


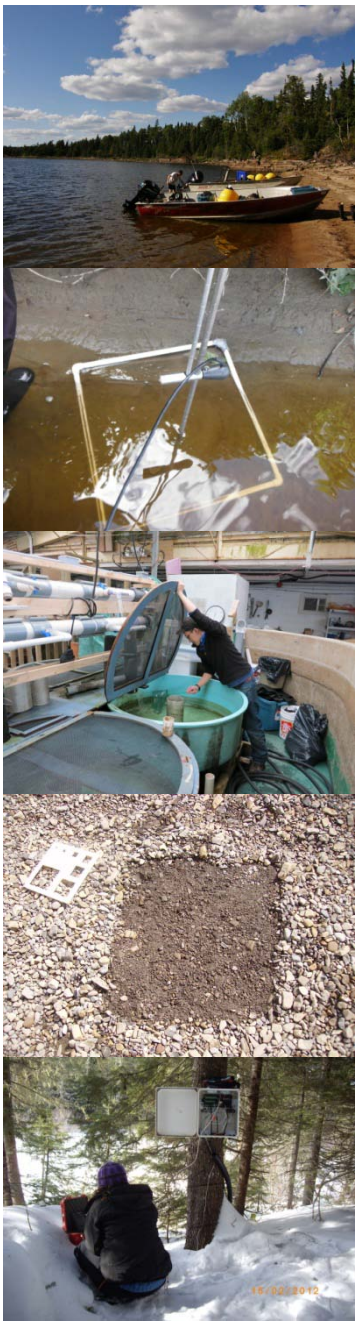

NSERC HYDRONET 3RD ANNUAL SYMPOSIUM

April 9th to 11th, 2013
in partnership with Environnement Illimité Inc. and LVM

Delta Centre-ville, 777 University Street
Montréal, Québec

Acknowledgments

http://www.envill.com/

http://www.dessau.com/fr/services/geotechnique-materiaux-et-environnement

Table of contents

Acknowledgments 2

Participating Organizations 5

Agenda 6

Tuesday, April 9th, 2013 6

Wednesday, April 10th, 2013 7

Thursday, April 11th, 2013 9

Conference Abstracts 11

Decision Tools in Support of Fish Passage 11

Brook trout habitat loss by hydroelectric project: learning's on habitat compensation methods 11

The implementation of mobile hydroacoustic surveys in determining fish distributions in fast flowing fluvial environments - its application in assessing an instream hydrokinetic turbine project 12

Sustainable development of hydropower - Case-studies and perspectives in Norway 12

Challenges and Solutions to Sustainable Hydropower in Canada 13

Hydropower development in the Mekong Basin – From a Canadian Private Environmental Consultancy Experience 13

Entrainment Vulnerability of Bull Trout and Burbot at the Mica Dam (Kinbasket Reservoir, BC) 14

Home range and spatial behaviour of burbot *Lota lota* in a hydropower reservoir in Southeastern BC 14

The spatial ecology of adfluvial bull trout in a large hydropower reservoir 15

Computational Fluid Dynamic Modeling of the Seton, Carpenter and Downtown Reservoirs on the Bridge and Seton River Systems 16

Estimation and Modeling of Fish Production in Reservoirs 16

Comparative analysis of sampling methods to develop habitat-use models of fish productivity in the littoral zone of reservoirs 16

Geostatistical Estimates of Pelagic Fish Production in Freshwater Ecosystems 17

Acoustic Size Spectra of Fishes: Spatial and Temporal Variation within a Hydropower Reservoir along the Winnipeg River 18

Nutrient and Species Richness as Drivers of Fish Productivity in Canadian Waters 18

Establishing the link between fish biodiversity, species richness and biomass production in freshwater ecosystems 19

Characterizing the impact of dams on the thermal regime of the Fourchue River (Quebec) 19

Modélisation thermique de la rivière Fourchue : modèle déterministe versus modèle statistique 20

Year 3 Advances in Two Components of the Integrated SNG Program: Geomorphic Impacts and Flow Regime Alteration. Context and introduction to the approaches followed 20
Using Natural Flow Classes to Estimate Hydrologic Alteration by Dams across Canada, a HydroNet study 21
Remote sensing of river structure in the context of mapping hydraulic habitat at the reach scale 21
Geomorphic Controls on Physical Habitat Variability in a Hydropeaking System 22
NSERC Canadian Network for Aquatic Ecosystem Services 23
The Canadian Aquatic Invasive Species Network II 23
How does flow regulation affect riverine fishes? 24
River ice observations on small regulated and unregulated streams in New Brunswick, Canada 24
The effects of flow regulation on the dynamic winter ice processes of the Kananaskis River 25
Winter condition of Atlantic salmon parr and pre-smolts experiencing hydropeaking flow regimes 25
The behavioural, physiological and morphological responses of fishes to streamflow regulation and the consequent effects on population dynamics 26
Genetic Diversity Analysis of Bull Trout (*Salvelinus confluentus*) in the Upper Lillooet River Basin, British Columbia: Enhancing our Understanding of the Effects of Hydropower Development and Operations on Fish Populations 26
Innovative lake trout spawning and incubation investigations and new information related to the effects of winter drawdown on lake trout in northern reservoirs 27
Field and laboratory assessment of turning pool hydraulics in a vertical slot fishway relative to fish passage 28
Biological evaluation of upstream lake sturgeon passage at the Vianney-Legendre fishway 28
NSERC HydroNet: a Glimpse into the Future. 29
Poster Session Abstracts 29
Long-term variation in food sources and fish trophic position in a natural and regulated river of northern Ontario 29
Nutrient Variability across diverse geographical regions of Canada in Regulated and Reference Rivers 30
Fish living in a regulated river with hydro-peaking operations have better swimming stress responses 30
Comparison of longitudinal patterns in fish growth rates between a regulated and natural river 31
Electrofishing versus visual surveying methods for the estimation of fish community structure 32
Quantifying Fish Avoidance of Small Acoustic Survey Vessels in Canadian Lakes and Reservoirs 32

Participating Organizations

AECOM Tecsult Inc.
BC Hydro and Power Authority
Canadian Electricity Association
Canadian Hydropower Association
Canadian Rivers Institute
Carleton University
Centre for Environmental Design of Renewable Energy
EDI Environmental Dynamics Inc.
Environnement Illimité inc.
Fisheries and Oceans Canada (Central-Arctic, Newfoundland-Labrador, Pacific, Mont-Joli)
Groupe Synergis
Hatfiled Consultants Partnership
INRS-ETE
Iowa State University
Kansas State University
Manitoba Hydro
McGill University
Memorial University of Newfoundland
Ministère des ressources naturelles et de la faune (MRNF)
Ministère du développement durable, de l'environnement et des parcs (MDDEP)
Natural Sciences and Engineering Research Council of Canada (NSERC)
New Brunswick Power Generation Corp.
North/South Consultants Inc.
Nova Scotia Power Inc.
Ontario Ministry of Natural Resources, Trent University
RER – Renewable Energy Research
Simon Fraser University
SNC Lavalin Environment
Université de Montréal
Université du Québec à Montréal
Université Laval, Canadian Aquatic Invasive Species Network
University of Alberta
University of British Columbia
University of Guelph
University of Lethbridge
University of New Brunswick
University of Waterloo

Agenda

Tuesday, April 9th, 2013

08:00 *Introduction: Today and the Days to Come.* **D. Boisclair**, Université de Montréal.

08:20 *Decision Tools in Support of Fish Passage.* **R. McLaughlin**, Associate Professor, University of Guelph.

08:40 *Brook Trout Habitat Loss by Hydroelectric Project: Lessons learned from habitat compensation methods.* **F. Burton**, Project Director, and M. Gendron, Environnement Illimité inc.

09:00 *The Implementation of Mobile Hydroacoustic Surveys in Determining Fish Distributions in Fast Flowing Fluvial Environments - Its application in assessing an instream hydrokinetic turbine project.* **K. Jacobs,** M. Gendron, Environnement Illimité inc.; and I. Hamad, Renewable Energy Research.

09:20 COFFEE BREAK AND POSTER SESSION

SPECIAL SESSION ***"CHALLENGES AND SOLUTIONS TO SUSTAINABLE HYDROPOWER AROUND THE WORLD"***

09:50 *Sustainable Development of Hydropower – Case-studies and perspectives in Norway.* **A. Harby**, Director, Centre for Environmental Design of Renewable Energy (CEDREN), Norway.

10:30 *Challenges and Solutions to Sustainable Hydropower in Canada.* **T. Toner**, Director, Environmental Services, Nova-Scotia Power, Canada.

11:10 *Hydropower Development in the Mekong Basin – From a Canadian Private Environmental Consultancy Experience.* **G. Bruce**, President and Partner, Hatfield Canada, Laos.

11:50 Discussion

12:00 LUNCH

13:00 *Entrainment Vulnerability of Bull Trout and Burbot at the Mica Dam (Kinbasket Reservoir, BC)*. **E.G. Martins**, L.F.G. Gutowsky, Carleton University; P.M. Harrison, University of Waterloo; M. Langford, D. Zhu, University of Alberta; D. A. Patterson, Fisheries and Oceans Canada; A. Leake, BC Hydro; M. Power, University of Waterloo; and S. J. Cooke, Carleton University.

