
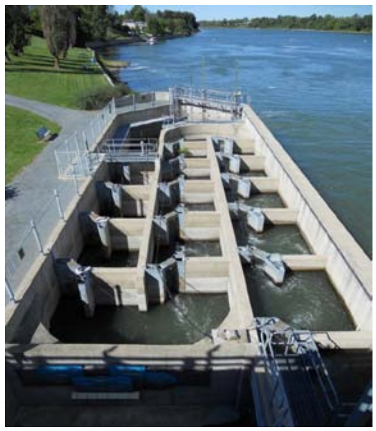


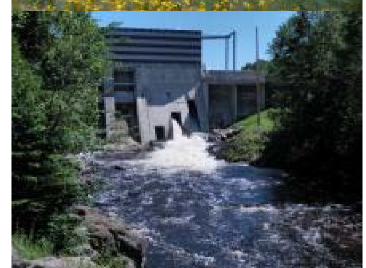


NSERC HYDRONET 2ND ANNUAL SYMPOSIUM

March 20th to 23rd, 2012

in partnership with BC Hydro, Ecofish Research Ltd. and Hemmera

BC Hydro, Centre Auditorium, 6911 Southpoint Drive

Burnaby, British Columbia

Acknowledgments

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Summary

The central theme of the Second Annual Symposium of NSERC HydroNet is « Networking ». The emphasis on collaboration, integration, and communication has taken numerous forms that are reflected in the program of this Symposium. Leaders of each research component will identify their general objective, the contributions of individual student projects to this objective, and the interactions among the different components. All presenters have been requested to describe the fundamental and practical contributions of their work, including the linkages between the science and the decision-making process regarding the effects of hydropower on aquatic environments. A special session on the Water-Use Planning Program in British-Columbia has been organized by BC Hydro. This will illustrate how science was applied to develop a management strategy in a multiple-stakeholder context. In addition, a training session has been organised to foster an exchange of expertise about relevant statistical tools that may be used to analyse data collected under individual and collaborative projects. The participation of approximately 110 representatives from universities, hydropower companies, provincial and federal governmental agencies, non-governmental organizations, and consulting firms from across Canada is expected to contribute to a dynamic exchange of ideas, and to inspire the development of projects that will continue to correspond to the research needs of present and future partners.

Participating Organizations

AECOM Tecsult Inc.
BC Hydro and Power Authority
Canadian Electricity Association
Canadian Hydropower Association
Canadian Rivers Institute
Carleton University
Chubra - Smith Holdings
Columbia Power
Compass Resource Management Ltd.
Fisheries and Oceans Canada (Calgary, Delta, Mont-Joli, Nanaimo, Nelson, Ottawa, Central-Arctic, Pacific, Prince Albert, Vancouver, Whitehorse, Winnipeg)
Ecofish Research
Gitanyow Fisheries Authority
Hemmera
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Iowa State University
Kansas State University
Manitoba Hydro
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Memorial University of Newfoundland
Natural Sciences and Engineering Research Council of Canada (NSERC)
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Northwest Hydraulic Consultants Ltd.
Province of British Columbia, Aquatic Conservation Science
Province of British Columbia, Ecosystems - South Coast
SaskPower
Simon Fraser University
SNC-Lavalin
Turner McGrath Strategies Inc.
Université de Montréal
University of Alberta
University of British Columbia
University of Lethbridge
University of New Brunswick
University of Waterloo
World Wildlife Fund (Canada)

Agenda

Tuesday, March 20th, 2012

08:00 *Welcome* (D. Boisclair, Université de Montréal)

08:05 **Opening remarks:** Paul Higgins, BC Hydro

08:10 *Evaluating Flow Ramping Effects at Run-of-River Hydroelectric Projects* (A. Lewis*, K. Healey, P. Gibeau, Ecofish Research Ltd.; and S. Babakaiff, Ministry of Forests, Lands and Natural Resource Operations)

08:30 *Standardized Methods for the Long-Term Monitoring of Run-of-River Hydropower Facilities in British Columbia and the Yukon: Summary and Preliminary Results* (A. Harwood*, A. Lewis, and S. Faulkner, Ecofish Research Ltd.)

08:50 *HydroNet's Network Structure* (D. Boisclair, U Montréal)

09:20 *Productive Capacity of Fish Habitats* (D. Boisclair, U Montréal)

09:40 Discussion

10:00 COFFEE BREAK

10:20 *Nutrients as Chemical Drivers of Fish Productivity: Comparing Regional Differences in Fish Biomass – Total Phosphorus Relationships for Lakes and Rivers* (J.B. Rasmussen, University of Lethbridge)

10:40 *Flow Regimes of Natural versus Regulated Rivers.* (M. Lapointe, McGill University)

11:00 *Understanding the Relation between Geomorphic Processes and Aquatic Ecosystems* (B.C. Eaton*, University of British Columbia; and M.F. Lapointe, McGill U)

11:20 *Winter Stressors for Fish in Rivers* (F. Hicks and M. Loewen*, University of Alberta)

11:40 Discussion

12:00 LUNCH

13:00 *Flow Regime and Fish Community Density* (C.J. Macnaughton*, G. Bourque, and D. Boisclair, U Montréal)

13:20 *Can Measurements of Stress Biomarkers of a Top Predator Help Assess the Effects of High Daily Flow Variations in a Hydro-Peaking River?* (S. Harvey-Lavoie* and D. Boisclair, U Montréal)

13:40 *Variability of Fish Production: Nutrients as Chemical Drivers across Diverse Regions* (C. Good* and J.B. Rasmussen, U Lethbridge)

14:00 *Flow Regimes of Natural versus Regulated Rivers across Canada: Project Proposal and Preliminary Results* (F. McLaughlin* and M. Lapointe, McGill U)

14:20 *Physical Habitat below a Hydro-peaking Dam: Examining Progressive Downstream Change and the Role of Tributaries* (L. Winterhalt*, B.C. Eaton, UBC; and M. Lapointe, McGill U)

14:40 *Use of Remote Sensing and Modelling to Assess Morphologic Change as a Result of a Hydro-peaking Dam* (H. Buehler*, B. Eaton, UBC; and M. Lapointe, McGill U)

15:00 COFFEE BREAK

15:20 *Mapping Fish Habitat Downstream of Hydro-dams in Canada: Estimation of Possible Long-term Modifications and Assessment of the Current Hydraulic Geometry Conditions* (F. Hugue*, M. Lapointe, M. Kalcska, McGill U; and B.C. Eaton, UBC)

15:40 *River Ice Observations on Small Regulated and Unregulated Streams in Newfoundland, New Brunswick and Alberta, Canada* (J. Nafziger*, J. Morley, S. Emmer, F. Hicks and M. Loewen, U Alberta)

16:00 *Modelling Instream Flow Effects on Juvenile Salmonid Capacity in Small Streams: Do Habitat Suitability Curves Systematically Underestimate Optimal Flows?* (J. Rosenfeld, B.C. Ministry of Environment)

16:20 Discussion

18:00 COCKTAILS AT THE KEG, sponsored by Ecofish Research Ltd. *(800 Columbia St., New Westminster)*

Wednesday, March 21st, 2012

08:00 *How does flow regulation affect riverine fishes?* (R.A. Cunjak, University of New Brunswick – Canadian Rivers Institute)

08:20 *Fish Passage in Canada – State of the Science with Particular Reference to Lake Sturgeon* (S.J. Cooke*, J.D. Thiem, C. Hatry, Carleton University; D. Zhu, U Alberta; J. Dawson, Carleton U; K. Smokorowski, K. Clarke, DFO; C. Katopodis, Katopodis Ecohydraulics Ltd.; P. Dumont, D. Hatin, Ministère des Ressources naturelles et de la Faune; A. Haro, T. Castro-Santos, USGC; R. Wilson, and A. Gleiss, Swansea University)

08:40 *Survival of Incubating Atlantic Salmon Eggs as a Function of Hyporheic Water Quality and Flow Regulation* (P. Thoms*, T. Linannsaari, A. Fraser, UNB; R. Randall, DFO; and R.A. Cunjak, UNB-CRI)

