H13: Advances in Hydroecology in Canada

Convenors: Daniel Peters[1], Wendy Monk[2]

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Session Description:

The objective of the Hydroecology Committee is to promote and advance the understanding of the linkages between hydrology and ecology in wetland, lake, and river systems across Canada. The goal of this session organized by the Chairs of the Hydroecology Committee is to convene scientists who are investigating the role of hydrology in influencing ecological processes and integrity in ecosystems across Canada. Topics of interest include, but not limited to: anthropogenic effects (e.g. climate change, flow regulation and resource development) on runoff generation and storage, such as on low flow and flood events, with implications for riverine and riparian/delta floodplain environments; development of hydroecological models and remote sensing monitoring approaches; environmental flows; hydrological connectivity and ecological integrity; hydroecological indicators.

NOTE: THIS DOCUMENT CONTAINS INFORMATION FOR ALL SESSION SUB-SECTIONS. PRESENTER ABSTRACTS ARE FOUND AT THE END OF THE DOCUMENT.

SCHEDULE MAY BE SUBJECT TO CHANGE.

ORAL SESSION H13a

Chairs: D. Peters & W. Monk **Room: ESB 1012**

Wednesday, May 31st

TIME	AUTHORS	TITLE
14:00	G. Ali, C. Oswald, C. Spence & C. Wellen	From a trendy concept to a unified approach: The T-TEL connectivity assessment method
14:15	A. Tamminga & B. Eaton	Linking stream channel change due to floods to ecological impacts
14:30	R.R. Shrestha, T.D. Prowse, L. Tso	Water quality analysis and modelling for the Western Canadian River basins
14:45	D. West & Yehya Imam	Assessing thermal habitat management strategies using the process-based Ecofish Water Temperature Model (ETMP)
15:00	J. Franssen	A new approach for modeling the quality of gravel-bed spawning habitats.
15:15	D.L. Peters, O. Niemann, R. Skelly & D.J. Baird	Water Level Fluctuation and Surface Water Connectivity in Wetland Basins of a Cold Region Deltaic Ecosystem

POSTER SESSION H13

Chairs: D. Peters & W. Monk **Room: ESB Atrium**

Wednesday, May 31st

Poster No.	AUTHORS	TITLE
P01-H13	J. Lindsay, J. Cockburn, R. Bhamjee, J. Tweedie & K. Roberts	Evaluating low-flow conditions from channel characteristics and water level
P02-H13	A.J.F. Mertens*, K. Devito & D. Olefeldt	Controls on lake chemistry across the Western Boreal Forest: Setting reference conditions
P03-H13	H. Jerreat-Poole*, T.D. Prowse & D. Jelinski	A Review on Changing Water Temperature in Alpine Basins in the Western Cordillera of Canada and the Implications for Local Fish Populations
P04-H13	D. Reid, S. Bird & M. Hassan	Linking channel morphology and spatio-temporal variability of environmental flow needs in Carnation Creek, B.C.

SUBMITTED ABSTRACTS

H13-01: From a Trendy Concept to a Unified Approach: The T-TEL Connectivity Assessment Method

Genevieve Ali[1], Claire J. Oswald[2], Christopher Spence[3], Christopher Wellen[4]

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Abstract
The concept of hydrological connectivity has been the subject of a great deal of recent research. The concept has provided new insights and breakthroughs, in particular, on runoff generation processes and watershed biogeochemistry. However, a firm definition and cohesive mathematical framework that would permit the consistent quantification of hydrologic connectivity, the examination of the inter-relation between water and material (e.g., sediment, nutrients, metals) connectivity, or rigorous study inter-comparison, have eluded the water resource community. Moving away from abstract conceptualizations, this review of the current state of science on hydrologic connectivity and its role in water-mediated connectivity of material such as conservative and non-conservative solutes and sediment provides the foundation for the introduction of a mathematical framework. This framework, called **T-TEL**, consists of assessing connectivity through the quantification of **T**imescales, **T**hresholds, **E**xcesses and **L**osses related to water and water-mediated material transport dynamics. The T-TEL framework is notably put forward to allow a wide range of connectivity properties to be quantified, namely the occurrence, frequency, duration, magnitude, and spatial extent of water and water-mediated material connectivity. A hypothesis-driven research agenda is also advocated that focuses on how quantitative estimates of connectivity can be used to infer predominant hydro-biogeochemical processes and function, and assess the impact of stressors on connectivity and function. [209 words]