13:20 *Home Range and Spatial Behaviour of Burbot* (Lota lota) *in a Hydropower Reservoir in Southeastern B.C.* **P.M. Harrison**, University of Waterloo; L.F.G. Gutowsky, E.G. Martins, Carleton University; D. Patterson, Fisheries and Oceans Canada; A. Leake, BC Hydro; S.J. Cooke, Carleton University; and M. Power, University of Waterloo.

13:40 *The Spatial Ecology of Adfluvial Bull Trout in a Large Hydropower Reservoir*. **L.F.G. Gutowsky**, Carleton University; P.M. Harrison, University of Waterloo; E.G. Martins, Carleton University; D. Patterson, Fisheries and Oceans Canada; A. Leake, BC Hydro; M. Power, University of Waterloo; and S.J. Cooke, Carleton University.

14:00 *Computational Fluid Dynamic Modeling of the Seton, Carpenter and Downtown Reservoirs on the Bridge and Seton River Systems.* **M.T. Langford**, A.B. Baki, D.Z. Zhu, University of Alberta.

14:20 COFFEE BREAK AND POSTER SESSION

14:50 *Estimation and Modeling of Fish Production in Reservoirs.* **D. Boisclair**, Theme Leader, Université de Montréal, and G. Rose, Memorial University of Newfoundland.

15:10 *Comparative Analysis of Sampling Methods to Develop Habitat-Use Models of Fish Productivity in the Littoral Zone of Reservoirs.* **N.A. Satre**, G. Bourque and D. Boisclair, Université de Montréal.

15:30 *Geostatistical Estimates of Pelagic Fish Production in Freshwater Ecosystems.* **R.A. Pollom** and G.A. Rose, Memorial University of Newfoundland.

15:50 *Acoustic Size Spectra of Fishes: Spatial and Temporal Variation within a Hydropower Reservoir along the Winnipeg River.* **L. Wheeland** and G.A. Rose, Memorial University of Newfoundland.

16:10 Discussion

18:00 COCKTAILS SPONSORED BY ENVIRONNEMENT ILLIMITÉ, INC. (FireGrill Restaurant and Bar, 1490 Stanley, Montréal).

Wednesday, April 10th, 2013

08:00 *Nutrient and Species Richness as Drivers of Fish Productivity in Canadian Waters.* **J.B. Rasmussen**, Theme Leader, University of Lethbridge.

08:50 *Establishing the Link between Fish Biodiversity, Species Richness and Biomass Production in Freshwater Ecosystems.* **P.A. Lennox** and J.B. Rasmussen, University of Lethbridge.

09:10 *Characterizing the Impact of Dams on the Thermal Regime of the Fourchue River (Quebec).* **A. Maheu**, A. St-Hilaire, L. Beaupré, A. Daigle, Institut national de la recherche scientifique; and D. Caissie, Fisheries and Oceans Canada.

09:30 *Thermal Modeling of the Fourchue River: Deterministic Model versus Statistical Model.* **L. Beaupré**, A. St-Hilaire, A. Daigle et N. Bergeron, Institut National de la Recherche Scientifique

09:50 Discussion

10:00 COFFEE BREAK AND POSTER SESSION

10:30 *Year 3 Advances in Two Components of the Integrated SNG Program: Geomorphic Impacts and Flow Regime Alteration. Context and introduction to the approaches followed.* **M. Lapointe**, Theme Leader, McGill University.

10:50 *Using Natural Flow Classes to Estimate Hydrologic Alteration by Dams across Canada, a HydroNet Study.* **F. McLaughlin** and M. Lapointe, McGill University.

11:10 *Remote Sensing of River Structure in the Context of Mapping Hydraulic Habitat at the Reach Scale.* **F. Hugue** and M. Lapointe, McGill University.

11:30 *Geomorphic Controls on Physical Habitat Variability in a Hydropeaking System.* **A. Tamminga**, H. Buehler, L. Winterhalt, and B. Eaton, University of British Columbia.

11:50 Discussion

12:00 LUNCH

SPECIAL SESSION ***"INTER-NETWORKING"***

13:00 *NSERC Canadian Network for Aquatic Ecosystem Services.* **P.R. Peres-Neto**. Université du Québec à Montréal.

13:30 *The Canadian Aquatic Invasive Species Network II.* **L. Johnson**, Université Laval.

14:00 Discussion

14:20 COFFEE BREAK AND POSTER SESSION

14:50 *How does Flow Regulation Affect Riverine Fishes?* **R. Cunjak**, Theme Leader, Canadian Rivers Institute, University of New Brunswick; R.G. Randall, K.D. Clarke, Fisheries and Oceans Canada; and F. Hicks, University of Alberta.

15:10 *River Ice Observations on Small Regulated and Unregulated Streams in New Brunswick, Canada.* **J. Nafziger**, University of Alberta; P. Thoms, Canadian Rivers Institute, University of New Brunswick; J. Banack, F. Hicks, University of Alberta; and R. Cunjak, Canadian Rivers Institute, University of New Brunswick.

15:30 *The Effects of Flow Regulation on the Dynamic Winter Ice Processes of the Kananaskis River.* **S. Emmer**, J. Nafziger, F. Hicks, M. Loewen and V. McFarlane, University of Alberta.

15:50 *Winter Condition of Atlantic Salmon Parr and Pre-Smolts Experiencing Hydropeaking Flow Regimes.* **S. Vue**, Canadian Rivers Institute, University of New Brunswick; K. D. Clarke, Fisheries and Oceans Canada; and R.A. Cunjak, Canadian Rivers Institute, University of New Brunswick.

16:10 *The Behavioural, Physiological and Morphological Responses of Fishes to Streamflow Regulation and the Consequent Effects on Population Dynamics.* **A.R. Hards**, R. Cunjak, T. Benfey, and J. Houlahan, University of New Brunswick.

16:30 Discussion

18:00 SOCIAL EVENT FOR THE COMMITTEE OF YOUNG RESEARCHERS AT BIÈRES ET COMPAGNIE (4350, rue Saint-Denis).

Thursday, April 11th, 2013

08:30 *Genetic Diversity Analysis of Bull Trout* (Salvelinus confluentus) *in the Upper Lillooet River Basin, British Columbia: Enhancing our Understanding of the Effects of Hydropower Development and Operations on Fish Populations.* **C.M. Bettles**, SNC Lavalin Environment; and E.B. Taylor, University of British Columbia.

08:50 *Innovative Lake Trout Spawning and Incubation Investigations and New Information Related to the Effects of Winter Drawdown on Lake Trout in Northern Reservoirs.* **B. Schonewille**, B. Snow and P. Tobler, EDI Environmental Dynamics Inc.

09:10 *Field and Laboratory Assessment of Turning Pool Hydraulics in a Vertical Slot Fishway Relative to Fish Passage.* **A. Marriner**, A.B. Baki, D.Z. Zhu, University of Alberta; J.D. Thiem, S.J. Cooke, Carleton University; C. Katopodis, Katopodis Ecohydraulics Ltd.

09:30 *Biological Evaluation of Upstream Lake Sturgeon Passage at the Vianney-Legendre Fishway.* **J.D. Thiem**, Carleton University.

09:50 Discussion

10:00 COFFEE BREAK AND POSTER SESSION

10:30 *NSERC HydroNet: a Glimpse into the Future.* **D. Boisclair**, Université de Montréal, S.J. Cooke, Carleton University, R. Mclaughlin, University of Guelph, G. Bourque, I. Dolinsek, G. Guénard, G. Lanthier, and C. Senay, Université de Montréal.

11:30 Discussion

12:00 MEETING ADJOURNED

13:00 BOARD OF DIRECTORS MEETING (Royer Meeting Room)

SCIENCE ADVISORY COMMITTEE MEETING (Vitré Conference Room)

SPECIAL SESSION ***"KNOWLEDGE TRANSFER FROM FUNDAMENTAL RESEARCH TO HYDROPOWER DEVELOPMENT":*** Discussion between guest speakers, students and post-doctoral fellows (St-Laurent Conference Room).

15:00 COMMITTEE OF YOUNG RESEARCHERS MEETING (St-Laurent Conference Room).

POSTER SESSION

Long-term Variation in Food Sources and Fish Trophic Position in a Natural and Regulated River of Northern Ontario. **J.M. Brush**, University of Waterloo; K.E. Smokorowski, K.D. Clarke, Fisheries and Oceans Canada; J. Marty, St. Lawrence River Institute; and M. Power, University of Waterloo.

Nutrient Variability across Diverse Geographical Regions of Canada in Regulated and Reference Rivers. **C. Good**, and J.B. Rasmussen, University of Lethbridge.

Fish Living in a Regulated River with Hydro-Peaking Operations have Better Swimming Stress Responses. **S. Harvey-Lavoie**, and D. Boisclair, Université de Montréal.

Comparison of Longitudinal Patterns in Fish Growth Rates between a Regulated and Natural River. **B. Kelly**, University of Waterloo; K. Smokorowski, Fisheries and Oceans Canada; and M. Power, University of Waterloo.

Electrofishing versus Visual Surveying Methods for the Estimation of Fish Community Structure. **C.J. Macnaughton**, S. Harvey-Lavoie, C. Senay, G. Lanthier, G. Bourque, D. Boisclair and P. Legendre, Université de Montréal.

Quantifying Fish Avoidance of Small Acoustic Survey Vessels in Canadian Lakes and Reservoirs. **L. Wheeland** and G.A. Rose, Fisheries and Marine Institute of Memorial University of Newfoundland.