09:00 *Winter Condition of Atlantic Salmon Parr and Pre-smolts Experiencing Variable Stream Flows* (S. Vue*, UNB-CRI; K. Clarke, DFO; and R.A. Cunjak, UNB-CRI)

09:20 *Effects of Hydroelectric Dam Ramping Rate Regimes on the Length-Weight Relationships of Four Freshwater Fish Species* (B. Kelly*, University of Waterloo; K.E. Smokorowski, DFO; and M. Power, U Waterloo)

09:40 *Biology of Lake Sturgeon (*Acipenser fulvescens*) Spawning below a Dam on the Richelieu River, Quebec: Endocrinology, Behaviour, and Egg Deposition* (J.D. Thiem*, Carleton U; P. Dumont, D. Hatin, MRNF; G. Van Der Kraak, University of Guelph; and S.J. Cooke, Carleton U)

10:00 COFFEE BREAK

10:20 *Trends in Fish Passage in Canada and a Case Study on Redhorse (*Moxostoma sp.) *Passage at a Vertical Slot Fishway* (C. Hatry*, Carleton U; K. Smokorowski, DFO; and S.J. Cooke, Carleton U)

10:40 *A Field Study of the Hydraulics at the Vianney-Legendre Vertical Slot Fishway, near St. Ours, Quebec* (A. Marriner* and D. Zhu, U Alberta)

11:00 Discussion

11:20 *Mesoscale Modeling of Littoral Habitats in Reservoirs* (D. Boisclair, U Montréal)

11:40 *Productivity of Freshwater Ecosystems: An Acoustics Approach* (G. Rose*, L. Wheeland, and R.A. Pollom, Marine Institute of Memorial University)

12:00 LUNCH

13:00 *Hydroacoustic Mapping of Fish Habitat Use in a Hydropower Reservoir* (L. Wheeland*, R.A. Pollom and G.A. Rose, Memorial U)

13:20 *Using Hydroacoustics to Spatially Quantify Productive Capacity in Freshwater Ecosystems* (R.A. Pollom, Memorial U)

13:40 Discussion

14:00 *Entrainment Vulnerability of Bull Trout and Burbot at the Mica Dam (Kinbasket Reservoir, B.C.)* (E.G. Martins*, Carleton U; P.M. Harrison, U Waterloo; L.F.G. Gutowsky, S.J. Cooke, Carleton U; M. Power, U Waterloo; and D.A. Patterson, DFO)

14:20 *Hydraulic Modeling for Healthy Aquatic Ecocsystems* (D.Z. Zhu*, M. Langford, B. Robertson, R. Islam, A. Marrier, A. Baki, U Alberta; A. Leake, P. Higgins, BC Hydro; and S. Cooke, Carleton U.)

14:40 COFFEE BREAK

15:00 *Adfluvial Adult Bull Trout* (Salvelinus confluentus) *Depth Distribution and Diel Vertical Migration across Multiple Seasons* (L.F.G. Gutowsky*, Carleton U; P.M. Harrison, U Waterloo; E.G. Martins, Carleton U; A. Leake, BC Hydro; M. Power, U Waterloo; and S.J. Cooke, Carleton U)

15:20 *Seasonal Shifts in Diel Vertical Migration (DVM) and Activity Patterns of Burbot* (Lota lota) *in a Large Hydropower Reservoir: Implications for Entrainment Risk* (P.M. Harrison*, U Waterloo; L.F.G. Gutowsky, E.G. Martins, Carleton U; D.A. Patterson, DFO; S.J.C. Cooke, Carleton U; and M. Power, U Waterloo)

15:40 *Reservoir Thermal Structures in Kinbasket Reservoir* (C.B. Robertson*, M.T. Langford, and D.Z. Zhu, U Alberta)

16:00 *Computational Fluid Dynamic Modeling of Headpond Hydraulics and Bed Shear Stress at Aberfeldie Dam on the Bull River, British Columbia* (M.T. Langford*, M.R. Islam, C.B. Robertson and D.Z. Zhu, U Alberta)

16:20 *Some Hydraulic Aspects of Nature-like Fishpasses under a Fish Habitat Compensation Project* (A.B. Baki*, D.Z. Zhu, G. Courtice and N. Rajaratnam, U Alberta)

16:40 Discussion

19:00 ADMINISTRATIVE BANQUET for the Board of Directors, Science Advisory and Research Management Committees, sponsored by Hemmera.

Thursday, March 22nd, 2012

08:00 *Water Use Planning Program in British Columbia*

08:10 *Life before Water Use Planning* (H. Smith, Chubra-Smith Holdings)

08:40 *Life during Water Use Planning (*D. Ohlson, Compass RM)

09:10 *Life after Water Use Planning* (P. Higgins and A. Leake, BC Hydro)

09:40 Discussion

10:00 COFFEE BREAK

10:20 *Using Stable Isotopes and Stomach Content Data to Compare the Food Webs of a Regulated and Unregulated River of South-Central Newfoundland* (J.M. Brush*, M. Power, U Waterloo; J. Marty, St. Lawrence River Institute; K.D. Clarke and K.E. Smokorowski, DFO)

10:40 *Low Stream Flows: Making Decisions in an Uncertain Climate* (D. Turner*, Simon Fraser University; M. Bradford, DFO; J. Venditti and R. Peterman, SFU)

11:00 Discussion

12:00 LUNCH

13:00 Meeting of the BOARD OF DIRECTORS (Edmonds Tower, Floor 13, Fraser Meeting Room)

Meeting of the SCIENCE ADVISORY COMMITTEE (Edmonds Tower, Floor 10, Meeting Room 1)

Meeting of the COMMITTEE OF YOUNG RESEARCHERS (Edmonds Tower, Floor 11, Meeting Rooms 1 & 2)

13:30 Joint meeting of the BOARD OF DIRECTORS and the RESEARCH MANAGEMENT COMMITTEE (Edmonds Tower, Floor 13, Fraser Meeting Room)

Friday, March 23rd, 2012

08:00 GRADUATE STUDENT TRAINING SESSION: Basic programming in R (Delta Burnaby, Firenze/Venezia Room)

Conference Abstracts

Evaluating Flow Ramping Effects at Run-of-River Hydroelectric Projects

**Adam Lewis[1], Katie Healey[1], Pascale Gibeau[1], and Scott Babakaiff[2].*

[1] Ecofish Research Ltd., Vancouver, BC. (fjalewis@ecofishresearch.com).
[2] Ministry of Forests, Lands and Natural Resource Operations.

Run-of-river hydroelectric projects do not have many of the environmental issues associated with large storage projects, however, they do have the potential to increase flow ramping rates. Flow ramping (a rapid decrease in water level downstream of dams and powerhouses) can strand and isolate fish, cause mortality, and violate the Fisheries Act. High rates of hourly stage change have been documented at some run-of-river facilities during both planned and unplanned operations, and fish kills have been observed, though the frequency and magnitude of these events is not well understood. Generic protective stage change rates (ramping rates) provide a starting point for setting flow change rates at hydroelectric plants, however it is not known whether these are sufficiently protective or too restrictive. Accordingly, ramping rates have been set for individual projects based on field testing of hydrometric response, patterns of habitat dewatering, and fish behavior. Alternative metrics of ramping impact have been developed and are now being evaluated via ongoing monitoring, however, interpretation of these results is hampered by a lack of information on habitat use, fish behavior, and physical factors influencing fish stranding. Applied research into habitat use, behavioral responses to flow change, and population modeling of the effects of flow ramping would allow for more effective management of flow ramping issues.

