


1ST SYMPOSIUM OF NSERC HYDRONET

March 29th to 30th, 2011
Delta Winnipeg, Victoria/Albert room
350 St. Mary Avenue
Winnipeg, MB

The presentations covered many subjects, including:

• Modelling the productive capacity of fish habitats in rivers. • Geomorphological processes in unregulated and regulated rivers. • Effects of flow and thermal regimes on fish egg survival and growth. • Ice and winter dynamics in unregulated and regulated rivers. • Biological and hydrological determinants of fish passage success.	• Interactions between biodiversity, trophic structure, and productive capacity. • Effects of ramping rates on downstream biota. • Assessment of the productive capacity of fish habitats in lakes and reservoirs. • Strategies to reduce fish entrainment risks in reservoirs.

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Summary

During the two day event, university, industry and government scientists from across Canada presented their findings from 2010, and the research activities planned for 2011. Collectively, the projects involve 16 university scientists (from 12 universities), 7 industry collaborators (BC Hydro, Manitoba Hydro, Brookfield Power, and Nalcor), 9 scientists from Fisheries and Oceans Canada, 4 researchers from provincial agencies (Manitoba Water Stewardship, Ontario Ministry of Natural Resources, and Ministère des ressources naturelles et de la faune), and 1 non-governmental organisation (Saint-Lawrence Institute). The goals of the first symposium were to: 1) communicate the most recent progress of ongoing projects; 2) present plans for future years; 3) receive comments/suggestions from collaborators, partners, and members of the Science Advisory Committee and the Board of Directors; and 4) develop new projects with existing or future partners. Approximately 100 participants attended the first symposium of NSERC HydroNet.

Participating Organizations

AECOM Tecsult Inc.
BC Hydro and Power Authority
Canadian Electricity Association
Canadian Hydropower Association
Canadian Rivers Institute
Canadian Wildlife Federation
Carleton University
Fisheries and Oceans Canada (Ottawa, Maritimes, Central-Arctic, Pacific)
Government of Alberta, Environment
Great Lakes Environmental Services
Hydro-Québec
Iowa State University
Kansas State University
Katopodis Ecohydraulics Ltd.
Leibniz-Institute of Freshwater Ecology and Inland Fisheries (Germany)
Manitoba Hydro
Manitoba Water Stewardship
McGill University
Memorial University of Newfoundland
Ministère des ressources naturelles et de la faune (Québec)
Natural Sciences and Engineering Research Council of Canada
North/South Consultants Inc.
SaskPower
St. Lawrence River Institute
Stantex
Université de Montréal
University of Alberta
University of British Columbia
University of Lethbridge
University of Manitoba
University of Waterloo
World Wildlife Fund (Canada)

Agenda

Tuesday, March 29th, 2011

08:30 *Welcome and Introduction to the Symposium.* (D. Boisclair, Université de Montréal)

08:35 **Opening remarks:** Mr. Ken Adams, Senior Vice President, Power Supply, Manitoba Hydro.

08:45 **Keynote speaker:** Keith Gido, Kansas State University – *Response of Arid River Fish Assemblages to Environmental Flow Regulation.*

09:30 *Measuring Productive Capacity of Fish Habitats.* (K. Minns, R. Randall*, K. Smokorowski, K. Clarke, A. Vélez-Espino, B. Gregory, S. Courtenay, and P. LeBlanc, Fisheries and Oceans Canada)

10:00 COFFEE BREAK

10:30 *NSERC HydroNet: A national research network to promote sustainable hydropower in Canada.* (D. Boisclair, Université de Montréal)

11:00 *DFO's Center of Expertise on Hydropower Impacts on Fish and Fish Habitat (CHIF): Projects in support of HydroNet's objectives.* (K. E. Smokorowski, Fisheries and Oceans Canada-Center of expertise on Hydropower Impacts on Fish and fish habitat)

11:30 *Saskatchewan Protocol Agreement - A Cooperative Approach to Prioritizing & Managing Fisheries Issues at Power-generating Facilities.* (R. West*, SaskPower and D. Lightle, Fisheries and Oceans Canada)

11:50 LUNCH

13:00 *Resizing a River: Using an experimental management approach to develop a downscaled environmental flow regime for Lower Bridge River, B.C.* (M. Bradford*, Fisheries and Oceans Canada; P. Higgins, B.C. Hydro; J. Korman, Ecometric Research)

13:20 *Quantifying Stress in Fish: The relationship between flow magnitude and stress biomarkers in hydro-peaking and natural rivers*. (S. Harvey-Lavoie, and D. Boisclair, Université de Montréal)

13:40 *Comparing Relative Fish Density Estimates from Electrofishing and Visual Surveying Methods.* (C. Macnaugthon*, S. Harvey-Lavoie, G. Lanthier, C. Senay, and D. Boisclair, Université de Montréal)

14:00 *Chemical and Biological Drivers for Fish Biomass and Productivity – Geographic variability in mountain streams.* (C. Good and J. Rasmussen, University of Lethbridge)

14:20 *Studying the Geomorphic Aspects of Changes to Fish Habitat Below Hydro Dams: Changes to bed substrate characteristics, as well as changes to size and morphology of channels.* (F. Hugue*, and M. Lapointe, McGill University and B. Eaton, University of British Columbia)

14:40 Fluctuations in Physical Habitat below a Hydropeaking Dam. (L. Winterhalt, and B. Eaton, University of British Columbia and M. Lapointe, McGill University)