Conference Abstracts

Decision Tools in Support of Fish Passage

*R. L. McLaughlin. University of Guelph, Department of Integrative Biology. (rlmclaug@uoguelph.ca)

As humans, we domesticate nature to acquire space, food, water, and energy to improve our well being. This domestication process can have unwanted effects that create trade-offs between management objectives, and tensions between stakeholder groups. The form and magnitude of these trade-offs can be uncertain due to ecosystem complexity. This talk will summarize our efforts to develop decision tools to reconcile tensions between the use of dams, for control of invasive sea lamprey (*Petromyzon marinus*), and fishways and dam removals, for the rehabilitation of native migratory fishes, in the Laurentian Great Lakes. To a limited degree, these tools can help characterize trade-offs, reduce uncertainty, and identify a "best" solution. To a larger degree, they can provide a more inclusive, objective, and transparent means of clarifying and communicating management objectives and possible outcomes of different management actions, building stakeholder trust, and developing more adaptive approaches to managing resources under competing objectives. Although our efforts have focused on tensions between control of invasive species and rehabilitation of native fishes, similar efforts are addressing tensions between hydro production and rehabilitation of fishes, and could be applied more widely.

Brook trout habitat loss by hydroelectric project: learning's on habitat compensation methods

*F. Burton and M. Gendron. Environnement Illimité inc. (frederic.burton@envill.com)

The impoundment of reservoirs for hydroelectric production generally causes habitat loss in lotic sections of rivers and streams. In many projects, salmonids are the most impacted species and, in Quebec, brook trout is one of the principal affected species. Although the entire habitat is normally affected, the habitat losses that are most often compensated are those associated with spawning and feeding. This presentation focusses on spawning habitat compensation methods employed in rivers, streams and lakes of James Bay, Saguenay-Lac Saint-Jean and St-Laurence drainage basins. In systems impacted by hydro-electric projects the compensation site was determined (based on criteria such as brook trout presence, real habitat needs, road access) and a construction concept and methodology was proposed. Diversity of site types causes a variety of challenges. In highly dynamic streams or small rivers, the substrate displaces easily, conversely in sectors of lower water velocities sand deposit and algae can be observed. In lakes, location of groundwater presence is of first importance. Although some of the follow-up studies are still in progress, we present the pros and cons of the different methods of construction with examples of stability over time and efficiency.

The implementation of mobile hydroacoustic surveys in determining fish distributions in fast flowing fluvial environments - its application in assessing an instream hydrokinetic turbine project

*K. Jacobs[1] , M. Gendron[1] and I. Hamad[2]

[1] Environnement Illimité inc. (keelan.jacobs@envill.com).
[2] Renewable Energy Research.

Hydroelectric production from hydrokinetic turbines is a rapidly developing field. This type of project, installed in fast flowing fluvial environments poses a difficulty for studying fish in this type of environment. The use of mobile hydroacoustic surveys has been exhibited as a valid method for lakes and rivers; however, its use in fast flowing environments is limited. A mobile hydroacoustic survey was utilized to achieve the following objective: to document the temporal and diel changes in fish densities and distributions, in the scope of a hydrokinetic turbine installation project by Renewable Energy Research, in the St. Lawrence River near Montreal. This reach of the river system is characterized by an average discharge of 8500 m^3/s, an average depth of 6.5 m and an average velocity of 3 m/s. A vertical split-beam mobile hydroacoustic system (HTI, model 241) was used to survey a series of transects spread over the width of the river every two weeks for one day and one night from July to November 2012. The system was configured for a high ping rate (30 pings/s) and a wide beam angle (15°) to ensure adequate signal detections from fish in the deep fast flowing waters. Temporal and diel changes in density and the overall distribution of fish within the study site will be compared and related to the species documented through experimental gill net captures in the calmer areas of the study site. The benefits and limitations of this type of survey in fast flowing fluvial environments will also be discussed.

Sustainable development of hydropower - Case-studies and perspectives in Norway

*Atle Harby. CEDREN, SINTEF Energy Research. (atle.harby@sintef.no)

Hydropower covers about 99 per cent of the Norwegian electricity production and has played a major role for developing industry and welfare in Norway. As we have gained more knowledge about environmental impacts of hydropower, the awareness of such impacts have also increased and is now incorporated in legislation and practice. This presentation will give a brief overview of Norwegian hydropower development, legislation and practice with respect to environmental impacts and mitigation. The focus further will be on case-studies of habitat, growth and migratory conditions for salmon from the regulated rivers Alta, Orkla, Surna and Mandal, and also from the Vefsna river where hydropower development was proposed but later refused by the parliament. In Alta and Orkla rivers, post-project assessments show wealthy salmon stocks. Field data and model simulations in Orkla show that negative impacts from decreased water temperature in summer is outweighed by the positive effect of avoiding very low flow periods in winter. In Surna and Mandal rivers, research has demonstrated possible measures to improve habitat, growth and migration of salmon. Solutions are now being tested, before eventual incorporation in the future license to operate. In Vefsna, a dialogue between

the hydropower company (state-owned Statkraft) and researchers proposed a development to minimize the negative impact on salmon and trout. Finally, the presentation will show some specific results from recent research about how the future flexible hydropower system should be operated to avoid further negative impacts on the environment.

Challenges and Solutions to Sustainable Hydropower in Canada

**Terry Toner, Nova Scotia Power, Director Environmental Services. (terry.toner@nspower.ca).*

More than 60% of Canada's electricity is provided by existing hydropower. Maintaining those systems and constructing new developments has become increasingly difficult as companies are faced with a broad array of expectations and requirements ranging from the science challenges (biodiversity, endangered species, nutrient depletion, wetland encroachment, and many more) to the socioeconomic and human aspects (including recreation, integrated resource planning, and other competitive water and land use). Furthermore, the advent of increased recognition of the rights and title of aboriginal people has created another important dynamic. The presentation will provide a broad perspective on this collection of competing challenges, exploring a few representative more detailed examples and identifying some of the emerging solutions in place or being developed.

Hydropower development in the Mekong Basin – From a Canadian Private Environmental Consultancy Experience

**G. Bruce, T. Boivin, S. Pech and A. Datta. Hatfield Consultants Partnership. (gbruce@hatfieldgroup.com)*

The BC Ministry of Environment (BCMOE), Alberta Environment and Sustainable Resource Development (AESRD), and Fisheries and Oceans Canada (DFO), have guidelines designed to mitigate impacts of hydro-electric dams on fish. Specific issues of concern include; ensuring migratory fish passage, maintaining downstream flows and minimizing dissolved gas super saturation levels below dams. Impact mitigation approaches that have been developed in temperate regions like Canada are only partially effective and largely untested in tropical regions. In the Mekong Region, there are plans for development of numerous large-scale hydropower developments on both the main stem Mekong River, and tributaries to the Mekong River. Millions of people depend on fish caught in the Mekong River as a primary source of protein and food security. Innovative approaches are required to balance the needs of revenues generated from hydroelectricity with the basic livelihood requirements of local citizens.

The construction of dams typically has negative impacts on several ecosystem components, improvements to dam design and operations can help mitigate impacts on some resources and potentially result in opportunities for compensation and/or enhancement activities for other aquatic resources. Hatfield staff are actively engaged in working with both hydro developers and regulatory authorities in Canada and internationally (specifically in the lower reaches of the Mekong river that includes Lao PDR, Cambodia, Viet Nam and Thailand).

Entrainment Vulnerability of Bull Trout and Burbot at the Mica Dam (Kinbasket Reservoir, BC)

*E. G. Martins[1], L. F. G. Gutowsky[1], P. M. Harrison, M. Langford[3], D. Zhu[3], D. A. Patterson[4], A. Leake[5], M. Power[2] and S. J. Cooke[1]. (egmartins@gmail.com)

[1]Carleton University, Department of Biology
[2]University of Waterloo, Department of Biology
[3]University of Alberta, Department of Civil and Environmental Engineer
[4]Fisheries and Oceans Canada
[5]BC Hydro

Fish entrainment occurs when individuals are displaced from reservoirs to downstream waters by way of water diversion through turbines or other water release structures. We used two years of acoustic telemetry data on adult bull trout (*Salvelinus confluentus*) and burbot (*Lota lota*) tagged in Kinbasket Reservoir (British Columbia) to investigate entrainment vulnerability and rates through Mica Dam. Our results revealed that 1) bull trout used the forebay more intensively and are potentially more vulnerable to entrainment than burbot; 2) entrainment vulnerability varied with water depth for both species, increasing as occupancy and intake depths converge as a result of seasonal drawdowns in the reservoir; and 3) both forebay use and entrainment varied on a seasonal basis (higher in the fall and winter). Entrainment rates over the two years of study were 6.7% for bull trout and 1.9% for burbot. We will also present preliminary results on a parallel study using acoustic telemetry to investigate fine-scale movement behaviour of bull trout and burbot in the vicinity (within 500 m) of the Mica Dam powerhouse. The fine-scale movement data will be integrated with modeled intake-induced flow data and will help us understand how the fish behave in relation to the flow field. Collectively, the results of these studies will help develop operational guidelines to reduce adult bull trout and burbot entrainment.