Standardized Methods for the Long-Term Monitoring of Run-of-River Hydropower Facilities in British Columbia and the Yukon: Summary and Preliminary Results

** Andrew Harwood, Adam Lewis, and Sean Faulkner. Ecofish Research Ltd., Vancouver, BC. (aharwood@ecofishresearch.com).*

With the development of multiple run-of-river projects in the past 15 years, there have been increasing calls by the regulatory agencies for more standardized approaches to baseline and long-term monitoring. As a result, a series of guideline documents have been developed to outline the types of data required and the recommended data collection methods to aid proponents and their consultants during the permitting and operation phases. The most recent of these documents, commissioned by Fisheries and Oceans Canada, describes the nine parameters that are recommended for study during long-term operational monitoring, and provides guidance as to if, when, where, and how each parameter should be monitored. We provide a brief summary of the guideline document along with some preliminary results from monitoring using these standardized approaches on a number of projects in the Lower Mainland and on Vancouver Island. We identify a variety of responses to project operation, note some common themes, and discuss some challenges and confounding factors. The adoption of these guidelines is in its infancy, but the hope is that by promoting standardized methods meta-analyses can be conducted to draw comparisons across multiple projects and evaluate common environmental effects. Ultimately, it is hoped that this will improve our ability to predict, mitigate and minimize adverse environmental effects of these projects.

HydroNet's Network Structure

** D. Boisclair, Université de Montréal, Département de sciences biologiques, C.P. 6128, Succursale Centre-ville, Montréal, QC, Canada. (Daniel.Boisclair@UMontreal.ca).*

The general objective of NSERC HydroNet is to provide knowledge and tools that will permit the sustainable development of hydropower in Canada. This is achieved by developing strategies to assess, minimize, and mitigate the effects of hydropower on fish and their habitats. Specific projects conducted by NSERC HydroNet have been designed to facilitate the decision-making process in the context of the application of existing regulations such as the Canadian Environmental Assessment Act, the Species at Risk Act, and the Habitat Policy. The Network presently consists of 16 university professors, 30 graduate students and post-doctoral fellows, 14 research associates, 8 industry collaborators (BC Hydro, Manitoba Hydro, Nalcor, Brookfield Power), 9 scientists from Fisheries and Oceans, and 4 scientists from provincial agencies (Manitoba Water Stewardship, Ontario Ministry of Natural Resources, Ministère des Ressources Naturelles et de la Faune du Québec). This group collectively conducts 21 projects in 44 regulated and unregulated rivers and 5 reservoirs distributed from Newfoundland to British-Columbia. The focus on a common set of study sites has played a critical role in the realization of collaborative projects. Networking and knowledge transfer has taken numerous forms including the development of a Web Site (restructured in 2012), the production of General Public Annual Reports, and the organization of Workshops (including a Workshop on Hydropower, Science, and Policies to be held in Ottawa in May 2012), Training Sessions (Introduction to R-Statistical Package for students of the Network, Vancouver, March 2012), and International meetings (HydroNet-CEDREN joint workshop planned for the fall of 2012 in Trondheim, Norway). Future developments of NSERC HydroNet will require additional government and industry partnerships and a research strategy adapted to answer questions posed by an anticipated new regulatory framework.

Productive Capacity of Fish Habitats

** D. Boisclair, Université de Montréal, Département de sciences biologiques, C.P. 6128, Succursale Centre-ville, Montréal, QC, Canada. (Daniel.Boisclair@UMontreal.ca).*

Estimating the net loss or gain of the productive capacity of fish habitats requires methods to estimate and predict metrics of this variable. The general objectives of this project are to improve methods to estimate metrics of productive capacity of fish habitats, to contribute to the development of tools to predict the productive capacity of fish habitats, and to facilitate the implementation of the principle of no-net-loss. The metrics of the productive capacity of fish habitats in rivers that are considered in this project are fish abundance, biomass, and growth (estimated for few fish species). Specific studies that are parts of this project focus on the development of relationships between flow regime, thermal regime, and fish growth, on the exploration of the potential for physiological indicators of fish condition/stress to better identify the environmental factors that affect metrics of productive capacity of fish habitats, and the evaluation of the relative effects of key environmental conditions on metrics of the productive capacity of fish habitats. Comparison of sampling methods indicated that, even in wadeable rivers, it is important to sampling fish using both electrofishing and visual surveys. Statistical analyses indicated that 75% of the information found in 211 flow indices may be summarized by only 7 flow indices. One of these flow indices could explain 40-50% of total fish community abundance or biomass in 10 rivers studied by HydroNet. The results suggest that it may be possible to develop a tool capable of predicting the productive capacity of fish habitats from Québec to Alberta.

Nutrients as Chemical Drivers of Fish Productivity: Comparing Regional Differences in Fish Biomass – Total Phosphorus Relationships for Lakes and Rivers

** J.B. Rasmussen, Department of Biological Sciences, University of Lethbridge.*

The productive capacity of ecosystems for fish, can be viewed as the product of the system's "food base" which can be expressed in terms of "**energy flow**" (primary & secondary productivity) or at the level of its **nutrient** regime. Physical factors can modify productive capacity, via their influence on the basic hydrology, the nutrient regime, or on primary and secondary productivity, but also as habitat factors via their effect on intra and inter-specific interactions among fish, and on the distribution and renewal rate of food.

Effects of the nutrient regime can arise through geographic (regional or geomorphological) differences in nutrient export capacity of watersheds, through factors that affect the fate and distribution of nutrients within the drainage network, or through anthropogenic inputs (i.e. eutrophication) or land use differences. Regardless of the source of nutrient variability trophic status is among the most pervasive contributors to system variability, and needs to be factored into any comparisons of productivity, no matter what the trophic level of interest.

Here I examine Fish biomass -- Total Phosphorus relationships for lakes (both littoral and profundal) and in streams and rivers obtained from published and unpublished literature sources, and compare relationships obtained on the island of Newfoundland to the corresponding patterns seen in continental regions of Canada and the northern U.S, and discuss possible factors responsible for the differences observed.

Flow regimes of natural versus regulated rivers

** Michel Lapointe, Department of Geography, McGill University.*

This study aims to characterize the impacts of river damming on a variety of ecosystem related metrics of river flow regime alteration at Hydronet study sites across Canada. The study will thus supply key information to the SNG modeling effort on the specific flow alterations in each study system that act as drivers of short term and long term changes to fish habitats.

River discharge (flow, $m^3 \cdot s^{-1}$), the product of velocity and the river's cross sectional area is naturally variable and dependent on regional climate and seasonal precipitation as well as watershed scale relief and storages such as lakes and aquifers, factors that vary widely across Canada. When discharge is regulated for hydropower, five main flow characteristics are affected, including: magnitude, duration, timing (seasonality), recurrence frequency and rates of change (Magilligan and Nislow, 2001, 2005). All affect riverine biota directly and indirectly via short term and long term impacts on fish behaviour and habitat, e.g. on the calibre and mobility of channel substrate, on channel width, bar structure and bank erosion rates, side channel number and complexity, on floodplain plant succession, on pond water balance and river thermal and chemical regimes (Richter et al. 1996).

One masters project has begun in September 2011 and is the subject of a separate presentation. The main objectives of this project are to estimate flow alteration metrics and to analyse in a subset of Hydronet study systems how the altered flow regime has modified the 'channel forming', geomorphologically dominant flow level and affected cross sectional morphology and habitat conditions.

Understanding the Relation between Geomorphic Processes and Aquatic Ecosystems

**B.C. Eaton[1], and Michel Lapointe[2].*

[1] Department of Geography, University of British Columbia.
[2] Department of Geography, McGill University.