15:00 COFFEE BREAK

15:30 *Applications of Airborne Remote Sensing: Assessing physical and ecological impacts of dams along the Kananaskis River, Alberta.* (H. Buehler*, B. Eaton, and M. Hassan, University of British Columbia and M. Lapointe, McGill University)

15:50 *Monitoring River Ice Processes at Newfoundland HydroNet Sites.* (J. Morley*, J. Nafziger and F. Hicks, University of Alberta)

16:10 *Hydraulic Modelling Options for Newfoundland HydroNet Sites.* (J. Nafziger*, J. Morley and F. Hicks, University of Alberta)

16:30 *Behaviour and Passage Success of Fish using a Vertical Slot Fishway in Québec: Case studies incorporating a single and multispecies approach.* (J. Thiem*, T. R. Binder, J. W. Dawson, C. Hatry, K. Stamplecoskie, S. J. Cooke, Carleton University; P. Dumont, D. Hatin, Ministère des ressources naturelles et de la faune du Québec; C. Katopodis, Katopodis Ecohydraulics Ltd; K. Smokorowski, Fisheries and Oceans Canada- Center of expertise on Hydropower Impacts on Fish and fish habitat; D. Zhu, University of Alberta)

16:50 *Comparative Aspects of Fish Passage Success by Three Redhorse Species at a Vertical Slot Fishway: Behavioural and physiological perspectives.* (C. Hatry*, and S. Cooke, Carleton University and K. Smokorowski, Fisheries and Oceans Canada- Center of expertise on Hydropower Impacts on Fish and fish habitat)

Wednesday, March 30th, 2011

08:20 *Mesoscale Modelling of the Productive Capacity of Fish Habitats in Lakes and Reservoirs.* (D. Boisclair, Université de Montréal)

08:40 *Acoustic Measures of Fish Distribution, Abundance, Movement and Habitat in Manitoba Lakes.* (R. Pollom, L. Wheeland*, and G. Rose, Memorial University of Newfoundland)

09:00 *Hydraulics Component Overview of the BC Hydro Fish Entrainment Study.* (C .B. Robertson*, M. T. Langford and D. Z. Zhu, University of Alberta)

09:20 *Hydraulic Measurements in Reservoirs: Capabilities and limitations.* (M. Langford*, C .B. Robertson, and D. Z. Zhu, University of Alberta)

09:40 *Upstream Sturgeon Passage at the Vianney-Legendre Vertical Slot Fishway.* (A. Marriner*, and D. Z. Zhu, University of Alberta)

10:00 COFFEE BREAK

10:30 *Modeling Selective Withdrawal Scenario Upstream of a Dam: Its impact and necessity.* (R. Islam*, and D. Z. Zhu, University of Alberta)

10:50 *Spatial Ecology of Bull trout in a Hydropower Reservoir: Implications for entrainment risk.* (L. Gutowsky*, and S. Cooke, Carleton University; P. Harrison, and M. Power, University of Waterloo)

11:10 *The Thermal and Spatial Ecology and Associated Entrainment Risk of Burbot (Lota Lota) in a Large Hydropower Reservoir in Southern British Columbia, Canada.* (P. Harrison*, and M. Power, University of Waterloo; L. Gutowsky and S. Cooke, Carleton University)

11:30 *Development of Metrics Relating Flow Alteration Impacts to River Food Web Dynamics.* (J. Marty*, St. Lawrence River Institute; M. Power, University of Waterloo; K.E. Smokorowski, Fisheries and Oceans Canada-Center of expertise on Hydropower Impacts on Fish and fish habitat)

11:50 *Numerical Investigation of Turbulent Flows through Trash Racks in Closed Conduits.* (S. Paul*, and H. Ghamry, Fisheries and Oceans Canada- Freshwater Institute)

12:10 MEETING ADJOURNED

12:30 BOARD OF DIRECTORS AND SCIENCE ADVISORY MEETINGS

Conference Abstracts

Response of Arid River Fish Assemblages to Environmental Flow Regulation

** K. B. Gido, Kansas State University, Division of Biology.*

Abstract

Data collected from 1993 to 2010 in the San Juan River, New Mexico and Utah was used to quantify interactions among native and nonnative fishes and their responses to flow regime attributes. Discharge in the San Juan River was partially manipulated by dam releases to simulate naturally high spring flows in this snowmelt-driven river system. Daily discharge, water temperature and catch rates of a dominant nonnative predator, channel catfish *Ictalurus punctatus*, were obtained from the primary channel. Annual autumn monitoring of fish assemblages in secondary channels, which primarily characterized abundance of young-of-year fishes, was conducted over the same period. An information theoretic approach was used to rank candidate models that predicted species densities based upon selected combinations of abiotic and biotic factors. Annual variation in densities of native fishes was less than that of nonnative fishes. Top ranked models for native species included positive associations with small-bodied nonnative fishes but negative associations with abundance of adult *I. punctatus*. Mean spring discharge was positively associated with densities of native speckled dace *Rhinichthys osculus* and flannelmouth sucker *Catostomus latipinnis*, but not bluehead sucker *C. discobolus*. With the exception of juvenile *I. punctatus*, the top candidate models predicting densities of nonnative fishes all included duration of low summer flows. Our results demonstrated different responses of native and nonnative fishes to flows, but densities of all fishes were generally lower in years with greater abundance of adult *I. punctatus*. Flow management in the San Juan River over the past 18 years has maintained stable populations of common native fishes, but managers should consider manipulations of seasonal flows as well as developing novel approaches to suppress nonnative predator populations to restore and maintain the entire native fish community.