Home range and spatial behaviour of burbot *Lota lota* in a hydropower reservoir in Southeastern BC

*P. M. Harrison[1], L.F.G. Gutowsky[2], E.G. Martins[2], D. Patterson[3], A. Leake[4], S.J.C. Cooke[2], and M. Power[1]. (pharriso@uwaterloo.ca)

[1]University of Waterloo, Department of Biology
[2]Carleton University, Department of Ecology and Evolution
[3]Department of fisheries and oceans, West Vancouver
[4]BC Hydro, Burnaby

Burbot, a holarctic distributed benthic piscivore, are valued for their contribution to winter recreational and First Nations fisheries. Burbot are commonly found in hydropower impoundments throughout Canada, however, they are threatened and endangered towards the southern edge of their range. Despite their threatened status and high value, little is known about burbot spatially distribute themselves in hydropower impoundments and how movement patterns may influence entrainment vulnerability. While burbot are generally thought of as

sedentary, several authors have anecdotally observed pre-spawning fall migrations in lake environments. In this study we utilized a continuous monitoring telemetry array to monitor the horizontal movements of 47 burbot over two full years in Kinbasket Reservoir, British Columbia. Specifically, we modelled the influence of season and body size on home-range size and horizontal movement rates. Our results suggest burbot exhibit sedentary behaviour and low movement rates in the Kinbasket system. While a wide variety of individual movement patterns were observed, our results indicate that burbot do not make predictable seasonal migrations and exhibit high site fidelity to capture site. Our results, therefore, suggest that burbot closer to the forebay, may be more likely to encounter the forebay area and therefore have a greater entrainment vulnerability. Study findings further suggest that any burbot entrainment compensatory strategies, such as habitat rehabilitation, would be more effective if focused on areas closer to the forebay.

The spatial ecology of adfluvial bull trout in a large hydropower reservoir

*L.F.G. Gutowsky[1], P.M. Harrison[2], E.G. Martins[1], D. Patterson[3], A. Leake[4], M. Power[2], and S. J. Cooke[1]

[1]Carleton University, Department of Biology
[2]University of Waterloo, Department of Biology
[3]Department of fisheries and oceans, West Vancouver
[4]BC Hydro, Burnaby

There are a variety of reasons why fish change their spatial position, for instance fish may move to forage, reproduce, evade predation, defend territories, thermoregulate, and explore. Knowing how fish move in their environment can help test theory, inform fisheries management, and improve the understanding of species of conservation concern. However, characterizing the movement of free-swimming fish is logistically challenging, particularly when posing questions about seasonal migrations for species that are capable of large movements. Bull trout (*Salvelinus confluentus*) is a North American charr that can have a pelagic-wandering and migratory life history. In addition, bull trout are relatively poorly understood compared with congenerics, threatened by hydropower entrainment, sensitive to environmental change, and of conservation concern across much of its range. Given the conservation status of bull trout and knowledge gaps about bull trout ecology, we used acoustic biotelemetry to help characterize movement in the pelagic life history form of this species over an entire year, including beneath ice. We found that the extent of bull trout movement and homerange size was dependent on season and body size. Bull trout also exhibited clustered centers of activity. The results are discussed in the context of entrainment vulnerability, fisheries management, and bull trout ecology.

Computational Fluid Dynamic Modeling of the Seton, Carpenter and Downtown Reservoirs on the Bridge and Seton River Systems

*M.T. Langford, A.B. Baki and D.Z. Zhu. University of Alberta, Department of Civil and Environmental Engineering. (Mathew.langford@ualberta.ca).

Fish entrainment has been identified as one of the key potential impacts of hydropower operations on the productivity and biodiversity of these aquatic species. Fish entrainment deals with a scenario in which resident fish of the upstream reservoir are passed through a hydropower facility. It is anticipated that the risk of fish entrainment at a particular dam facility is correlated with the effect of hydropower operations on the flow and thermal structures of the forebay. A computational fluid dynamic study was initiated to compliment the assessment of entrainment risk at the Seton dam, Bridge 1 and 2 generating stations, Terzaghi dam and La Joie dam on the Bridge and Seton River systems. The project includes simulation of the forebay hydraulics of each facility under multiple operational scenarios and environmental conditions. Simulations were completed using a solution to the Reynolds-averaged Navier Stokes equations and a κ-ε turbulence model. The simulations included a broad range of discharges and operational scenarios, as well as thermally stratified and non-stratified flows to represent each facilities typically annual operations. This project has proceeded hand-in-hand with a biological assessment of the entrainment risk for these facilities. The flow field and thermal structure of the forebay's is used to evaluate the likelihood of fish entrainment, based on the species that are known to use (or are likely to use) habitat adjacent to the structures at different times of the year.

Estimation and Modeling of Fish Production in Reservoirs

* D. Boisclair[1] and G. Rose[2]

[1] Université de Montréal, Département de sciences biologiques, Montréal, Québec. (Daniel.Boisclair@UMontreal.ca).
[2] Centre for Fisheries Ecosystems Research, Marine Institute of Memorial University, St. John's, Newfoundland.

Abstract not available

Comparative analysis of sampling methods to develop habitat-use models of fish productivity in the littoral zone of reservoirs

*N.A. Satre, G. Bourque and D. Boisclair, Université de Montréal, Département de sciences biologiques, Montréal, Québec. (nathan.satre@umontreal.ca).

Presently, government and industry are seeking clear definitions and effective means of measuring and predicting production metrics of fish habitat. In response, a portion of

this project aims to develop habitat-use models of fish productivity that will identify what sampling method or combination of methods may be best to estimate/predict metrics of production. With this charge, a project was developed on the Lac du Bonnet reservoir situated in southeastern Manitoba. In our first sampling season, forty-three sampling locations were established and sampled with seine, gillnets, and boat electrofishing in order to obtain a representative sample of the littoral fish community. In addition, a survey describing local habitat variables was conducted in all sampling locations. Simultaneous with fish sampling, environmental conditions were recorded as these variables, along with those associated with habitat may hold some degree of explanatory value. As a result of the collected data, preliminary results indicate that seining yields the greatest average of species richness per site and greatest average CPUE in abundance. In addition, this method also yields the greatest average CPUE in biomass when sampling methods are expressed in the same units. Preliminary analyses of local habitat data suggest two major habitat types across the system, which may interestingly correlate with fetch. These initial findings seem to suggest that seining is most representative of the littoral fish community and may be best suited for model development. These results will be used to effectively focus our sampling effort during the 2013 field season, which is expected to be conducted during hours of darkness.

Geostatistical Estimates of Pelagic Fish Production in Freshwater Ecosystems

**R. A. Pollom and G. A. Rose. Centre for Fisheries Ecosystems Research, Memorial University of Newfoundland.*

Freshwater ecosystems around the world are generally declining in ecological integrity. Ongoing scientific information is needed to properly manage and restore these systems, especially within the context of hydropower operations. Reliable estimates of fish density through the use of traditional passive sampling methods such as netting typically require large amounts of time and effort to obtain. Additional issues arising from fish avoidance and mortality further complicate the interpretation of this data, indicating that a more active and non-invasive approach is desirable. This study makes use of an active multi-frequency hydroacoustic survey system to discover how several different trophic levels varied in density across a Manitoba reservoir. Acoustic surveys were conducted across the short-axis of the Lac du Bonnet reservoir for maximal coverage of the pelagic zone, and data obtained include high-resolution bathymetric mapping, fish sizes (obtained through standard target strength – length relationships) and distributions, as well as plankton densities across the reservoir. Autocorrelation analysis was performed, and geostatistical interpolation was carried out using the semivariograms from several size classes of fish and plankton to perform ordinary kriging techniques. Interpolated values were then used to estimate the density of each class within each of the three basins characteristic of Lac du Bonnet. Preliminary results reveal higher densities of fish in the two northeastern basins, while the riverine section of the reservoir had lower estimates for all size classes of fish and plankton. These survey methods show promise for future freshwater monitoring programs across Manitoba and elsewhere.

Acoustic Size Spectra of Fishes: Spatial and Temporal Variation within a Hydropower Reservoir along the Winnipeg River

L. Wheeland and G.A. Rose. Centre for Fisheries Ecosystems Research, Fisheries and Marine Institute of Memorial University of Newfoundland. (Laura.Wheeland@mi.mun.ca).

Aquatic ecosystems are widely considered to be shaped by size-based processes. Size-spectra provide indicators for ecosystem status, and may be used to assess differences in fish communities among systems, habitats and over time. Hydroacoustics were used to derive length-frequency spectra of fish communities and map physical habitat characteristics at Lac du Bonnet, a hydropower reservoir along the Winnipeg River, Manitoba. A BioSonics DTX echosounder operating at multiple frequencies was deployed from a 17-foot Boston Whaler. Systematic surveys of parallel transects were used to assess the pelagic fish community. Additional habitat mapping tracks were completed perpendicular to survey transects, as well as near-shore circumscribing the reservoir. Size-spectra were derived from linear regressions of ln(abundance) x ln(length) of fishes within 5cm length intervals, with lengths derived from target strength measures. Spectra height is used as an index of overall abundance of fishes, with slope representative of the relative proportions of fish by size. Three distinct basins were identified within the reservoir, characterized by differences in bathymetry, substrate and flow. Spectra differed among these mesoscale habitats. Variation in spectra between surveys reflected changes in fish community structure across the season. Inter-annual variation in spectra within the basins occurred: height was greater in 2011 than 2012 in all three basins, while spectra slope did not vary significantly between years. The use of size-spectra from acoustic data has potential to provide cost-effective monitoring of changes in structure and productivity of aquatic ecosystems, in particular those associated with hydropower development.