It is axiomatic that changes in the flows of water and sediment to a river system will result in physical changes to the characteristics of the river channel itself. In some instances, these changes will include adjustments of the average gradient of the stream, the average channel width, and the number and character of the bars and pools within the system. These sorts of changes affect the gross spatial structure of the depth and velocity fields in the river system at both high and low flows, as well as the accessibility of off-channel habitats during high flows, with obvious implications for fish species inhabiting the water column. In other instances, the changes will involve textural modification of the river bed, which can affect the quality and availability of spawning habitat, as well as the habitat available for benthic invertebrates and bottom-dwelling fish species. While numerical tools exist to quantify the physical habitat associated with a particular stream flow level contained within a channel of known configuration, our ability to predict how future changes in streamflow and/or sediment supply may affect physical habitat is restricted by our (in)ability to predict how stream channel morphology is likely to respond to such changes. Furthermore, our ability to quantify historical changes in physical habitat due to activities such as dam construction is limited by the precision with which the pre-existing channel conditions are known. As part of the HydroNet project, we are conducting research on a number of dammed river systems that will allow us to validate and improve an existing, physically-based model relating reach-average channel conditions to the imposed streamflow and sediment supply (the UBCRM model). We have used the UBCRM model to predict the response of the Kananaskis River to the construction of the Pocaterra Dam in the 1950's, and in doing so, we have identified important processes related to riparian vegetation dynamics linked to the dam operation that need to be added to the model. We have also studied the habitat characteristics of Kananaskis River: the river is subject to large daily flow fluctuations, which impact the habitat suitability to varying degrees at different points downstream of the dam. In addition, our research group has recently begun developing models that explore the linkages between streamflow characteristics, large wood input from the riparian forests and sediment storage within a river reach to the habitat available within the reach. While the results are preliminary, it appears feasible to use the UBCRM to predict changes in physical habitat as a result of environmental change, including (but not limited to) hydropower generation. The future work planned as part of the HydroNet project will serve both to quantify the historical impact of hydropower activities on fish habitat, and to validate the physical habitat modelling approach.

Winter Stressors for Fish in Rivers

*Faye Hicks and * Mark Loewen, Department of Civil and Environmental Engineering, University of Alberta. (fhicks@ualberta.ca, mrloewen@ualberta.ca).*

Winter, especially on Canadian rivers that realize freezing conditions, imposes some of the most significant physical disturbances encountered in aquatic ecosystems. Since hydroelectric operations can alter both a river's hydrological and ice regime, the environmental effects of altered flow regimes are complicated by dynamic ice conditions in winter. At present, the mechanism and nature of these 'cold season' complications are poorly understood. Winter conditions can have significant impacts on fish at the individual, community and population level and water level regulation by hydroelectric generating stations may serve to mitigate or amplify these impacts. Although hydrological investigations have been carried out in several large, regulated rivers, and under conditions of variable ice formations, few have been carried out in biologically complex small (wadable) rivers and almost no data exist on the relevance of physical habitat characterization in winter in terms of implications for biota. The principal aim of this study component is to broadly characterize and quantify the winter regime of rivers so as to identify those environmental stressors that directly influence fish habitats and productive capacity, and to distinguish how those stressors may vary in regulated versus unregulated systems.

Research under this project encompasses both field research (at sites in NB, Nfld., and Alberta) as well as historical research, investigating the effects of regulation and climate change on the winter ice regimes of river. Interactions with other project components, specifically, those investigating fish survival in response to river regulation as well as impacts of ice on river geomorphology will also be discussed.

Flow Regime and Fish Community Density

**C. J. Macnaughton, G. Bourque and D. Boisclair, Département de sciences biologiques, Université de Montréal. (camille.macnaughton@gmail.com).*

Extensive ecological alteration and loss of biodiversity resulting from river regulation has generated widespread concern for the viability of maintaining and restoring healthy river ecosystems. Fish are typically adapted to a range of variability in stream flow, but the scarcity of high-quality data sets showing accurate quantitative data on fish communities complicates the task of comparing environmental and biological parameters between natural and regulated systems. In an attempt to investigate the relationship between fish community structure and calculated hydrologic metrics, 10 rivers across Canada representing the range in flow regimes from natural to regulated systems were selected for study. Electrofishing surveys to estimate the densities of all species present in 10 rivers were conducted during the summer of 2011 at 407 sites. Approximately 48% of the variability in fish densities is explained by three of 207 flow indices; these are related to the variability in flow magnitudes and duration. Redundancy analysis revealed that flow plays a significant role in explaining fish densities in the studied rivers, with 22% of the variability in fish densities explained by two flow indices. However, variance partitioning indicates that flow indices explain much less of the total variance than geographic variability. This result likely reflects the differences between both the fish communities sampled and the environmental conditions of the different rivers, which vary considerably between regions. Further characterization of how altered flow regimes shapes fish community structures in impacted rivers therefore requires a more selective approach, focussing on rivers within an area with similar fish communities.

Can Measurements of Stress Biomarkers of a Top Predator Help Assess the Effects of High Daily Flow Variations in a Hydro-Peaking River?

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

A field study on fish stress has been conducted in a context of natural flow regime alteration. The study took place in a hydro-peaking river, where hydropower facilities usually run in response to a high demand in energy. Therefore, events of massive and unpredictable flow discharge happen daily. The effects of this high flow variation have been assessed in a top predator, *Esox lucius* (Northern pike). A total of 40 fish have been caught in Mississagi River, regulated by Aubrey Falls Dam, and Aubinadong River, unregulated, both situated in Northern Ontario. Aubinadong River serves as a control for absence of high variations in flow, related to hydro-peaking management strategy. The natural river, which is a tributary of the regulated river, has similar physical characteristics of Mississagi River. Chosen traditional stress biomarkers are part of the primary, secondary and tertiary physiological responses. Besides, a heat shock proteins (HSP) expression assessment has been conducted on Northern pikes to determine the relationships between traditional stress biomarkers and HSP expression in fish cells. Assessing stress state of fish in regulated river is important for conservation of natural fish populations. By providing useful tools and concrete recommendations for healthy fish populations, this study will help dam hydropower managers to take decisions regarding their future hydropower flow management strategy.

Variability of Fish Production: Nutrients as Chemical Drivers across Diverse Regions

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

Nutrient regimes, primarily total phosphorus, are known for the role they play in driving primary production in aquatic systems, having a measurable effect on the productivity of fish communities. These water quality interactions have been investigated in freshwater lakes, but few studies have measured trends across a range of landscapes in lotic systems and reservoirs. A unifying trend between these three systems is the variability of their nutrient sources and loading due to both natural and anthropogenic factors.

An example of natural nutrient variability is found in the headwaters of the Kootenay-Columbia River system in British Columbia where differences in catchment geology plays a role in nutrient behaviour. We used the characterisation of the water quality attributes of the underlying geology in this region to identify how physiochemical relationships in comparable mountain systems will affect nutrient sources and shift productivity of fish communities. Nutrient regimes have also been modified anthropogenically by the development of dams, impacting the longitudinal transport of nutrients. Regulated systems are highly influenced by shifts in the natural flood pulse and nutrient release from reservoir outflows. We will investigate the nutrient regime in regulated and unregulated paired rivers, compared against measured fish biomass, which should provide indicators of expected fish production in these systems.

Investigating aquatic systems across an extensive geographical range, we expect that nutrient concentrations (predominantly total phosphorus) will be a strong predictor of productive capacity of fish habitats. For river management, the ability to identify the specific baseline nutrient regime of regulated and unregulated systems, and what our expectation should be of the aquatic community, will be useful tools for regulation in hydropower.

Flow Regimes of Natural versus Regulated Rivers across Canada: Project Proposal and Preliminary Results

**Fraser McLaughlin, Dept. of Geography, McGill University. (Fraser.McLaughlin@mail.mcgill.ca).*

A river's flow regime determines channel form and habitat availability. Some rivers regulated by dams are subject to drastically altered flows while others remain largely unchanged. In order to gauge the effects of river regulation on riverine habitats, we must quantify how regulation has altered flow parameters known to impact ecosystems. Since pre-dam discharge data does not exist for the vast majority of the regulated rivers in the NSERC HydroNet dataset, regional flow analyses must be performed in order to estimate the baseline hydrographs of the altered systems (using surrounding watersheds as reference systems) and selecting flow indices that describe the discrepancy between current flow and hypothetical unregulated flow. In systems that appear to be highly altered, the regulated rivers and unregulated references will be compared using field measurements to determine differential impacts of flow on channel form. Preliminary results include hydrographs of altered and reference systems in Quebec and selected flow indices that stand out and are geomorphologically or ecologically relevant. This project is important to the cumulative HydroNet effort since it contextualizes observed ecological differences across the country, enables educated research decisions by other researchers, and empowers dam operators to make informed operational decisions.