NSERC HydroNet: A national research network to promote sustainable hydropower in Canada.

** D. Boisclair, Université de Montréal, Département de sciences biologiques.*

Abstract

The 470 hydroelectric facilities that have been developed in Canada produce 60% of the electricity used for domestic, commercial, and industrial purposes in this country. The capacity to generate renewable energy significantly contributes to the wellbeing and the prosperity of Canadians. However, the benefits provided by hydropower come at the cost of the effects on the physical, chemical, and biological attributes of natural ecosystems. It has long been recognized that reconciling the production of hydroelectricity with the conservation of aquatic ecosystems represents a major challenge requiring a collaborative structure that actively integrates industry, government, and academic partners. NSERC HydroNet constitutes the realization of this partnership. The general objective of this national research network is to provide new knowledge and tools that will permit us to better assess, minimize, and mitigate the effects of hydropower, and hence, permit the sustainable development of hydropower in Canada. Given its central role in the decision-making process, the productive capacity of fish habitats has been adopted as the central theme for NSERC HydroNet. Conceptual models developed to synthesize processes that determine the productive capacity of fish habitats in rivers, lakes, and reservoirs were used to develop 20 research projects. These projects are conducted with the support of funding sources such as, the Strategic Network Grants, the Collaborative Research and Development Grants, and Fisheries and Oceans Canada's Center of Expertise of hydropower impacts on fish and fish habitats. These projects collectively involve 16 university scientists (from 12 universities), 7 industry collaborators (BC Hydro, Manitoba Hydro, Brookfield Power, and Nalcor), 9 scientists from Fisheries and Oceans Canada, 4 researchers from provincial agencies (Manitoba Water Stewardship, Ontario Ministry of Natural Resources, and Ministère des Ressources Naturelles et de la Faune du Québec), and 1 NGO (Saint-Lawrence Institute). The goals of the 1st Symposium of NSERC HydroNet are: 1) to communicate the most recent progress of ongoing projects; 2) to present plans for future years; 3) to receive comments/suggestions from collaborators, partners, and members of the Science Advisory Committee and the Board of Directors; and 4) to develop new projects with existing or future partners.

DFO's Center of Expertise on Hydropower Impacts on Fish and Fish Habitat (CHIF): Projects in support of HydroNet's Objectives

* K. E. Smokorowski, *Fisheries and Oceans Canada, Center of expertise on Hydropower Impacts on Fish and fish habitat.*

Abstract

DFO's Center of Expertise on Hydropower Impacts on Fish and Fish Habitat supports DFO scientists in their collaborations with HydroNet researchers, and/or to conduct research directly related to HydroNet priorities. An overview of projects supported by CHIF in 2010 was presented. Projects include an evaluation of the longitudinal and lateral responses of riverine communities to altered seasonal flow regimes, thermal aspects of fish entrainment risk in a B.C. reservoir, evaluating changes in productive capacity of mountain stream affected by small hydro diversions, and modelling turbulence and assessing the biological response of fish to trashracks. A more thorough overview of a long term experimental determination of ramping rate effects on downstream biota (Magpie River, Ontario) was presented. Preliminary results on invertebrates and fishes demonstrated that both have responded negatively to the change from restricted to unrestricted ramping rates, although climate factors confound a clear interpretation of response and a more detailed analyses is warranted.

Saskatchewan Protocol Agreement - A Cooperative Approach to Prioritizing & Managing Fisheries Issues at Power-generating Facilities

** R. West[1] and D. Lightle[2].*

[(1)] SaskPower, Environmental Strategic Planning;
[(2)] Fisheries and Oceans Canada.

Abstract

In 2005, SaskPower and Fisheries and Oceans Canada (DFO) piloted a workshop under the auspices of a Memorandum of Understanding signed between the Canadian Electricity Association (CEA) and DFO. The objective of the workshop was to build a greater understanding amongst operational staff of each other's respective mandates and operations. As a result of this workshop, SaskPower and DFO agreed to develop a process by which SaskPower's facilities could be reviewed for compliance with the Fisheries Act and any necessary mitigations implemented on a priority basis. Since 2005, a steering committee comprised of DFO, SaskPower, the Saskatchewan Watershed Authority (SWA) and Saskatchewan Ministry of Environment (SE) has been working to implement this process. A Protocol Agreement was signed in July of 2007

and sets out the objectives and governance of the process by which the Parties will prioritize issues, develop and implement an action plan, and resolve disputes. Three action plans have been developed under the Protocol Agreement and outlined the actions proposed to be undertaken to clarify and/or address prioritized issues at SaskPower facilities.

Resizing a River: Using an experimental management approach to develop a downscaled environmental flow regime for Lower Bridge River, B.C

** M. Bradford[1], P. Higgins[2], and J. Korman[3].*

(1) Fisheries and Oceans Canada
(2) BC Hydro
(3) Ecometric Research

Abstract

Water managers must make difficult decisions about the allocation of streamflows between out-of-channel human uses, and environmental flows for aquatic resources. However, the effects environmental flows on stream ecosystems are infrequently evaluated. We used a 13 year experiment in the regulated Bridge River, British Columbia, Canada, to determine whether an environmental flow release designed to increase salmonid productivity was successful. A hierarchical Bayesian model was used to compare juvenile Pacific salmon (*Oncorhynchus spp*.) abundance before and after the flow release. We found that the total number of salmonids did increase after the release, but most of the gains could be attributed to the rewatering of a previously dry channel located immediately below the dam. In reaches that had flowing water during the baseline period the response of individual salmon species to the increase in flow was variable, and there was little change in total abundance after the flow release. Our results were inconsistent with both habitat modelling, which predicted a decrease in habitat quality with increasing flow, and holistic instream flow approaches that imply greater benefits with larger flows. We question whether biotic responses to flow changes can be predicted reliably with currently available methods, and suggest that adaptive management or the use of decision tools that account for the uncertainty in the biotic response are required for instream flow decisions when the competing demands for water are great.

