERM RECOVERY OF ZOOPLANKTON FROM SEVERE HISTORICAL ACIDIFCATION AND METAL CONTAMINATION IN SUDBURY LAKES
One-third of the 19000 historically acidified (pH<6) lakes, and the majority of the severely acidified (pH ~4) lakes in Ontario are located in the greater Sudbury area. While recovery of zooplankton from modest historical acidification has been demonstrated, there is, as yet, little evidence of recovery from severe, long-term acidification. We present three decades of changes in zooplankton community composition from four Sudbury lakes – three experimentally neutralized lakes (Lohi, Middle and Hannah), and Clearwater Lake, the acidic reference lake. At the start of the study the four lakes had pH levels near 4, and greatly elevated concentrations of several metals, including Cu, Ni, and Al. Middle and Hannah lakes have remained circum-neutral since the mid-1970s, when they were experimentally neutralized. Lohi Lake was also neutralized, but it re-acidified in the late 1970s. Thereafter, the pH of both Lohi and Clearwater lakes rose monotonically reaching 6 by the late 1990s. Associated with the reductions in acidity, there have been dramatic improvements in water quality and thermal regimes in all four lakes. While there have also been large changes in zooplankton, none of the four zooplankton communities has fully recovered. Their species composition still differs from all 22 non-acidic communities that provided recovery targets. Nonetheless progress is evident. Populations of acidophilic taxa have fallen in all four lakes, and several genera (eg. daphniids, *Holopedium*, *Diaphanosoma*) typically found in non-acidic lakes have re-appeared. Nonetheless, because many acid-sensitive species are still missing, and relative abundances of the remaining taxa remain unusual, it appears that recovery of zooplankton from severe, and long-lasting acidification and metal contamination takes a long-time.