Physical Habitat below a Hydro-peaking Dam: Examining Progressive Downstream Change and the Role of Tributaries

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Hydropeaking dam operations often drastically alter natural flow regimes, to time flow releases with consumer energy demands. These large alterations to natural flow regimes affect aquatic organisms and their habitats. In this study, a 40-km stretch of the Kananaskis River (Ab) below a hydropeaking facility was examined to assess quantitative physical changes at progressive distances downstream from the dam, with particular attention given to the role of tributaries. The physical habitat properties examined were depth, velocity, total suspended solids, substrate size, and channel bed mobility. Additionally, benthic invertebrate samples were taken immediately upstream and downstream of four tributaries. These samples are compared to similar samples from an unregulated river to examine the relative importance of tributaries for population recovery downstream of the dam. Seven sites were chosen to examine physical habitat characteristics which were measured at high and low flow dam releases. Depths and velocities were modeled using RIVER2D (a 2D hydraulic modeling program). Preliminary results suggest that changes in physical habitat characteristics are great close to the dam, but follow less discernible patterns at great distances downstream.

Use of Remote Sensing and Modelling to Assess Morphologic Change as a Result of a Hydropeaking Dam

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The 1955 damming of the Kananaskis River provides a unique opportunity to assess dam induced changes in channel morphology. This system experienced changes in flow regime through reduction in the magnitude of high flows and creation of daily peaking flows which still maintain the competence to partially mobilize sediment with no associated alteration in sediment supply. We assessed reach scale morphological change of the Kananaskis with an emphasis on the role of vegetation in affecting channel adjustment. Pre and post-dam channel conditions were assessed through historical photo analysis, field measurements, and airborne remote sensing techniques. The 8 most upstream sites were characterized by modest to no narrowing over the 50 period of interest while the downstream sites exhibited statistically significant narrowing over this same period. Additionally, throughout the entire study region the vegetated banks shifted from dominance by grasses and shrubs to dense coniferous forests. That the response signal is most strongly represented in the downstream section may relate to the hydro-peaking forcing rather the reduction in formative discharge. In these downstream reaches with a more attenuated flood pulse it appears that bank stability associated with riparian vegetation acts as an important control on channel adjustment. Model simulations from the UBCRM support these observations. The observed morphological dynamics correspond to a shift from approximately 5% vegetative cover to over 50%, as defined by the bank stability parameter of the UBCRM. Therefore changes in channel morphology cannot be explained solely by altered flow regime, but also must consider vegetation dynamics.

Mapping Fish Habitat Downstream of Hydro-dams in Canada: Estimation of Possible Long-term Modifications and Assessment of the Current Hydraulic Geometry Conditions

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Although the use of remote sensing to study fluvial environments exists for decades, only recent techniques proved their efficiency to map fish habitats. I present here the usefulness, for a multidisciplinary network such as HydroNet, of integrating classic multispectral remote sensing to classify fish habitat downstream of several hydro-dams in Canada. The resulting classification maps of the different river units can be used as a framework either to estimate and understand the long-term geomorphologic modifications in the river channel, but also to assess the current hydraulic geometry conditions. In fluvial geomorphology, especially for a fish ecology focus, it is important to consider the hydraulic geometry of particular river section, because the parameters resulting from this analysis (mean water depth, channel width, wetted area and perimeter) can be incorporated into predictive models for fish habitat alteration. Field measurements have been linked with the hydraulic geometry parameters found in the remote sensing analysis, in a manner to test the University of British Columbia Regime Model (UBCRM). The UBCRM is a simple model which predicts the equilibrium for the hydraulic geometry of an alluvial channel from descriptive river parameters (formative discharge, slope, sediment size and bank strength).

In the same context, I show how hyperspectral remote sensing can eventually improve the river habitats classification. This work consist in using Casi (36 bands between 400-950nm) and Sasi (160 bands between 850-2500nm) scenes from the Kiamika and Picanoc rivers (Qc, Canada) to develop algorithms of spectral signature separations in order to differentiate features such as aquatic vegetation species, substrate composition and water depth.

River Ice Observations on Small Regulated and Unregulated Streams in Newfoundland, New Brunswick and Alberta, Canada

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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 juvenile fish and eggs. River ice conditions were observed on eight regulated and unregulated streams: four in Newfoundland (winter 2010-2011), three in New Brunswick (winter 2011-2012), and one in Alberta (winter 2011-2012). Winter ice conditions were observed using remote cameras on all streams while water levels, water temperatures, and dissolved oxygen content were observed at select sites. This presentation will discuss data observed thus far and outline data collection activities for this 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 in different regions across Canada.

Modelling Instream Flow Effects on Juvenile Salmonid Capacity in Small Streams: Do Habitat Suitability Curves Systematically Underestimate Optimal Flows?

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The Instream Flow Incremental Methodology (in conjunction with Habitat Suitability curves) remains one of the most widely used methods for assessing the consequences of reduced instream flows for fish. Despite its widespread use, IFIM predictions are rarely validated against direct measures of fish abundance or production, and recent studies suggest that IFIM may underestimate the consequences of low flows for production of juvenile salmonids. I compared instream flow predictions using IFIM to predictions of optimal energy flux to fish using a drift-foraging model applied to a small coastal stream using standard habitat suitability curves for juvenile coho. The use of a drift-foraging model is based on the inference that production of juvenile drift-feeding salmonids depends not only on the availability of habitat, but also on the flux of energy to available habitat, and that the available energy flux may better represent productive capacity. Relative to energy flux estimates from the drift-foraging model, IFIM using Habitat Suitability curves systematically underestimated the negative consequences of decreasing flow, indicating that the delivery of energy (invertebrate drift) to useable habitat declines much more quickly with decreasing flow than the availability of useable habitat as modelled with Habitat Suitability curves, supporting the potential for a systematic bias in IFIM predictions.

How does flow regulation affect riverine fishes?

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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 students are testing predictions that deal with the consequences of river flow regulation on egg/alevin survival and development, as well as seasonal changes in growth and physiological condition of juvenile and adult stages of fishes. While focused on flow variation, concomitant changes in physicochemical environmental attributes (e.g., dissolved oxygen, water temperature, ice dynamics) are also being investigated to assess their importance in measuring biological response. Much of the work is being carried out in Maritime rivers with a focus on Atlantic salmon *(Salmo salar)*. However, comparative studies at HydroNet sites in central Canada, and with other riverine species, is planned for the next few years. Collectively, such studies are fundamental to quantifying juvenile recruitment and the potential impacts of anthropogenic activities on fish population dynamics.

Fish Passage in Canada – State of the Science with Particular Reference to Lake Sturgeon

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Since the NSERC workshop on fish and hydropower interactions and the development of the NSERC HydroNet proposal, there have been a number of advances in our understanding of fishway science in Canada and beyond. For example, in Canada the CanFishPass database now exists and serves as a repository of geo-referenced biological and engineering information on over 200 fishways in Canada. There have also been several syntheses and meta-analyses that provide insight into the ways in which fishways have been studied and information on their effectiveness. A notable pattern is that few studies adopt an interdisciplinary approach. Through HydroNet, our team of biologists and engineers have been working collaboratively to explore fish passage issues for lake sturgeon. Combining fields as disparate as functional morphology, endocrinology, hydraulic engineering, and behavioural ecology our team has improved our knowledge of fish passage for sturgeon (including information on when it may not be needed). Many questions remain to be answered with respect to fish passage in Canada and we are confident that the knowledge and approaches used as part of our HydroNet project will inform future studies and improve fish passage science and practice.