Quantifying Stress in Fish: The relationship between flow magnitude and stress biomarkers in hydro-peaking and natural rivers

**S. Harvey-Lavoie, and D. Boisclair, Université de Montréal, Département de sciences biologiques.*

Abstract

Stress in fish has been widely studied in response to different stressors, particularly in regards to temperature variations. For one of the first time, a field stress study will be directed to assess the effect of hydropeaking and therefore unpredictable flow discharge in the river on stress of *Salvelinus fontinalis* (Brook trout) and *Cottus cognatus* (Slimy sculpin). Magpie River will be sampled for three different distances from the Steephill Falls Dam in Algoma district, Northern Ontario. A gradient of stress response is expected to be seen as the sampling unit are getting further from the Steephill Falls Dam. Batchawana River, a natural river without hydropower dam, serves as a control for absence of stressful conditions related to hydropeaking management strategy. Batchawana River is also situated in Algoma district and has similar physical characteristics of Magpie River. Chosen stress biomarkers are cortisol, glucose, lactate and Fulton's *K* condition factor. Besides, a heat shock proteins (hsp's) expression assessment will be conducted on both species to determine the relationships between traditional stress biomarkers, as listed above, and HSP70 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 decision regarding their future hydropower plant flow management strategy.

Comparing Relative Fish Density Estimates from Electrofishing and Visual Surveying Methods

**C. J. Macnaughton, S. Harvey-Lavoie, G. Lanthier, C. Senay, and D. Boisclair, Université de Montréal, Département de sciences biologiques.*

Abstract

Electrofishing and visual sampling are two methods commonly used to estimate fish abundance in shallow areas and much effort has gone into setting sampling standards that increase the efficacy of both methods. For the purpose of comparing the efficiency of either sampling method, a single-pass electrofishing survey along with a snorkelling survey as part of the 2010 NSERC HydroNet's objectives, were conducted over 161 sites, across 22 rivers in Canada. Mean estimated species densities from the electrofishing and visual samplings were significantly correlated ($r=0.20$, $p<0.05$), while species richness was greater while electrofishing versus visual sampling (34 vs. 30 species). Most

of these discrepancies were due to the presence of more cryptic species observed while electrofishing. The discriminate analysis revealed a final model that included water temperature (correct classification rate= 0.70); indicating that higher estimates of fish abundance while snorkelling were characterized by sites with warmer water temperatures. This result may reflect the fish community sampled. In fact, cyprinids and centrarchids generally live in warmer waters and were generally more accurately estimated while snorkelling. Taken separately, either method fails at providing a complete description of the fish community sampled and to better evaluate the fish communities within our sites across a wide range of environmental conditions, both methods should be used in tandem.

Studying the Geomorphic Aspects of Changes to Fish Habitat below Hydro Dams: Changes to bed substrate characteristics as well as changes to size and morphology of channels

*F. Hugue[1], M.Lapointe[1], and B. Eaton[2]

(1) McGill University, Department of Geography;
(2) University of British Columbia, Department of Geography.

Abstract

Rivers are dynamic systems where changes constantly occur on the channel bed due to sediment transport and flow variations. Human interventions on rivers, such as dam construction for flood control, electricity generation and irrigation are known to modify the natural flow regime and sediment throughput to the system. Depending on the type and operation of the dam, the resulting hydrograph may largely differ from the natural state in terms of high flow intensities, durations and magnitudes. Consequently, the sediment transport capacity below dam may increase or decrease. Geomorphic theory shows that changes to these drivers can entrain long term adjustments in channel geometry, back channel size, bed material grain size, river bed level with respect to floodplain level, etc.

In fluvial geomorphology, fish habitats are often characterised by the substrate composition and mobility as well as water depth, wetted area and flow speed. Channel modifications post damming can thus lead to habitat alterations, affecting reproduction success, benthic community composition, invertebrate drift regime, refugia characteristics, etc.

Our work investigates river bed channels evolution below hydro dams. Remote sensing techniques as well as field surveys will help us to describe the evolution by looking for indices of morpho-sedimentologic changes. Our databases will be useful for the Hydronet project by linking the impacts of habitat modifications to fish population data.

Surveys across Canada on about twenty regulated sites and their non-regulated references will provide a general trend of the impact of hydro dams on fish habitats.

Applications of Airborne Remote Sensing: Assessing physical and ecological impacts of dams along the Kananaskis River, Alberta

*H. Buehler[1], B. Eaton[1], M. Hassan[1], and M. Lapointe[2]

(1) University of British Columbia, Department of Geography;
(2) McGill University, Department of Geography.