Presentation type: Oral Presentation

H13-02: Linking stream channel change due to floods to ecological impacts

Aaron Tamminga[1] and Brett Eaton[1]

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Abstract
Stream morphodynamics, hydraulic organization, and aquatic habitat are intimately linked and sensitive to changes in governing conditions. To investigate the relationships between geomorphic processes and in-stream habitat, this study took advantage of multi-temporal topographic datasets collected through UAV-based remote sensing to characterize the structural changes to a reach of the Elbow River, AB that resulted from a high magnitude flood event in June 2013. Through a combination of geomorphic change detection, numerical hydrodynamic modeling, and habitat unit classification, we assessed patterns of hydrogeomorphic features at a range of sub-bankfull discharges for three unique geomorphic configurations bracketing the flood event. We documented a major readjustment of channel form as the result of the flood due to widespread bank retreat and turnover of the active channel bed. These physical changes caused a reorganization of hydraulics within the reach; post-flood flows were more confined to a single anabranch and had less diverse patterns of depth and velocity due to the loss of complex geomorphic units. To interpret these changes in an in-stream habitat context, we applied a bottom-up fuzzy clustering method to classify hydrogeomorphic units and assess spatiotemporal arrangements of unique flow conditions upon which aquatic organisms depend. This approach revealed a homogenization of these habitat units as a result of the flood and corroborated findings of reductions in salmonid habitat as measured through conventional species preference curves. Overall, this study provides an integrative assessment of the mechanisms driving fluvial ecosystem dynamics in an environmental change context. [244 words].

Presentation type: Oral presentation

H13-03: Water quality analysis and modelling for the Western Canadian River basins

Rajesh R. Shrestha[1], Terry D. Prowse[2], Lois Tso[3]

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Abstract

Nutrients and organic matter transport from watersheds are linked to the spatial and temporal variability of hydrologic fluxes. Across the Arctic and Subarctic regions, changes in the hydrologic fluxes due to snow and permafrost regime changes could have major implications on the transport process and affect magnitude and seasonality of the water quality constituents. Hence, we initiated a study to evaluate the water quantity-quality relationships for the Hay, Liard and Peel Rivers in Western Canada. Our analysis revealed that the Total Phosphorus (TP) and Dissolved Organic Carbon (DOC) concentrations are highest in late spring and early summer, and are positively correlated with river discharge. But, the relationships are highly variable both seasonally and interannually. Based on such understanding, we employed the Load Estimator (LOADEST) model for simulating the TP and DOC fluxes. Preliminary results indicate a reasonable representation of magnitude and dynamics of the constituent fluxes.

Presentation type: Oral Presentation

H13-04 Assessing thermal habitat management strategies using the process-based Ecofish Water Temperature Model (ETMP)

David West[1] & Yehya Imam[1]

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Abstract
Changes in watershed land use, flow management, and climate can significantly alter aquatic thermal habitat. Salmonids are particularly sensitive to these changes due to their complex life-stages and narrow thermal tolerances. Stream temperature models can assist managers in quantifying the magnitude of impacts and assessing mitigation options. However, existing models often have too coarse of resolution or are too data intensive. As such, we have developed a process-based stream temperature model (ETMP) suitable for modelling each component of the stream heat budget. To model heat transport in streams, ETMP simulates the downstream and temporal evolution of flow velocity, flow area, and surface width using the kinematic-wave approximation of the one-dimensional unsteady hydraulic equations. While heat is transported along the stream, ETMP simulates heat transfer due to solar radiation, long-wave radiation, latent and sensible heat flux, friction, conduction through the streambed, inflows, and any in-pipe flow. The model relies on measured or estimated hydraulic geometry, shade conditions, cloud cover fraction, air temperature, relative humidity, wind speed, atmospheric pressure, inflow temperatures, and groundwater temperature. We have applied ETMP to assess the effects of six hydroelectric projects including run-of-river and reservoir storage with 15 min time step, 50 m nodal spacing, and validation accuracies of 0.5 - 1.0ºC RMSE. The model has supported the design of flow regimes that minimize impact on various life-stages of salmonids by assessing economic and ecological trade-offs. Current model developments include integration of a more robust shade model, hyporheic exchange model, and ice formation prediction. [246 words]

Presentation type: Oral Presentation

H11-05: A new approach for modeling the quality of gravel-bed spawning habitats.