Survival of Incubating Atlantic Salmon Eggs as a Function of Hyporheic Water Quality and Flow Regulation

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Atlantic salmon *(Salmo salar)* egg survival is heavily dependent on the environmental conditions *in situ.* The hyporheic zone is a dynamic area of mixing groundwater and surface water in the substrate where adult salmon dig redds and spawn. It is believed that flow regulation will alter temperature and DO (dissolved oxygen) concentration and impact the mortality, growth and development of Atlantic salmon eggs. Hydroelectric activities provide renewable energy but have a physical impact on salmon habitat and form barriers for salmon migration. An unanswered question; is to which extent is egg survival impacted by hydroelectric activities? In November 2011; eggs were planted in the Tobique river system, NB., placed in the streambed at 100, 200 and 300mm below the streambed at three sites downstream of dams in two regulated rivers; the Dee and the Serpentine and in an unregulated control river the Gulquac. Separate controls for base survival rate and transport/time taken to deposit the eggs were incubated at the Mactaquac Biodiversity Unit, NB. At each site temperature of surface water and at 300mm depth in substrate will be monitored for temporal and spatial variation in growth and development of the salmon eggs. The uppermost sites of the Gulquac and the Dee contain *in situ* oxygen optodes to monitor DO concentration within artificial redds. Egg survival will be monitored in conjunction with flow, DO and temperature data to assess the implications of hyporheic water quality and flow regulation.

Winter Condition of Atlantic Salmon Parr and Pre-smolts Experiencing Variable Stream Flows

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Winter conditions for Atlantic salmon parr are demanding. For many overwintering stream fishes, winter represents the period when significant energy reserves (i.e. lipids) are depleted. In many regulated rivers, winter hydropeaking flows representing 2-50 times the base flow 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 flow regime changes representing 2-3 times the baseflow in large outdoor tanks with natural substrate and various habitats. We assessed changes in the 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. We predict that, relative to fish in a controlled flow regime, overwintering parr in the treatment tanks will realize a decrease in condition factors and fat measurements, and will have a reduced capacity to smoltify.

Effects of Hydroelectric Dam Ramping Rate Regimes on the Length-Weight Relationships of Four Freshwater Fish Species

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Hydroelectric dams alter the physical environment in downstream river reaches, which can impact the condition of fish populations living in those reaches. However, the operation of hydroelectric dams, including their ramping regimes, can be managed and regulated in an attempt to mitigate possible negative impacts on fish species. Fish length and weight data were collected over a period of nine years from two Northern Ontario boreal forest rivers: the Magpie River (regulated) and the Batchawana River (unregulated). The sampling period included two distinct hydroelectric ramping rate regimes on the regulated river. The weight-length relationships of four numerically abundant fish species with a range of life history characteristics were analyzed to determine the effect of ramping rate regimes on fish condition: Longnose Dace (*Rhinichthys cataractae*), Slimy Sculpin (*Cottus cognatus*), Brook Trout (*Salvelinus fontinalis*) and Trout Perch (*Percopsis omiscomaycus*). The effects of water temperature and discharge on weight-length relationships were also examined to determine if either factor significantly influenced growth patterns. Strategies for identifying the causal mechanisms of differences in fish condition between natural and regulated flows will be discussed.

Biology of Lake Sturgeon (Acipenser fulvescens) Spawning below a Dam on the Richelieu River, Quebec: Endocrinology, Behaviour, and Egg Deposition

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Knowledge of the reproductive biology of wild populations of sturgeon is critical to ensure the perpetuation of this unique group of animals. We combined intensive netting surveys, non-

lethal blood sampling, radio telemetry and egg collection to examine the reproductive biology of lake sturgeon (*Acipenser fulvescens*) at a suspected spawning ground below a dam on the Richelieu River, Quebec, Canada. Using the aforementioned techniques we quantified and described the timing of spawning, the characteristics and location of a spawning ground, the composition and residency of reproductive and non-reproductive individuals, and temporal trends in reproductive hormone titers. Lake sturgeon were present at the site when sampling began at the start of May, however spawning was not detected until 30 May, with back calculated embroyonic ageing indicating that spawning took place from 26 May – 5 June when water temperature averaged 13.4 ± 0.1^{o}C (range 11.5–15.5^{o}C). We estimated the spawning population at 1629 individuals (1129–2452; 95% C.I.). These results indicate that suitable spawning habitat for lake sturgeon exists downstream of a dam equipped with a fishway and have important implications for passage which will be discussed in the broader context of sturgeon fishway passage.

Trends in Fish Passage in Canada and a Case Study on Redhorse (Moxostoma sp.) Passage at a Vertical Slot Fishway

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Barriers resulting from anthropogenic activities (e.g., hydropower development, irrigation, flood control, low flow augmentation) can prevent the upstream migration of fish, reducing the connectivity of river systems. As a result, great efforts have been devoted to the design and installation of engineered fishways to enable the movement of fishes across barriers. In 2009 we created a national database, CanFishPass, designed to act as a national repository for upstream fishway-related information. We evaluated the information gathered in the CanFishPass database to identify trends concerning fishways and fish passage in Canada. In addition to the evaluation of CanFishPass, a comprehensive examination of fish passage at a vertical slot fishway by three redhorse species is being carried out. Fish are being studied for their time to exhaustion and recovery rate as well as for their attraction and passage efficiency at the fishway. Through this research we hope to both describe the state of fishways in Canada as well as interpret the ability and success of passage for species of interest at a vertical slot fishway.

A Field Study of the Hydraulics at the Vianney-Legendre Vertical Slot Fishway, near St. Ours, Quebec

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This study focused on the field hydraulics measured at the Vianney-Legendre vertical slot fishway. The fishway is a staircase style, vertical slot fishway on the Richelieu River, in southwestern Quebec, Canada. The fishway sits on the west bank of the river adjacent to a

3.4m high water controlling dam. Velocity measurements were taken in two straight pools and two turning pools. The maximum slot velocities ranged from 1.00 m/s to 1.23 m/s. The two straight pools shared a common flow pattern, similar to Pattern 2 flow. Kinetic energy levels were calculated for two straight pools. The turning pools also shared a common flow pattern. The pattern is characterized by a jet flow that wraps around the back wall of the pool leaving a large recirculation zone, approximately half the pools area, in the pool centre. A second, smaller recirculation zone formed in the upstream corner of the pool behind the long baffle. Water levels were measured in 5 pools. Water depths were greatest in the downstream ladder pools and least in the upstream ladder pools. Water level changes between adjacent pools were greatest in the upstream ladder pools and decreasing to the smallest in the downstream ladder pools.

Mesoscale Modeling of Littoral Habitats in Reservoirs

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Accurate estimation of metrics of the productive capacity of fish habitats is crucial to the assessment of the effects of hydropower of fish communities. The general objective of this project is to contribute to the development of methods aimed at estimating metrics of productive capacity in lakes and reservoirs. This project is based on the view that ecosystems consist of mosaics of habitat patches that play different roles for different species and life-stages. Changing water levels in lakes or reservoirs may not only modify total wetted area but the size, the spatial structure, and the proportion of habitat patches. It therefore appears potentially useful to develop modelling approaches in which habitat patches are explicitly considered. The specific objectives of this project are: 1) to identify what sampling method/combination of sampling methods may be best to estimate metrics of the productive capacity of fish in the littoral zone; 2) to assess the relative roles of local, lateral, and contextual variables on metrics of the productive capacity of littoral habitats; 3) to evaluate the potential difference between estimates of productive capacity obtained on the littoral zone during the day and the night; 4) Document the utility of using the concept of guilds of fish to improve the explanatory power of models of the productive capacity of fish habitats in the littoral zone. Results of the 2011 sampling season suggest that the 3 preferred sampling methods to study the littoral zone should be gill nets (no more than 3-4 h of continuous sampling to minimize mortality and maximise the capacity to associate catch to habitat use by fish), seining, and boat electrofishing. Given the size of the study ecosystems it may be strategically preferable to intensively study (76 sampling sites per lake) only one ecosystem (Lac du Bonnet, a reservoir managed by the industry partner of this project, Manitoba Hydro). The preliminary study of habitat structure indicates that the littoral zone of Lac du Bonnet comprises no more than 5-6 littoral habitat types. The sampling design for summer 2012 will be developed using this information.