Abstract

An understanding of the impacts of dams on river systems requires knowledge of the feedbacks between hydrology, geomorphology, and vegetation dynamics. However, because knowledge of the ways these interactions related to dam induced river change is limited further research is needed. This study will therefore focus on the geomorphic and ecologic response of the Kananaskis River to the 1955 damming and consequent hydrologic alteration. In order to address this question, the predam conditions will be determined based upon historic flow records and aerial photos which will be compared to field and remotely sensed data of the modern state of the system. The pre and post dam data will then be used as input values for the UBC Regime model. This model appears to be representative of similar systems by identifying the equilibrium channel geometry. Using this model calibrated to the historic Kananaskis system, the various input values can be adjusted to determine how the channel should respond to various perturbations, such as shifts in riparian vegetation density. Additionally, techniques will be developed to assess the status of riparian vegetation using airborne remotely sensed imagery. These methods were designed to allow characterization of the geomorphic and ecologic conditions associated with the historic and dam influenced system and provide a tool to predict and assess changes associated with dam induced hydrologic changes.

Monitoring River Ice Processes at Newfoundland HydroNet Sites

J. Morley, J. Nafziger and F. Hicks, University of Alberta, Department of Civil & Environmental Engineering.

Abstract

Ice processes can have a significant effect on fish and egg survival in small steep streams, especially if anchor ice formation is evident. Only a handful of studies have characterized the hydraulics of small (<70m width), steep stream under winter

conditions so that the effects on fish can be better understood. Additionally, the extent to which streamflow regulation affects the winter environment for fish just downstream of dams is not well known. In the fall of 2010 four study sites were selected from a biological perspective as part of NSERC Hydronet Project SNG 3.4 – Winter Stressors for Fish in Rivers. The objective at each site is to broadly characterize and quantify the winter iceregime and, specifically, to characterize the environmental stressors and the differences in ice formation between the regulated and unregulated sites. To achieve these objectives, sixteen time lapse cameras were along the banks of the rivers in October 2010. These cameras took hourly photos of ice conditions over the winter of 2010/2011. They will be retrieved in May 2011 and will aid in determining future monitoring efforts at these sites. Expected ice processes could include accumulation of frazil ice on the bed of the channel. This type of ice formation is called anchor ice and can be very detrimental to fish as entire pools can fill with ice.

Hydraulic Modelling Options for Newfoundland HydroNet Sites

** J. Nafziger, J. Morley, and F. Hicks, University of Alberta, Department of Civil & Environmental Engineering.*

Abstract

Ice processes can have a significant effect on fish and egg survival in small, steep streams, especially if anchor ice formation is evident. Only a handful of studies have characterized the hydraulics of small (<70m width), steep streams under winter conditions so that the effects of ice on fish can be better understood. In the fall of 2010 four study sites were selected as part of NSERC Hydronet Project SNG 3.4 – Winter Stressors for Fish in Rivers. This talk focuses on options for modelling ice processes at these four sites, including a discussion of the available models and their limitations. Modelling options for different ice covers including typical floating ice covers and non-typical ice covers which may occur on small, steep streams are discussed. Finally, the potential effects of streamflow regulation on the ice regime of the study streams are discussed.

Behaviour and Passage Success of Fish using a Vertical Slot Fishway in Quebec: Case studies incorporating a single and multispecies approach

**J. D. Thiem[1], T. R. Binder[1], J. W. Dawson[1], P. Dumont[2], D. Hatin[2], C. Hatry[1], C. Katopodis[4], K. Smokorowski[3], K. Stamplecoskie[1], D. Zhu[5]and S. J. Cooke[1]*

[(1)] Carleton University, Fish Ecology and Conservation Physiology Laboratory;
[(2)] Ministère des ressources naturelles et de la faune du Québec;

[3] Fisheries and Oceans Canada, Center of expertise on Hydropower Impacts on Fish and fish habitat;
[4] Katopodis Ecohydraulics Ltd;
[5] University of Alberta, Department of Civil & Environmental Engineering.

Abstract

The freshwater spawning migrations of many species have been influenced by the development dams which create barriers to migration. Although fishways are commonly installed to reinstate passage at these sites, their success at passing target species often remains unknown. We conducted two field studies at a vertical slot fishway on the Richelieu River in Quebec during May and June 2010 to: 1) determine passage success of lake sturgeon at the fishway and, 2) examine the utility of this fishway as a model for a multispecies approach. An extensive Passive Integrated Transponder (PIT) antenna array enabled us to quantify passage success, passage rates and determine the spatial location of individuals. In the first study, migratory lake sturgeon (n=107, 939–1625 mm TL) were captured, PIT tagged and released into the fishway. Sturgeon exhibited an ability to traverse the 70 m fishway quickly (minimum passage rate of 1.2 hrs), however, successful passage rates were variable (6.2–75.4 hrs from release) and only 30% successfully ascended. In the second study, 17 species comprising 492 individuals were captured in a fish trap, PIT tagged and released into the fishway. Passage efficiency was highly variable among species (range 0–100%), however >50% for seven of the species encountered (Atlantic salmon, carp, channel catfish, freshwater drum, smallmouth bass, walleye and white sucker). Passage rates were likewise highly variable both among and within species (e.g., 1.0–452.9 hrs for smallmouth bass, 2.4–237.5 hrs for shorthead redhorse). These results are discussed in the context of balancing fishway design for priority species while maintaining diversity.