Nutrient and Species Richness as Drivers of Fish Productivity in Canadian Waters

**J.B. Rasmussen, Dept. of Biological Sciences, Water Institute for Sustainable Ecosystems. University of Lethbridge. Lethbridge, Alberta.*

This talk presents an overview of projects 1.2.1 Chemical drivers and 1.4.3 Biological drivers: Biodiversity. Empirical models based on a review of published and grey literature show that the biomass and productivity of fish communities across Canada is strongly related to the nutrient regime which the supports the food base of the community. The best predictor representing the nutrient regime is the total phosphorus (TP) concentration of the water. While TP can reflect a range of anthropogenic influences on trophic status, it can also reflect underlying geology and geographical nature of the watershed. While rivers support higher fish biomass than lakes of similar nutrient richness, the highest fish biomass is present in fish communities from the littoral zone of lakes. TP concentrations in HydroNet Rivers fall within the oligotrophic to low mesotrophic range, and TP concentrations in regulated rivers are very similar to those of their corresponding reference systems, indicating that nutrient richness is not expected to be a confounding influence in fish community comparisons between regulated and unregulated systems. Fish biomass and productivity for a given system type (e.g. river, lake, lake littoral) and

level of nutrient richness, is several times higher in rivers and lakes from the interior basin where species richness is high (usually > 10 spp and many families present) than on the island of Newfoundland and in systems west of the rocky mountains where communities are generally species poor and salmonid dominated.

Establishing the link between fish biodiversity, species richness and biomass production in freshwater ecosystems

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

The generation of fish biomass is an integral function of freshwater aquatic ecosystems and is largely influenced by both the diversity of organisms as well as their functional organization within a food web. As such, species diversity has been a recent focal point of ecological research with respect to its influence on food chain characteristics (length and width) and subsequent effects on ecological functions. Much of this research, however, has been limited to theoretical studies based on complex models, with the emphasis of most being allocated to the examination of species diversity in relation to functionally significant groups. While this research has provided valuable insight as to how the addition or subtraction (or lengthening) of entire trophic pathways affect ecosystem function, it fails to address functional group species richness, which likely plays an important underlying role. To address this gap in our knowledge, we have designed a comparative study to examine the relationship between fish diversity, species richness and fish biomass production in both lentic and lotic ecosystems across Canada. A component of this research will also involve the examination of this relationship across hydro-regulated and non-regulated lotic systems where regulation has led to a shift in fish community composition.

Characterizing the impact of dams on the thermal regime of the Fourchue River (Quebec)

A. Maheu[1], A. St-Hilaire[1], L. Beaupré[1], A. Daigle[1] and D. Caissie[2]

[1]Institut National de la Recherche Scientifique. (audrey.maheu@ete.inrs.ca)
[2]Fisheries and Oceans Canada

Although dams have been shown to modify water temperatures, few studies have detailed which specific aspect of the thermal regime is altered. The objective of this study was to characterize the impact of a dam on five components of the thermal regime of the Fourchue River (Quebec): magnitude, duration, frequency, timing and variability. Water temperature was monitored upstream and downstream of the Morin dam during the summer 2011 and winter 2011-2012. Temperature duration curves and thermal indices were used to describe the thermal regime of the natural and regulated reaches of the river. A principal component analysis was also performed to determine which components of the thermal regime were most modified by

the dam. In the summer, the dam modified the magnitude and variability of water temperatures: it had a warming effect on cool temperatures and a cooling effect on warm temperature extremes. Modification of the summer thermal regime by the dam can be described by two thermal indices: the mean July water temperature and the variance in maximum daily temperature. In the winter, the dam suppressed freezing conditions for 2 km downstream of the dam and reduced the duration of freezing conditions by 30 % at 5 km from the dam. Four indices were selected to characterize the modification of the winter thermal regime by the dam. This study highlighted the importance of 1) a comprehensive characterization of all components of the thermal regime and 2) a year-around perspective to understand the impacts of dams on the thermal regime of rivers.

Modélisation thermique de la rivière Fourchue : modèle déterministe versus modèle statistique

** L. Beaupré, A. St-Hilaire, A. Daigle and N. Bergeron, Institut National de la Recherche Scientifique. (laurie.beaupre@ete.inrs.ca).*

La température de l'eau est un facteur important qui modifie les patrons de distribution ainsi que l'abondance des l'ichtyofaune en rivière. Sachant que les barrages modifient le régime thermique des rivières, la compréhension de ces changements est primordiale pour gérer efficacement l'habitat du poisson. Le projet a pour objectif d'approfondir les connaissances de l'impact des barrages sur le régime thermique des rivières en eau libre. Pour ce faire, un modèle déterministe (SnTEMP) ainsi qu'un modèle statistique basé sur l'analyse des corrélations canoniques, ont été calés sur la rivière Fourchue (St-Alexandre-de-Kamouraska, Québec), en amont ainsi qu'en aval du réservoir Morin. Les prédictions des deux modèles sont comparées sur la base de leur efficacité dans l'estimation des indices de température qui sont des paramètres importants pour comprendre la distribution et la croissance de l'ichtyofaune. Des thermographes ont été installés dans les deux sections de rivière pour les périodes estivales de 2011 et 2012 afin de caractériser le régime thermique et de caler les modèles. Le modèle statistique s'est montré plus efficace que SnTEMP pour estimer l'ensemble des indices thermiques sélectionnés, plus particulièrement pour les variations journalières moyennes et maximales avec un RMSE de 4.1°C et 4.9 °C respectivement pour SnTEMP comparativement à 0.73°C et 1.0 °C pour le modèle statistique. Ces résultats démontrent que pour un système simple comme la rivière Fourchue, des indices thermiques peuvent être obtenus à l'aide d'un modèle statistique nécessitant peu de ressources.

Year 3 Advances in Two Components of the Integrated SNG Program: Geomorphic Impacts and Flow Regime Alteration. Context and introduction to the approaches followed

**M. Lapointe. Mcgill University, Department of Geography , Montréal, Québec.*

Abstract not available

Using Natural Flow Classes to Estimate Hydrologic Alteration by Dams across Canada, a HydroNet study

*F. McLaughlin and M. Lapointe, McGill University, Department of Geography, Montréal, Québec. (Fraser.Mclaughlin@mail.mcgill.ca).

It is well established that a river's flow regime is a key determinant of ecological integrity and that dam regulated-hydrology can be detrimental. Regional flow classes, groups of rivers that share similar flow regimes and to which regional fish communities are adapted, have been proposed as units of analysis to identify flow alteration. This is particularly useful for HydroNet since determining historical flow class membership for regulated rivers does not rely on pre-dam discharge data, unavailable here. Based on 99 unregulated rivers in proximity to 18 regulated HydroNet sites across Canada, 5 distinct unregulated flow class clusters were identified using ecologically important flow indices. The distinguishing characteristics of natural flows within each class (regional cluster) were explored through visualization in three dimensional principal component space. Regulated sites were then assigned to flow classes based on shared geographic location and watershed characteristics. The resulting analysis of alteration found, as recently identified in US studies (McManamay *et al.* 2012), that dams do not always homogenize flow dynamics, as regulated sites in each flow classes diverged from regional class norms by various directions and magnitudes in principal component space. The analysis highlights which hydrograph features are most altered downstream from the HydroNet dams, depending on both dam operation mode and regional flow regime norms. These results suggest that regional flow classes must be considered as a means to identify regional gradients of alteration, and how these correlate with ecological integrity.

Source:
McManamay, R. A., Orth, D. J., & Dolloff, C. A. (2012). Revisiting the Homogenization of Dammed Rivers in the Southeastern US. *Journal of Hydrology* v. *424-425*, p. 217-237

Remote sensing of river structure in the context of mapping hydraulic habitat at the reach scale

*F .Hugue and M. Lapointe. McGill University, Department of Geography, Montréal, Québec. (fabien.hugue@mail.mcgill.ca)

Recent techniques of remote sensing and geographical information science have improved efficiency of analyzing earth surface features. Various applications of these techniques are much used to assess environmental and ecological processes. With the development of new sensors and the availability of high resolution multi spectral imagery, fluvial geomorphology is experiencing a revolution in mapping rivers. Exploiting the power of aerial or satellite imagery is indispensible in multi-river studies such as conducted in HydroNet SNG, given poor accessibility to remote sections of river systems and large spatial extent of rivers studied, constraints which make the collection of high resolution field data impractical. This study presents a satellite remote sensing method that helps describe river habitat structure, in which hydraulic habitat statistics (depth-velocity) at the pixel, reach and segment scales can be generated to help interpret fish community data.

Spectral based, depth maps for HydroNet river sites were extracted from high resolution (2m) multispectral satellite images (4 to 8 bands). In the absence of the high cost topographic surveys of river bed and water surface slopes needed to conduct CFD hydraulic simulations, empirical, pseudo 2D hydraulic rules were used here to generate flow velocity maps over 10 km reaches. Information on riparian cover, emergent boulders, rock outcrops and LOD visible on the image (0.5m pixel for panchromatic Worldview images) combined with depth-velocity maps can be used to assess the river habitat structure at a finer grain and with less subjectivity than classical meso-habitat classifications.
The method described allows a reasonably accurate characterization of the hydraulic habitat over large extents, without the need of intensive field surveys. Applications from this method include understanding how river habitat heterogeneity affects fish distribution and locating habitats more sensitive to alteration due to upstream damming. It can also be used to describe habitat variability across the HydroNet river sites as well as identifying any systematic variations in habitat structure between the regulated sites and the natural rivers.