Productivity of Freshwater Ecosystems: An Acoustics Approach

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This project attempts to develop multi-frequency acoustic methods to assess the productivity of shallow freshwater ecosystems at high spatial resolution with respect to habitat. We have developed equipment, methods and new analytical strategies to do so. Experiments indicate that boat avoidance by fish is minimal and can be corrected for. Survey methods enable high-resolution measures of bathymetry, macrophyte distribution and substrate type. Habitat maps of the reservoir will be produced, to be compared with independent grab or pole samples. Plankton and fish can be discriminated within the acoustic backscatter employing multi-frequency analyses. Fish were ensonified almost entirely as measurable single targets ranging from large fish (TS >-35 dB) to small (TS < -50 dB). Problems of species identification are severe. Hence, to assess productivity, we are investigating the use of size based approaches that utilize the resolution capabilities of single fish. We may extend this approach to functional groups based on acoustic size (e.g, large, medium, small fish, plankton). We will then compare size-frequency data over different habitats (and temporal consistency) using Exponential Decay models commonly used to assess mortality rates in fisheries.

Hydroacoustic Mapping of Fish Habitat Use in a Hydropower Reservoir

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To assess habitat use and production by fishes in a hydropower reservoir in eastern Manitoba (Lac du Bonnet), a splitbeam Biosonics DTX scientific echosounder operating at multiple frequencies (1000, 430, and 200 kHz) was used to conduct full systematic surveys and near-shore tracks that circumscribed the reservoir. Resolution was at a scale of metres along transects and approximately 300 metres between. Acoustic data were used to map bathymetry and develop classification criteria for bottom types. Physical sampling was used to assist classification according to depth, bottom substrate (bedrock/boulder; gravel/cobble; sand; mud) and the presence or absence of submerged aquatic vegetation. Distribution of fishes and plankton, and size-frequency spectra derived from single targets from acoustic surveys, were spatially referenced to habitat maps to determine if variation in distribution and productivity occurs among habitat types. In addition, diel variation in habitat use and depth preferences of fishes will be examined.

Using Hydroacoustics to Spatially Quantify Productive Capacity in Freshwater Ecosystems

** R. A. Pollom, Centre for Fisheries Ecosystems Research – Memorial University of Newfoundland.*

Hydroacoustics is a technology that has long been used in fisheries stock assessments in the marine environment, and is increasingly being used to assess fish stocks and productive capacity in freshwater environments. Many authors have claimed that the lack of reliability of assessments using traditional passive netting techniques demands an alternate approach, and that such passive tools should be used in a supplementary fashion with active observation techniques such as hydroacoustics. An appropriate combination of these assessment tools provides a relatively complete and accurate picture of the aquatic ecosystem allowing for a better understanding of productive capacity over multiple spatial scales. Acoustic surveys performed in Lac du Bonnet, Manitoba were undertaken in the summer of 2011 to obtain information about productive capacity in a reservoir system affected by hydropower. Fish abundances and densities were mapped throughout the pelagic portion of the large reservoir using Echoview 5.1 software. Plankton samples were collected haphazardly throughout the survey area in regions where unique acoustic signals were obtained, and spatial relationships between fish and plankton were assessed with GIS. The challenge of species identification with hydroacoustics was overcome by assessing productive capacity and energy flux through the ecosystem based on the body size-abundance relationship of fish of different sizes. Hydroacoustics, along with a limited amount of gill-netting, proved to be an informative method of assessing the productive capacity of the reservoir.

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

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Fish using habitats near hydropower dams are vulnerable to being non-volitionally displaced from reservoirs (i.e. entrained) when water is diverted through turbines for the generation of electricity. We are investigating entrainment rates and vulnerability of bull trout (*Salvelinus confluentus*) and burbot (*Lota lota*) in a large hydropower reservoir (Kinbasket Lake, Mica Dam) in the upper Columbia River, British Columbia. Bull trout (n = 192) and burbot (n = 50) were acoustically tagged in the spring of 2010 and monitored for one year with an array of receivers deployed in the forebay and tailrace of the Mica Dam. Three (1.6% of the total tagged) bull trout and one (2%) burbot were detected in the tailrace, indicating that they were entrained, and all of these detections occurred during the fall or winter months. We developed an entrainment vulnerability metric based on the percent time that a fish spends in the forebay per month (%FTM) and analyzed it as a function of fish size, sex, season, and tagging season (sex and tagging season for bull trout only). Our results indicated that %FTM was associated with season, with both bull trout and burbot spending on average about twice as much time in the forebay during winter and fall than during the spring and summer. This finding is consistent with the timing of fish detections in the tailrace. We are currently collecting one more year of data (to be downloaded in the spring of 2012) that will supplement our preliminary analysis. Furthermore, we started another telemetry study to investigate fine-scale movements of bull trout and burbot in the vicinity (within 200 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 risks.

Hydraulic Modeling for Healthy Aquatic Ecocsystems

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In this talk, I will first review the hydraulic modeling work that has been conducted for fish entrainment risk assessment, fish passes, stream rehabilitation and connectivity, as well as river physical habitat modeling. In addition to field measurements, physical laboratory modeling and computational fluid dynamics modeling have also been used in these studies. I will also discuss the path forward where the need for the integration of hydraulic modeling and biological studies is highlighted.

Adfluvial Adult Bull Trout (Salvelinus confluentus) Depth Distribution and Diel Vertical Migration across Multiple Seasons

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For fish at temperate latitudes, lake depths offer a range of environmental conditions that can be accessed to optimize physiological processes such as metabolism and maximize species' and life-stage specific fitness functions. The depths that fish occupy are ecologically relevant, however, only recently have detailed assessments that monitor individuals over a variety of temporal and spatial scales been possible through the use of biotelemetry. In the current study, acoustic biotelemetry transmitters equipped with pressure sensors were used to provide a detailed ecological assessment of adfluvial bull trout depth distribution and vertical migration relative to several biotic and abiotic variables. The results showed that bull trout depth distribution fluctuated seasonally with a clear pattern in diel vertical movement. Overall, bull trout were deepest during the summer (July, August, September) and shallowest in the spring (April, May, June), especially in April. The reproductive period (September-October) was characterized by moderate depths whereas the period associated with ice cover (January, February and March) showed moderate to deep depths. In addition we found that adfluvial bull trout exhibit diel vertical migration that was prominent in July and August but also existed in other months including January, February, and March (winter). Fish depth was related to the water depth of the reservoir, but not to fish size. Interestingly, males were observed to use shallower depths than females in every month except October (part of the reproductive season).

The results of this study provide detailed ecological information on a threatened species, identify how cold-water stenotherms might accesses various depths on a daily and seasonal basis to theoretically maximize fitness, and suggest that seasonal variability in fish depth relative to turbine intakes may be an important consideration when assessing entrainment vulnerability at a dam powerhouse.

Seasonal Shifts in Diel Vertical Migration (DVM) and Activity Patterns of Burbot (Lota lota) in a Large Hydropower Reservoir: Implications for Entrainment Risk

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To minimise the impacts of hydropower on burbot *Lota lota*, we must first understand more about the basic ecology of this species. A key step in this process is the ability to predict burbot seasonal and diel depth distributions. While a number of horizontal movement studies suggest burbot are most active during the winter and spend the summer in a quiescent state, few fine-scale vertical distribution studies exist corroborating these behaviours. Diel vertical migration (DVM) is a depth distribution strategy common amongst freshwater organisms and has been described in juvenile burbot, however evidence describing this migration in adult burbot is scarce and the function of this behaviour in burbot is unknown. Explanations for the function of DVMs in other freshwater fishes include thermal or foraging habitat optimization and predation/completion avoidance. In this study we utilized a continuous monitoring telemetry array to model the seasonal and diel depth distribution and thermal habitat use of 30 burbot over 360 days. We found burbot exhibited a clear DVM and nocturnal activity pattern through most of the year, except during their pre-spawning/spawning period (Nov-Jan), when DVM ceased and high night-time activity rates continued through the day. Burbot in our study system did not enter a quiescent state during the summer, and while they remained inactive during the day in summer, night-time activity rates were not different from the rest of the year. Burbot DVM continued during periods when no thermal advantage was available and DVM was more pronounced among larger individuals, which together suggests that thermal optimization and competition/predation avoidance were not the sole drivers of this behaviour. Given the high night-time vertical activity rates, we hypothesise that burbot DVM may be driven by the need to optimise foraging opportunity.