Mesoscale Modelling of the Productive Capacity of Fish Habitats in Lakes and Reservoirs

** D. Boisclair, Université de Montréal, Département de sciences biologiques.*

Abstract

Canadians expect to have access to healthy aquatic ecosystems and to benefit from the advantages provided by the production of renewable energy, such as hydroelectricity. Numerous regulations are aimed at protecting aquatic ecosystems. One of these regulations is Fisheries and Oceans Canada's *Policy for the Management of Fish Habitat*. The «No Net Loss» of the productive capacity of fish habitats is the guiding principle of this policy. Compliance with this guiding principle implies the estimation of metrics of the productive capacity of fish habitat before a perturbation and the prediction of these metrics after the perturbation. Rivers, lakes, and reservoirs may be perceived as a

mosaic of tiles possessing different environmental conditions. These tiles, hereafter referred to as mesohabitats, may play different purposes (*e.g.* areas for growth, survival, or reproduction) for different combinations of species and life-stages. When natural rivers or lakes are transformed into regulated rivers or reservoirs, specific mesohabitats are modified, some may disappear, and others may be created. The net effect of the development of hydroelectric facilities is therefore a result of the cumulative biological consequences for fish and the balance between mesohabitat modification, destruction, and creation. The specific objectives of this project are: 1) to augment our understanding of the role played by different types of mesohabitats in the littoral zone of lakes and reservoirs for a complete suite of fish species and life stages; 2) to gain knowledge of the daily variation of littoral habitat use in different types of mesohabitats; and, 3) to compare the relative performance of different sampling gears that may be used to develop predictive mesohabitat models in the littoral zone of lakes and reservoirs. The study, supported by Manitoba Hydro, will be conducted in one lake (Lake Manigotagan) and one reservoir (Lac du Bonnet) in Manitoba. The fish community of the littoral zone will be sampled day and night using gill nets, Fyke nets, seines, and electrofishing boats (in collaboration with Manitoba Water Stewardship and Fisheries and Oceans Winnipeg). The sampling conducted in the littoral zone will be complemented by surveys performed in the pelagic zone using hydroacoustics (in collaboration with George Rose, MUN). This study is expected to improve our ability to estimate and predict the productive capacity of lakes and reservoirs.

Acoustic Measures of Fish Distribution, Abundance, Movement and Habitat in Manitoba Lakes

**L. Wheeland, R. Pollom, G. A. Rose, Memorial University of Newfoundland, Fisheries Conservation.*

Abstract

Hydroacoustics is a useful tool to assess fish, habitat and bottom characteristics in lake environments. A splitbeam Biosonics DTX scientific echo sounder at three frequencies (1000kHz, 420kHz, 200kHz) will be used for acoustic surveys of Lac du Bonnet and Lake Manigotogan, Manitoba in the summers of 2011 and 2012. Acoustic data will be analyzed to determine summer distribution, abundance and size of pelagic fish species and to examine thermal use and diel movements at the scale of the habitats. Habitat (macrophytes), bathymetry and bottom type will also be mapped at high resolution using the data from these surveys. Groundtruthing of the acoustic data will be achieved with an underwater camera or ROV, grab samples and fishing catch analysis. Boat avoidance by fish can be an issue in shallow water acoustic survey work, therefore this study will use a quiet by design boat (17' Whaler with a foam-cored hull, 4 stroke motor and storage battery power), and experiments will be run to quantify any avoidance by fish. Target strength experiments, multi-frequency analysis, and simultaneous gill-

netting will be used to identify and verify fish species within the acoustic data. In the summer of 2012 Vemco VRAP telemetry will be used to track individual fish movements nearly continuously over a broad spatial scale. Geospatial statistics will utilize spatial autocorrelation in these data. The combination of acoustic surveys and VRAP tracking will allow this study to estimate fish abundances, movements and distributions at fine spatial and temporal scales and to make scale-dependent connections between fish and habitat.

Hydraulics Component Overview of the BC Hydro Fish Entrainment Study

**C. B. Robertson, M. T. Langford, D. Z. Zhu, University of Alberta, Department of Civil & Environmental Engineering.*

Abstract

Fish entrainment occurs when resident fish are passed through a dam's internal workings, resulting in displacement and possibly injury or death. The overall objective of the study is to combine both hydraulic and biological research in order to develop general methods to assess fish entrainment risk. The parameters of concern from a hydraulic point of view include the velocity field within a reservoir, as well as the thermal structure and how it is affected. Overall, there are four sites of interest: Mica Dam (MCA), Revelstoke Dam (REV), Hugh Keenleyside Dam (HLK), and Aberfeldie Dam. Computational fluid dynamic models have been constructed for MCA, REV, and HLK, but require verification. Therefore, in the summer of 2010, field work studies measuring the velocity and thermal regime of the HLK dam forebay near Castlegar, BC were undertaken. This presentation focussed on temperature data collected in the thermally stratified forebay, revealing fluctuations that were attributed to dam operations and/or internal seiching. Further investigations of oscillatory frequencies revealed periods of 3.5 days, 24 hrs, 14 hrs (related to diurnal fluctuations) and 6 hrs. Several theoretical internal seiche periods were calculated by choosing several upstream boundaries related to major bends and narrows in the reservoir. The theoretical results were fairly well related to the observed periods. Critical discharge, the point above which flow will be pulled from all temperature layers, was examined. This is an important factor to consider in dam operations when considering selective withdrawal and its effect on fish entrainment risk.