Geomorphic Controls on Physical Habitat Variability in a Hydropeaking System

**A. Tamminga, H. Buehler, L. Winterhalt, and B. Eaton, University of British Columbia, Department of Geography. (tamminga@geog.ubc.ca).*

The hydropeaking operation of the Pocaterra Dam on the Kananaskis River, AB has resulted in decadal-scale geomorphic changes and daily flow reversals that have impacted fish habitat. Analysis of historical air photos combined with reach-scale predictions of channel width changes from physically based modeling demonstrated variable responses at sites throughout the 40km of river studied; sites nearest the dam widened, sites farther downstream narrowed, and there was a general pattern of channel planform simplification and backchannel abandonment. Two-dimensional hydrodynamic modeling of select reaches showed that peaking significantly reduces weighted usable area, with low flows limiting adult habitat and high flows limiting younger life stages. These effects were primarily controlled by the morphological character of the reach, and did not decline with distance from the dam. To build on these findings, planned research will focus on integrating morphodynamics and physical habitat variability by using high resolution bathymetric maps to determine contemporary low-flow depth and mesohabitat distributions. These spatial patterns will be interpreted in the context of historical channel changes as predicted by theoretical models to determine how geomorphic controls drive reach-scale morphology and constrain micro- and meso-habitat development. This framework will then be used to set up two-dimensional morphodynamic models that link the effects of altered flow regime with sediment transport patterns to test how changing morphology under different conditions can affect hydraulic attributes at high and low flows. This research will provide a mechanistic understanding of the multi-scale linkages between geomorphology and fish habitat on the Kananaskis River.

NSERC Canadian Network for Aquatic Ecosystem Services

** P.R. Peres-Neto. Université du Québec à Montréal, Département des sciences biologiques, Montréal, Québec. (peres-neto.pedro@uqam.ca).*

Aquatic ecosystem services include the goods and services that ecosystems provide such as nutrient cycling, pollination, flood mitigation by wetlands. The NSERC Canadian Network for Aquatic Ecosystem Services (CNAES) is a five-year research program that represents a national network of approximately 30 researchers from 11 universities, various federal and provincial government agencies, and industrial partners. The research group ranges from expertise in biogeochemistry, hydrology, fish ecology, statistics, policy and economics and will advance our understanding in issues ranging from ecological resilience to the trade-offs in ecosystems depending on the choices society makes (e.g. resource development vs tourism). Our research focuses under the three major research themes of: (1) Coupling the Landscape, Aquatic Ecosystems, Services, and Environmental Change in Canada's North; (2) Theme II: Healthy Forests, Healthy Aquatic Ecosystems; and, (3) Quantitative Indicators & Metrics of Ecosystem Services, Health and Function.

The Canadian Aquatic Invasive Species Network II

**Ladd E. Johnson, Université Laval, Département de biologie. (ladd.johnson@bio.ulaval.ca)*

The NSERC Canadian Aquatic Invasive Species Network II (CAISN) is comprised of university and government-based scientists with expertise in various aspects of aquatic invasive species (AIS), working in collaboration with industries and NGOs. The Network is in its second term of funding, following highly successful achievements of CAISN I (2006-2011) in the study of the vectors of invasion and in improving our understanding and management of AIS. Training of a highly talented pool of graduate students and postdoctoral fellows with specialization in AIS is a key outcome of the network, providing them access to world-renowned lake and marine ecologists, modellers, mathematicians and statisticians. CAISN II is exploring new AIS issues in several research themes: **Early Detection:** Using state-of-the-art techniques, CAISN II is improving our abilities to detect AIS. **Rapid Response:** Following early detection, CAISN II researchers are exploring current rapid response capabilities and developing new programs, policy and decision support programs. **AIS as Part of Multiple Stressors:** Other stressors affect aquatic ecosystems, but their interactions with AIS are not known. CAISN II is exploring key stressors, such as climate change, and their interactions in lake, river and coastal marine ecosystems. **Reducing Uncertainty and Prediction in Management:** In an effort to prioritize management strategies, CAISN II is developing predictive models that will more accurately determine which AIS are likely to become established and disruptive across Canada. A scientific steering committee and board of directors oversees the Network's research and administration, ensuring CAISN's partners and stakeholders are well represented.

How does flow regulation affect riverine fishes?

*R. A. Cunjak [1], R.G. Randall[2], K.D. Clarke[3] and F. Hicks[4]

[1] Canadian Rivers Institute, Department of Biology and Faculty of Forestry and Environmental Management, University of New Brunswick, Fredericton, NB. (cunjak@unb.ca)
[2] Department of Fisheries & Oceans, Burlington, ON
[3] Department of Fisheries & Oceans , St. John's, NL
[4] Department of Civil Engineering, University of Alberta, Edmonton, AB

Our group's integrated research program is focused on the response of fishes to regulated flow regimes. Using a combination of field-based and laboratory studies, our graduate students (4) are testing predictions that deal with the consequences of winter flow regulation on egg/alevin survival and development, pre-smolt survival and smoltification, as well as seasonal changes in stream fish assemblages and population dynamics. While focused on flow variation, concomitant changes in physicochemical environmental attributes (i.e., , dissolved oxygen, water temperature, and ice dynamics) are also being investigated to assess their importance in affecting biological response. Preliminary results from the Atlantic salmon egg survival research in the Tobique River basin (northern NB) indicate that regulated headwater reaches experience accelerated egg development but the lowest average survival and highest variability in survival to eyed and hatch stages of development. Complex interactions between hyporheic dissolved oxygen in redds and fluctuating river stage may be contributing to reduced survival during early spring. The experimental work showed no differences in winter survival, condition, or growth of pre-smolt salmon subjected to diel flows 2-4 times greater than in control tanks. Collectively, such studies are fundamental to quantifying the potential impacts of flow regulation on fish productivity so that effective mitigative measures can be adopted.

River ice observations on small regulated and unregulated streams in New Brunswick, Canada

*J. Nafziger[1], P. Thoms[2], J. Banack[1], F. Hicks[1], R. Cunjak[2]

[1]Department of Civil and Environmental Engineering, University of Alberta. (jnafzige@ualberta.ca)
[2]Canadian Rivers Institute, Department of Biological Sciences, University of New Brunswick

Winter conditions can have significant negative effects on fish living in rivers. Regulated environments may mitigate or aggravate the negative effects that winter conditions have on fish survival. The presence of river ice, combined with water level regulation by hydroelectric generating stations, creates a poorly understood and complicated physical habitat for fish and eggs. River ice conditions were observed on two regulated streams and one unregulated stream in north-central New Brunswick. Water levels, water temperature, and winter ice conditions were monitored on all streams, while dissolved oxygen content was measured at select sites. This presentation will discuss selected data analyzed thus far and outline data collection activities for the current winter. The principal aim of this project is to broadly characterize and quantify aspects of the winter regime of regulated streams so as to identify those environmental

stressors that directly influence fish habitats and their productive capacity, and to distinguish how those stressors may vary in regulated versus unregulated systems.

The effects of flow regulation on the dynamic winter ice processes of the Kananaskis River

**S. Emmer, J. Nafziger, F. Hicks, M. Loewen and V. McFarlane. University of Alberta, Department of Civil and Environmental Engineering. (emmer@ualberta.ca).*

Recent research has shown that winter is a critical time period for fish survival. Ice dynamics, and important aspect of winter stream habitat, are significantly affected by the sudden changes in flow caused by reservoir operation. The purpose of this project is to investigate and characterize the unique ice processes of regulated streams. Our study river is the Kananaskis River, a steep, gravel bed stream in the Rocky Mountains. Four sites were studied downstream of the Pocaterra dam, whose flowby fluctuates daily from 0.5 to 23 m^3/s during the winter. Preliminary observations were made during the winter of 2011-2012, and more detailed observations including time lapse cameras, water level sensors, and temperature sensors were made during winter 2012-2013 to document ice processes. Data from this automated equipment was supplemented with direct observation and ice sampling. Patterns of frazil ice, border ice and anchor ice production unique to hydro-peaking rivers was observed. These observations will be compared to meteorological and flow conditions to build the groundwork for predicting how reservoir operation affects winter fish habitat for various physical and climate conditions.

Winter condition of Atlantic salmon parr and pre-smolts experiencing hydropeaking flow regimes

**S. Vue[1], K. D. Clarke[2] and R.A. Cunjak[1].*

[1]Canadian Rivers Institute/University of New Brunswick, Department of Biology, Fredericton, NB. (sherr.vue@unb.ca)
[2]Department of Fisheries and Oceans Canada, St. John's Newfoundland.

For many fishes, winter represents the period when significant energy reserves (i.e. lipids) are depleted and body condition is reduced. Some Atlantic salmon spend 2-3 winters in streams that experience hydropeaking flow regimes where fluctuations in flow (2-50 times) are realized on a daily basis. The combination of limited physiological capacity and environmental stressors associated with hydropeaking flows may impose limiting conditions for the survival and development of overwintering Atlantic salmon parr. We investigated the effects of winter hydropeaking flows on wild Atlantic salmon parr (41 – 168 mm), by introducing daily peaking flow regime changes in large outdoor mesocosms with natural substrate and various habitats. We assessed changes in the overwintering condition of Atlantic salmon parr by evaluating changes in condition factor (K), estimated fat content (using bioelectrical impedance analysis (BIA)), and the ability of parr to complete smoltification (NaK-ATPase activity). During our first winter experiment (Feb-May 2012), we simulated a daily hydropeaking flow regime that created

a 2-fold increase in flow with a 2-fold increase in velocity compared with a control group with a stable flow regime. We found no significant changes in growth, condition factor, lipid content, or NaK-ATPase activity between hydropeaking and control mesocosms suggesting that low increases in flow and velocity do not affect the overwintering condition of Atlantic salmon parr. In a subsequent experiment (January-May 2013), we are currently testing the effects of an increased instream velocity (3-4 fold). Preliminary results suggest the increased velocity does not affect the condition of Atlantic salmon parr.