Reservoir Thermal Structures in Kinbasket Reservoir

**C. B. Robertson, M. T. Langford, D. Z. Zhu, University of Alberta.*

Fish entrainment is partially a function of reservoir forebay thermal characteristics and therefore it is important to understand how hydropower operations can affect the temperature stratification within a reservoir. This presentation will focus on the thermal regime of Kinbasket reservoir upstream of Mica dam. Field studies in 2011 were undertaken, where thermal stratification was measured for 6 months in the dam forebay. A review and analysis of collected water temperature profile data was completed. Spectral analysis of thermistor time series was undertaken to determine dominant periods of oscillation. Longer periods (11.3 days, 6.7 days, 5.6 days, and 2.6 days) and shorter periods (8 hours, 12 hours, and 20 hours) at several vertical modes were found. In order to understand the natural reservoir dynamics, theoretical calculations of seiche periods was undertaken. Wave like solutions were achieved from the component equations of two dimensional motions. Two reservoir lengths were used, a main reservoir length (150 km) and a local reservoir length (14.6 km, smaller arm where dam was located). Results indicated that longer internal seiche periods were due to the main reservoir, while shorter internal seiche periods were due to the local reach. Further analysis was undertaken on the effects of dam operations on the thermal stratification. A covariance analysis of the thermistor time series and ~24 hour cycling dam operations revealed both positive and negative relationships, with the deepest thermistors being most severely affected. Both natural and dam induced fluctuation trends were identified in recorded temperature stratification plots throughout the year.

Computational Fluid Dynamic Modeling of Headpond Hydraulics and Bed Shear Stress at Aberfeldie Dam on the Bull River, British Columbia

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The upstream flow regime induced by hydropower operations at dams is physically complex and is inferred to be one of the key aspects effecting fish entrainment. It is important to assess the forebay hydraulics for fish entrainment risk assessment. This can be done using a three dimensional numerical simulation to predict upstream hydraulics under varying operating conditions.

Aberfeldie dam, located on the Bull River, upstream of its confluence with the Kootenay River, operates as a run-of-the-river facility, which operates by two intake units and a spillway. A computational fluid dynamic (CFD) model was constructed for this facility using the Reynolds Averaged Navier Stokes equations and κ-ε turbulence model to assess the forebay hydraulics under a variety of discharges and operational scenarios. This model has been validated against acoustic field measurements upstream of the facility. Additionally, the model has been used to predict the induced bed shear stress throughout the forebay to assess the likelihood of sedimentation and sediment mobilization, which is of particular importance for this dam. The model has been able to accurately predict eddy formation and flow structure under the field measurement scenario and has been extended to other operations. The model suggests that over the size range of bed particles measured in the field, that the form of the bed is dynamic, and fluctuates based on the river discharge throughout the year. This presentation will focus on the numerical model development and the simulated effects of the dam on the upstream hydraulics and bed shear stress.

Some Hydraulic Aspects of Nature-like Fishpasses under a Fish Habitat Compensation Project

**Abul Basar Baki, David Z. Zhu, Gregory Courtice, and Nallamuthu Rajaratnam, Dept. of Civil and Environmental Engineering, University of Alberta. (baki@ualberta.ca).*

A more holistic approach to fish passage has advanced over the last two decades, leading to nature-like fishpasses with a principle objective to accommodate both the movements and habitat needs of most biota living in a water body. Although they are gaining increased popularity as a means of providing improved fish passage, systematic studies of nature-like fishpasses are still in preliminary stages. There are two different types of nature-like fishpasses, namely the pool-riffle type and the rocky-ramp type, both of which are primarily constructed of boulders. This research program is comprised of a three phase hydraulic model study: prototype model (field studies), physical model (laboratory experiments), and numerical model (CFD modeling). This work is based on the results obtained from physical hydraulic models of a rocky ramp-type fishpass configuration with a staggered arrangement of isolated boulders having a slope of 5%. The data includes 3D instantaneous velocities and 2D mean velocities obtained by an Acoustic Doppler Velocimeter (ADV) and Yaw probe, respectively. Experimental observations and results obtained from the laboratory experiments are presented, which includes the water velocity fields and potential habitat metrics that have potential importance for fish habitat. The objective of this research is to develop potential improvements for the design and operation of nature-like fishpasses and develop a general nature-like fishpass design guideline.

Water Use Planning Program in British Columbia

* H. Smith, Chubra-Smith Holdings,
* D. Ohlson, Compass RM,
* P. Higgins and A. Leake, BC Hydro.

Since its early years as electricity provider for a developing province and through recent years as a key pillar of BC's economy, BC Hydro has gone from a utility governed solely by the Hydro and Power Authority Act to one that is accountable to several provincial and federal laws. This workshop reviews the approach taken to address regulatory uncertainty for its existing facilities and identifies opportunities for applications to new projects. The workshop will be divided into *three parts*:

- *Life before Water Use Planning* – describes the regulatory environment and opportunity for collaboration and operation improvements that led to the development of Water Use Plan (WUP) Guidelines (Hugh Smith, BC Hydro)

- *Life during WUPs* – goes through a typical WUP process on Campbell River employing Structured Decision Making to gain consensus on an operating regime (Dan Ohlson, Compass Resource Management)
- *Life after WUPs* – reviews the wrap up of WUPs, and the efforts taken to resolve fish passage and fish entrainment issues towards Fisheries Act Authorizations for all facilities (Alf Leake, BC Hydro)

There will be a 20min Q&A session open to attendees after the talks. Themes highlighted in the workshop include:

- What is the role of collaboration in developing a Water Use Plan?
- What is the role of science?
- How does a Water Use Plan address regulatory requirements (e.g. Fisheries Act)?

Using Stable Isotopes and Stomach Content Data to Compare the Food Webs of a Regulated and Unregulated River of South-Central Newfoundland

** Jaclyn M. Brush[1], Michael Power[1], Jérôme Marty[2], Keith D. Clarke[3], Karen E. Smokorowski[4].*

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Disturbances, such as flow regulation have the potential to alter energy flow and resource availability for downstream river inhabitants. Dam operation modifies river ecosystems by altering natural flow regimes, physical habitat and affecting resource use by consumers in regulated reaches. Few studies have attempted to quantify spatial or temporal variability in consumer resource and food web structure use in regulated and unregulated rivers. A combination of stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes and stomach content analysis was used to evaluate how seasonally variable flow regimes affected consumer resource use, consumer trophic position and food web relationships among fishes within the rivers. Three-spined stickleback (*Gasterosteus aculeatus*) did not exhibit large differences in resource use, and had similar trophic positions in the altered and unaltered river. In contrast, Atlantic Salmon (*Salmo salar*) and Brook Trout (*Salvelinus fontanalis*) had lower trophic positions than conspecifics in the unaltered river. Trophic position also varied seasonally, likely corresponding to the change to increased flows in the summer. Thus food web related studies can provide important insights for flow and habitat management in this region and in other rivers affected by variable flow regimes.

Low Stream Flows: Making Decisions in an Uncertain Climate

** Dorian Turner[1], Mike Bradford[2], Jeremy Venditti[3] and Randall Peterman[1].*

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Water resource managers must make decisions regarding minimum instream flow requirements for rivers, despite many uncertainties. Two important uncertainties concern (1) estimates of usable fish habitat at different discharges, and (2) effects of climate change on future stream discharge. We examined the implications of these two uncertainties for the North Alouette River, British Columbia (BC). Using the British Columbia Instream Flow Methodology, which is an assessment method for water diversions needed by small-scale hydroelectric projects, We found that uncertainty in habitat preferences of rainbow trout (*Oncorhynchus mykiss*) fry generally dominated uncertainty in the results of the BCIFM when numerous transects were used. In contrast, for fewer than 15 transects, variation in physical habitat among sampled transects was the most important source of uncertainty. In addition, the increasing frequency of climate driven low-flow events suggests that operations of small-scale hydroelectric projects in BC may become more restricted in the future.

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