Hydraulic Measurements in Reservoirs: Capabilities and limitations

**M. T. Langford, C. Beth Robertson, and D. Z. Zhu, University of Alberta, Department of Civil & Environmental Engineering.*

Abstract

The construction of a hydropower dam can have a drastic change on the physical morphology of regional water resources. In addition, hydropower operations can have a significant impact on the flow field of water within the forebay, and on established aquatic ecosystems upstream of these facilities. Employing concepts of environmental sustainability and protection of aquatic habitat, it is important that the effect of upstream hydropower hydraulics be investigated as it relates to fish entrainment risk assessment.

The instrumentation that is currently available for the field investigation of velocity fields is typically limited to river current metering devices and acoustic devices such as the acoustic Doppler velocimeter (ADV) and the acoustic Doppler current profiler (ADCP). Typically the acoustic devices are better suited for the measurement of limnic flows due to the relatively low velocity, and the dynamic nature of flows in lakes and reservoirs. When completing hydraulic measurements in these water bodies it is important to consider water quality factors, specifically salinity and quality of seeding as these may reduce the correlation of measured data. As the velocity in lakes and reservoirs is relatively low in magnitude, the fluctuation in velocity measurements, contributed both by turbulence and the instrument, may be relatively large. The amplitude of this fluctuating velocity component may be greater than the magnitude of the mean velocity. It is therefore important that velocity measurements are time averaged over the course of each measurement to ensure that a representative mean velocity is obtained. This corresponded to averaging in excess of 50 measurements at each point at the Hugh Keenleyside dam forebay, however is anticipated to vary from site to site.

Additionally, other environmental factors (such as reservoir depth, bed cover and bathymetry), and instrument capabilities (range, ping rate, beam angle, bin size) should be clearly identified prior to field investigation of forebay hydraulics. When properly executed, ADCP measurements have been found to closely match computational fluid dynamic modelled results, validating the strength of acoustic measurements in deep reservoirs.

Upstream Lake Sturgeon Passage at the Vianney- Legendre Vertical Slot Fishway

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Abstract

The vertical slot fishway located on the Richelieu River, approximately 20km upstream of the confluence with the St. Lawrence River has been designed to pass numerous species of fish including lake sturgeon. It is one of very few fishways worldwide that successfully passes sturgeon. Additionally, the St. Lawrence River is home to a healthy population lake sturgeon. This makes the Vianney- Legendre Vertical Slot Fishway an exceptional candidate to study in order to determine how and why it successfully passes lake sturgeon.

A detailed study of the fishway hydraulics will be undertaken over the next 3 years. During the spring 2011 lake sturgeon migration, detailed velocity measurements will be taken in 7 of the 16 fishway pools. The entrance and exit pools, the 2 turning pools, and 1 representative pool from each of the 3 straightaways have been selected for measurement. Velocity measurements will be taken using an ADV. 50cm x 50cm x 50cm (x, y, z directions) will be used for grid spacing. Finer grid spacing will be used in regions of specific interest (for example up and downstream of the slot openings). Turbulence levels, shear stresses, and energy dissipation rates will be calculated from the velocity measurements made in the field. Data divers placed upstream, downstream, and in selected pools will continuously monitor changes in water levels and corresponding flow rates in the fishway over the course of the migration period. The field data collected will be used to validate the physical scale (laboratory) and CFD (computational fluid dynamics) models to be constructed upon completion of the field season.

The knowledge gained on the hydraulics of the fishway will be combined with a concurrent study focusing on the biological aspects of the lake sturgeon migration.

Modeling Selective Withdrawal Scenario Upstream of a Dam: Its impact and necessity

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Abstract

During summer, lakes upstream of a reservoir can be stratified and density can vary across the depth. Close to the surface, water is warmer and at the bottom it is colder. If water is withdrawn from such a stratified reservoir, either warm layer or cold layer can be withdrawn depending on the location of the intake and the velocity field can be significantly changed. This phenomenon is known as selective withdrawal. The velocity field affected by the stratification may also affect the fish entrainment and movement pattern, and therefore understanding the selective withdrawal scenario is important. This study is focused on selective withdrawal with a point sink, and a line sink for both the discrete and continuous stratification. A computational fluid dynamic (CFD) solver is used and the boundary conditions are formulated to generate the flow-field for both the discrete and continuous stratification. A theoretical expression is developed to determine the incipient Froude number considering the effect of boundaries for discrete stratification with point sink. The theory is also extended for a line sink located on the horizontal bottom with discrete stratification. It is observed that the effect of boundary is insignificant when the ratio of the distance of the boundary to the distance of the interface from the intake is greater than two. It is found that the CFD solver can successfully model velocities and the interface profile in the selective withdrawal scenario. The CFD solver is used to model the Hugh L. Keenleyside dam facility located in BC considering stratification. It is also found that the velocities obtained from the homogenous potential theories can be applied in stratified conditions after some adjustments.

Spatial Ecology of Bull trout in a Hydropower Reservoir: Implications for entrainment risk

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Abstract

To date, the majority of research on fish entrainment in hydropower reservoirs has focused on migrating smolts whereas comparatively little known about the risk of entrainment to adult fish. Given the risk of entrainment in a large hydropower reservoir

is likely to fluctuate with seasonal changes in adult behaviour (e.g. spawning migrations), the first step to quantifying entrainment risk is to examine spatial ecology over multiple seasons. Here we present an ongoing study to examine the spatial ecology of adult bull trout (*Salvelinus confluentus*) in Kinbasket Reservoir, British Columbia. Kinbasket Reservoir is 210 kilometres long and was created after the completion of the Mica Dam, a large earth fill structure designed to impound the upper Columbia River to control flooding and generate hydroelectricity. In the spring of 2010 we deployed 43 acoustic telemetry receivers and tagged 187 bull trout to examine behaviour including depth and temperature use. Data were downloaded after monitoring fish movements for a year including under ice conditions. The results from this study provide the first year round assessment of bull trout spatial ecology in a large lentic system. This study also lays the ground work for a sophisticated entrainment risk assessment that will examine high-resolution movement in conjunction with hydrodynamics at the dam/forebay interface.