The behavioural, physiological and morphological responses of fishes to streamflow regulation and the consequent effects on population dynamics

A. R. Hards, R. Cunjak, T. Benfey & J. Houlahan. University of New Brunswick.
(adrian.hards@unb.ca).

The Canadian hydropower industry accounts for nearly half of the country's electricity generating capacity and is forecast to grow substantially over the coming decades. Yet, despite the prevalence of hydroelectric dams there remains a paucity of information regarding how fishes downstream of them are affected. Indeed, the majority of previous relevant studies focused on the response of a single species at a specific life-history stage during a particular season. Given the economic value of many of the species concerned it seems prudent to gain a more comprehensive understanding of the extent and means by which hydropower-induced streamflow regulation affects fishes.
The principal objectives of this research are to determine: which parameters are altered by regulation; the behavioural, physiological and morphological consequences of such alterations; and how these consequences in turn affect fish assemblage composition, age structure and abundance. More specifically, sampling will be conducted along the length of 3 regulated and 3 unregulated rivers in the Tobique River Basin, northwest New Brunswick, throughout the spring, summer, and fall to determine whether and to what extent regulation affects: the distribution, isotopic signature, growth rate, proximate composition, reproductive maturation, body form and size of fishes therein. A second field season will be conducted in the following year to estimate longer-term variation.
Understanding whether and to what extent regulation affects fishes is an essential step towards finding a balance between electricity production and fish conservation.

Genetic Diversity Analysis of Bull Trout (*Salvelinus confluentus*) in the Upper Lillooet River Basin, British Columbia: Enhancing our Understanding of the Effects of Hydropower Development and Operations on Fish Populations

*C.M. Bettles[1] and E.B. Taylor[2]

[1] *SNC Lavalin Environment. (cory.bettles@snclavalin.com).*
[2] *University of British Columbia, Department of Zoology and Beaty Biodiversity Research Museum*

An understanding of the distribution of ecological and evolutionary variation within and among geographically isolated populations is necessary for successful species conservation. Without an

explicit understanding of the degree to which a species is subdivided into genetically distinct populations and of their level of interconnectedness there is a risk that incorrect management decisions at the landscape level could initiate, or restrict, gene flow between historically isolated, or connected, populations. In addition, levels of genetic variability within populations are thought to be important to their long term persistence, especially under environmental change. This is especially important because human-induced environmental alterations are considered to be the greatest reason for species loss in freshwater systems. We used genetic techniques to assess collections of bull trout from three locations in the Upper Lillooet River basin where hydroelectric facilities have been approved for development. Overall population subdivision was 0.011 ($P < 0.001$) indicating differentiation among collections and follows the 'isolation-by-distance' model. An estimated 11% of fish sampled in one locality were inferred ($P < 0.05$) to be immigrants from another locality and estimates of effective number of breeders (N_B) ranged from 46 to 165, suggesting small breeding populations. Our results not only provide good evidence of genetic distinction among populations of bull trout but the importance of connectivity among tributaries in the region sampled. Furthermore, the study provides an example of the importance of genetic data as an indicator of environmental condition and its effectiveness enhancing the value of landscape and species information during hydropower development and operations.

Innovative lake trout spawning and incubation investigations and new information related to the effects of winter drawdown on lake trout in northern reservoirs

**B. Schonewille, B. Snow and P. Tobler. EDI Environmental Dynamics Inc., Whitehorse, YT. (bschonewille@edynamics.com).*

Yukon Territory relies on hydro facilities to generate power. Water storage in reservoir lakes is critical to supplying the Yukon with renewable energy, particularly during the winter months when demand is high. Yukon Energy Corporation, Yukon's public utility company, is exploring the optimization of two of its hydro facilities by increasing the storage/drawdown range in its reservoirs. Lake trout (*Salvelinus namaycush*) are a focal species for management in large Yukon lakes due to their importance in recreational and subsistence fisheries in the region. Being a fall spawning species, lake trout eggs are particularly susceptible to winter drawdown as they incubate over the winter months; this period co-incides with the drawdown of the reservoir lakes for power generation. We studied lake trout egg deposition and survival in two Yukon lakes with different water level management regimes. Through innovative studies on spawning habitat categorization, egg deposition, incubation survival and spawning habitat enhancement, we have acquired a detailed understanding of lake trout spawning ecology and better comprehension of the effects of winter drawdown on these populations, most of which is new knowledge for northern Canada. Our studies have documented the ability of dewatered lake trout eggs to survive under the ice for extended periods of time and a successful habitat enhancement trial that has attracted lake trout to rehabilitated, deep water spawning beds. Our results suggest that lake trout egg deposition depth is related to the water level management regime of the lake; this regime must be considered when assessing the impact of winter drawdown on lake trout egg survival in northern lakes.

Field and laboratory assessment of turning pool hydraulics in a vertical slot fishway relative to fish passage

*A. Marriner[1], A.B. Baki[1], D.Z. Zhu[1], J.D. Thiem[2], S.J. Cooke[2], C. Katopodis[3].

[1]Department of Civil and Environmental Engineering, University of Alberta; (marriner@ualberta.ca)
[2]Fish Ecology and Conservation Physiology Laboratory, Carleton University;
[3]Katopodis Ecohydraulics Ltd.

The hydraulics of turning pools in vertical slot fishways were studied in the field and using CFD modelling. The velocity field results from measurements of two turning pools at the Vianney – Legendre vertical slot fishway in southwestern Quebec are presented. Additionally, 9 turning pool designs were simulated using CFD modelling. Velocity, turbulent kinetic energy, and vorticity were simulated in at depths of z = 0.13*h*, 0.5*h*, and 0.8*h* for all designs. Designs 2 and 5 produced hydraulics very similar to Design 1. Velocity, turbulent kinetic energy, and vorticity results were found to be comparable to single slot pools in vertical slot fishways. The maximum slot velocity measured in all pools is less than the theoretical burst speed of wild adult lake sturgeon and should not hinder upstream passage. The average volumetric energy dissipation is lower than the maximum acceptable level suitable to fish passage and similar to levels found in single slot pools. Flow turbulence is lowest close to the pool floor and therefore fish swimming close to the bottom will encounter lower levels during ascension. The turbulence is 'high' in the slot area and typically 'low' throughout the remainder of the pool in all designs. Vorticity is highest at the slots and lower through the rest of the pool.

Biological evaluation of upstream lake sturgeon passage at the Vianney-Legendre fishway

*J.D. Thiem, Department of Biology, Carleton University. (jthiem@connect.carleton.ca).

Spawning migrations of sturgeon have been affected by the construction of dams, which create barriers to migration and have contributed to the imperilment of sturgeon. Although devices have been installed to facilitate the upstream passage of fish at barriers, they have been generally unsuccessful and not designed for sturgeon. Using a successful sturgeon fishway as a model enabled quantification of passage efficiency and fine scale passage behaviours of lake sturgeon (*Acipenser fulvescens*). Turning basins within the fishway delayed upstream passage and contributed to a disproportionate reduction in overall passage efficiency. Accelerometers were subsequently deployed on individuals to determine location-specific activity and energy use, and to compare the energetic costs of successful and unsuccessful passage. A physical model of a sturgeon fitted with force transducers was also used to determine the effect of path selection on profile drag during upstream fishway passage. Despite evidence of lake sturgeon spawning downstream of the dam and fishway, the Vianney-Legendre fishway is still regarded globally as one of the few facilities that has successfully passed sturgeon. Collectively, data from this study contribute to understanding how fishways can be used to facilitate the upstream passage of imperilled sturgeon at dams.

NSERC HydroNet: a Glimpse into the Future.

*D. Boisclair[1], S.J. Cooke[2], R. Mclaughlin[3], G. Bourque[1], I. Dolinsek[1], G. Guénard[1], G. Lanthier[1], and C. Senay[1].

[1]Université de Montréal, *Département de sciences biologiques, Montréal, Québec. (Daniel.Boisclair@UMontreal.ca).*
[2] Carleton University, *Department of Biology*
[3] University of Guelph, *Department of Integrative Biology.*

Abstract not available

Poster Session Abstracts

Long-term variation in food sources and fish trophic position in a natural and regulated river of northern Ontario

*J. M. Brush[1], K. E. Smokorowski[2], K. D. Clarke[3], J. Marty[4], and M. Power[1]

[1]*University of Waterloo, Department of Biology.*
[2]*Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Sault Ste. Marie, Ontario.*
[3]*Department of Fisheries & Oceans, St. John's, NL.*
[4]*St. Lawrence River Institute.*

A river's flow and temperature regime are key drivers structuring its food webs. The operation of hydro-electric dams can result in flow modifications, which may significantly alter downstream food webs by modifying food availability and species interactions. Weather conditions such as precipitation and temperature can also influence the quantity and quality of prey available within rivers. In years with low flow and high temperatures, quantity and quality of prey sources may decrease relative to that within a regulated river with a minimum flow requirement and have bioenergetic consequences for fish through influences on prey consumption. Few studies have examined spatial, temporal or longitudinal trends in consumer trophic position within regulated rivers (or within an appropriate reference river).
We address this lack of knowledge on long-term food web variability using data from an unaltered river in Sault Saint Marie, Ontario, and a regulated river in Wawa, Ontario collected over a ten year (2003-2012) period. Stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes were measured from taxa collected from multiple trophic levels to evaluate fish resource use and trophic position, respectively, at spatial, temporal, and longitudinal scales relative to isotopic variation in basal resources (benthic invertebrates). Consumer trophic position, which is the outcome of species interactions (predation, competition) and assimilated resource use, was evaluated relative to annual minimum, mean, and maximum annual flow within each river. Comparisons of these factors within natural and regulated river will provide insights on the influence of natural and anthropogenic factors affecting food web structure and function.

Nutrient Variability across diverse geographical regions of Canada in Regulated and Reference Rivers

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

Variability in nutrient cycling and accumulation within a watershed is dictated by many influences including land use, local hydrology and climate, basin characteristics, and ecosystem interactions. Nutrients have been widely established as drivers for primary productivity in aquatic habitats, yet these processes may differ among diverse freshwater ecosystems. Regulated rivers create a low velocity depositional zone, impacting the longitudinal connectivity of rivers by disrupting nutrient pulses and transport of materials downstream. Reservoirs may act as a sink or source of nutrients through internal loading from sediment accumulation or hypolimnetic release downstream. Evaluation of the variability of chemical parameters of regulated and reference systems will help to identify geographic variability of nutrient regimes, and their influence on fish communities.

To advance our understanding of the relationship between fish productivity (biomass) and nutrient regimes among diverse aquatic systems, we compared Total Phosphorus and Total Nitrogen in systems modified by hydropower (regulated) and reference rivers in BC, AB, QC, ONT and NL in 2011 and 2012. In combination with this, we sampled regulated rivers up and downstream of reservoirs to monitor nutrient trends and develop a consistent nutrient database for HydroNet river sites. Using known nutrient values, estimates of fish biomass can be calculated using species specific biomass prediction tools. Continual development and expansion of a nutrient/ fish biomass database to strengthen our estimates provide a useful tool for Hydropower management across diverse aquatic systems.

Fish living in a regulated river with hydro-peaking operations have better swimming stress responses

S. Harvey-Lavoie and D. Boisclair, Département de sciences biologiques, Université de Montréal, Montréal, Québec. (simonne.harvey-lavoie@umontreal.ca).

A field study on consequences of chronic flow increments on fish swimming stress response has been conducted in a context of natural flow regime alteration. The level of physiological stress to a sudden increase in flow velocity has been assessed in a comparative study on Northern pikes (*Esox lucius*). Besides, to ensure that differences that could be seen were not due to an impaired stress response by fish living in the regulated river, an experiment on the degree of stress response and muscular fatigue after a standardized angling procedure has been conducted. The study took place in a hydro-peaking river, where events of massive and unpredictable flow discharge happen daily. A total of 58 fish were caught in Mississagi River, regulated, and Aubinadong River, unregulated, both situated in Northern Ontario. Indicators of the general response to stress along with blood lactate have been quantified on both experiments. Results show that the blood lactate concentrations of fish subjected to a fast increase in flow velocity were significantly higher in individuals living in the unregulated river. On the other hand, the acute stress response and the muscular anaerobic capacities are not

impaired by a fluctuating flow environment in wild fish. These experiments tend to show that an increase in flow velocity stressed the fish the same way, independently of the river in which they live. The muscular fatigue, however, seems to be lower in fish habituated to a frequent increase in river flow.

Comparison of longitudinal patterns in fish growth rates between a regulated and natural river

*B. Kelly [1], K. Smokorowski[2], and [1]M. Power[1].

[1]Department of Biology, University of Waterloo. (bmkelly@uwaterloo.ca)
[2] Center of expertise on hydropower impacts on fish and fish habitat, Department of Fisheries and Oceans.

Hydroelectric dam operation can alter the riverine environment in downstream reaches. Such alterations include changes in water temperature and discharge, and have the potential to impact biotic communities. These alterations can be attenuated as distance from the dam increases, creating a longitudinal gradient of physical conditions. Aquatic communities, in turn may change along the river reaches below a dam as they adapt to physical gradients. This study compares longitudinal patterns of fish growth between river reaches downstream of a hydroelectric dam and analogous reaches in a naturally flowing river. Two northern boreal rivers were sampled in July and August of 2011 and 2012, one with a 15MW peaking hydroelectric dam (Magpie River) and one with a natural flow regime (Batchawana River). Longitudinal patterns in invertebrate community abundance and composition on the Magpie River differ compared to patterns in nearby naturally flowing rivers. However, fish are relatively mobile and can actively seek out preferred habitats, potentially avoiding gradient effects. Three fish species with varied life history characteristics are used to explore the potential impacts of hydroelectric dam operation on fish growth, given the differences in invertebrate abundance patterns on the two rivers: *Cottus cognatus* (Slimy Sculpin), *Percopsis omiscomaycus* (Trout Perch) and *Salvelinus fontinalis* (Brook Trout). Growth rates are determined using back-calculations from otolith annuli and a comparison of results along the longitudinal gradient and between the natural and regulated rivers are presented.

Electrofishing versus visual surveying methods for the estimation of fish community structure

**C. J. Macnaughton, S. Harvey-Lavoie, C. Senay , G. Lanthier , G.Bourque , D. Boisclair and P. Legendre, Département de sciences biologiques, Université de Montréal, Montréal, Québec. (camille.macnaughton@gmail.com)*

Studies designed to describe fish community structure in shallow riverine environments have used various sampling gears, namely electrofishing and visual or snorkelling surveying methods. While much work comparing sampling gear efficiency has been conducted for salmonid populations occupying cold freshwater habitats, few have addressed their respective efficacy at estimating relative fish density and biomass across a wide range of species and size-classes. Extensive paired electrofishing and visual surveys across 18 Canadian temperate rivers was conducted to obtain community-wide relative density and biomass estimates, for which partial canonical multivariate analyses of variance on each of the fish communities levels, family, species and size-classes, were performed to assess the effect of sampling method (electrofishing vs. visual). Comparison of similarity indices across a range of riverine habitats reveal an interesting trend, where electrofishing and visual surveys are more variable and dissimilar as specific species or size-classes are targeted. Furthermore, results show that while family and species richness scores are greater for electrofishing surveys, many salmonid and cyprinid species of larger size-classes (>10 cm total length) have higher relative density and biomass estimates for visual surveys. This would indicate that both electrofishing and visual surveying methods generate complementary types of information, which depending on the level at which the study is considered, can allow researchers to fine-tune their sampling protocols and gain better quality fish data for targeted species and size-classes.

Quantifying Fish Avoidance of Small Acoustic Survey Vessels in Canadian Lakes and Reservoirs

**L. Wheeland and G.A. Rose, Centre for Fisheries Ecosystems Research, Fisheries and Marine Institute of Memorial University of Newfoundland. (Laura.Wheeland@mi.mun.ca).*

Avoidance by fishes in response to survey vessels may introduce bias in hydroacoustic estimates of fish abundance. Increasing applications of acoustic survey methods in Canadian lakes and reservoirs has resulted in a need to examine vessel effects in these environments. We developed a method to quantify avoidance through the use of paired drift:drift and drift:motor transects. This study was completed at two sites in eastern Manitoba, Canada, aboard 17-foot Boston Whalers powered by four-stroke outboard engines. Acoustic data were collected using a BioSonics DTX echosounder, with a downward facing 200 kHz splitbeam transducer. The magnitude of avoidance was found to differ between study areas ($F_{1,41}$=5.24, P=0.03). We detected no change in avoidance with changes in water depth ($F_{1,41}$=3.13, P=0.08), or increasing vessel speed ($F_{1,41}$=1.58, P=0.22). There was also no evidence of diving by fishes in the presence of the motoring vessel (t=-1.04, P=0.30), and avoidance was not size-selective (t=0.89, P=0.38). Our data do not provide evidence for visual cues as a cause of avoidance in these systems. We conclude that avoidance cannot be generalized between similar study areas. Avoidance can be

quantified in the field, and does not represent a major problem in acoustic estimation of fish abundance in shallow lakes and reservoirs with low water clarity.


NSERC
CRSNG
Université de Montréal
McGill
Canadian Rivers Institute
BC hydro
FOR GENERATIONS
Canadian Hydropower Association
Association canadienne de l'hydroélectricité
Ontario
UNIVERSITY OF WATERLOO
Manitoba Hydro
Manitoba
Water Stewardship
Canadian Electricity Association
Association canadienne de l'électricité
Ressources naturelles et Faune
Québec
Énergie NB Power
Carleton UNIVERSITY
University of Lethbridge
UNIVERSITY OF ALBERTA
MEMORIAL UNIVERSITY
TransAlta
Brookfield
Renewable Power
INRS
Université d'avant-garde
UBC
UNB
UNIVERSITY OF NEW BRUNSWICK
NSERC
HydroNet
CRSNG
Pêches et Océans Canada
Fisheries and Oceans Canada