The Thermal and Spatial Ecology and Associated Entrainment Risk of Burbot (*Lota lota*) in a Large Hydropower Reservoir in Southern British Columbia, Canada

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Abstract

The burbot (*Lota lota)* is a fairly recent marine coloniser of freshwater and the only member of the cod family (*Gadidae*) to complete its entire lifecycle in freshwater. While burbot are abundant through much of their circumpolar distribution, many populations towards the southern edge of their North American range are threatened or in serious decline. In Canada, burbot are often found in impounded hydropower reservoirs and a recent collapse of a number of burbot fisheries in the highly impounded Columbia River watershed has highlighted the vulnerability of burbot to hydropower infrastructure development. Despite burbot's unique life history, and a recent increase in scientific interest in the species, many aspects of burbot thermal and spatial ecology and interactions with hydropower operations remain poorly understood. Given the global increase in hydropower demand and predicted global temperature rises, improving our knowledge of burbot thermal and spatial ecology and entrainment risk in hydropower systems may be essential for the future conservation of this important recreational and subsistence fishery species. In light of the risks of hydroelectric development to burbot and current knowledge gaps, the general objectives of our research are: 1) To further our understanding of burbot thermal and spatial ecology in hydropower systems and the influence of hydropower operations on burbot behaviour; 2) To investigate and

determine the factors that influence burbot entrainment risk and inform on entrainment mitigation and compensatory strategies. In order to address these objectives our research will focus on Kinbasket Reservoir and Mica Dam, located in south eastern British Columbia, and will utilize three linked studies: 1) a thermal ecology study utilising thermal and depth telemetry and otolith thermometry; 2) a spatial ecology and entrainment risk study utilising a broad-scale presence/absence acoustic telemetry array; 3) A fine-scale study of burbot behaviour in the vicinity of turbine intakes utilising a positional acoustic telemetry array.

Development of Metrics Relating Flow Alteration Impacts to River Food Web Dynamics

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Abstract

The alteration of flow regimes is one of the most common perturbations in lotic ecosystems. The modification of flow leads to a loss of diversity and changes in food web structure resulting from habitat loss and altered consumer-prey relationships. In this study, carbon and nitrogen stable isotopes were used to develop food-web metrics to determine differences in the functioning and structure of food webs in relation to the hydrological characteristics of two boreal rivers. Specifically, carbon pathways supporting the food web and food web length were compared to evaluate the impact of damming and ramping rate on downstream food webs.

Carbon stable isotope signatures of aquatic vegetation, invertebrates and fish were measured during a 4-year period in an unregulated river (Batchawana River, BR) and in a regulated river (Magpie River, MR). In the MR, constraints on the operating flow regime were applied in 2003/2004 and lifted in 2005/2006. We compared the carbon signatures of autochthonous carbon (as periphyton, macro-algae and macrophytes) to that of consumers (macro-invertebrates and fish). Carbon signatures were significantly higher in the regulated river, likely as result of effects of water velocity on primary producers and upstream reservoir processes. Periphyton signatures were strongly related to that of both invertebrates and fish taxa, and the relationship did not differ significantly from the 1:1 line. Unregulated ramping rates resulted in a shorter food web length, emphasizing the need for appropriate flow management regimes to reduce impacts on aquatic biota. Results from this study highlight the potential for stable isotopes to be

used as a tool to track environmental perturbations for a whole-ecosystem approach to management.

Numerical Investigation of Turbulent Flow through Bar Racks in Closed Conduits

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Abstract

This research presents the results of numerical investigations of turbulent flow through arrays of vertical bars with different geometrical spacing and blockage ratios in closed conduits. The simulations were performed using two classes of turbulence models: the Reynolds-Averaged Navier–Stokes (RANS) based on turbulence closure models and the Reynolds stress models (RSM). The RANS models comprised the k-epsilon, k-omega, and k-omega-based shear stress transport (SST) while the RSM includes the epsilon-based second moment closure developed by Launder, Reece, and Rodi (LRR) and the omega-based Reynolds stress developed by Speziale, Sarkar and Gatski (SSG). These models were examined using the commercial 3D CFD code, ANSYS CFX-12 in order to select the most appropriate one for prediction of flow in bar racks. The results from a series of closed channel experimental tests conducted at the University of Manitoba Hydraulic Research & Testing Facility were used to assess the adopted turbulence models. Both quantitative and qualitative comparisons of the measured and the predicted by the turbulence models were performed. Predictions were made using bar arrangement with arrays of 3, 7, and 14 bar racks of square leading edges with the approach velocity, $U\infty$ that ranges from 0.26 and 1.42 m/s. The results showed that all the models predict both in trends and values the mean velocity. However, the standard k-epsilon turbulence closure model produced consistently more satisfactory results with lowest computational time over the other models. The results show that the near wake turbulent structure is strongly influenced by the bar spacing (blockage ratio) rather than the approach velocity.


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