Jan Franssen[1]

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Abstract

The physical structure of streambeds is a critical determinant of the early life stage survival of benthic spawners, such as salmon and trout, that bury their fertilized eggs within the streambed. The deleterious effect of excess fine sediment in gravel-beds on egg-to-emergence survival is well established, with numerous laboratory studies demonstrating that survival is negatively related to the amount of fines within a gravel-bed. However, extant models of survival as a function substrate fines content exhibit considerable variability, which inhibits accurate assessment of spawning gravel quality. Methods that more accurately determine spawning gravel quality are needed to assess habitat degradation related augmented fine sediment loading to river systems, and to provide guidance for spawning habitat rehabilitation schemes. Here I present a new approach for modeling the quality of gravel-bed spawning substrates, an approach that accounts for the two key mortality inducing mechanisms that control in-situ survival: (i) asphyxiation, which occurs when oxygen flux drops below critical threshold for survival; and (ii) entombment, which prevents hatched embryos from emerging. This approach provides a more robust assessment of the quality of gravel-bed spawning habitats, and should be of interest to scientists and practitioners involved in the assessment, protection and rehabilitation of these habitats. [201 words]

Presentation type: Oral Presentation

H13-06: Water Level Fluctuation and Surface Water Connectivity in Wetland Basins of a Cold Region Deltaic Ecosystem

Daniel L. Peters[1], Olaf Niemann[2], Rob Skelly[2], and Donald J. Baird[3].

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Abstract
The Peace-Athabasca Delta (PAD) is a deltaic lake/wetland system of international importance (Ramsar & UNESCO World Heritage site). This 6000 km^2, low-relief ecosystem, which formed at the confluence of the Peace, Athabasca and Birch rivers at the west-end of Lake Athabasca, contains more than 1000 lake/wetland basins with varying degrees of connectivity to the main flow system. Delta wetland hydroperiod is influenced by occasional ice-jam and open-water inundations that recharge the basins. Prior studies have identified pathways of river-to-wetland floodwater connection and historical water level fluctuation/trends as a key knowledge gaps, limiting our knowledge of deltaic ecosystem status and potential responses to climate change and upstream water uses. To address this gap, high-resolution surface elevation digital mapping of the PAD has been conducted since 2012 using aerial remote sensing LiDAR and ground-based measurements. The surveyed areas contain a set of wetland monitoring sites where ground-based water level/depth, water quality, and aquatic ecology have been monitored for the past five years. The goal of this presentation is to present our initial assessment of: i) surface water fluctuation and connectivity for select PAD wetland sites; ii) reconstruction of a 40+ year inter-annual hydroperiod for a perched basin using a combination of field measurements, remote sensing estimates, and historical documents; and iii) outline an approach to integrate this newly available physical information into a novel, multi-platform aquatic ecosystem observation system for cold regions deltaic wetlands that will enable the assessment of ecosystem change resulting from multiple stressors, such as climate change and development (hydroelectric and mining).

Presentation Type: Oral

P01-H13: Evaluating low-flow conditions from channel characteristics and water level

John Lindsay[1], Jacklyn Cockburn[1], Rashaad Bhamjee[2], John Tweedie[1], Kevin Roberts[1]

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Abstract
Low-flow conditions are important limits on stream habitat and are reflective of seasonally dry periods or drought conditions within watersheds. Changes in low-flow conditions over the span of years can result from climate change, groundwater abstraction, flow regulation, irrigation, changes in vegetation (particularly afforestation and deforestation), and land-use changes associated with urban expansion and other disturbances. The definition of low-flow is inherently subjective due to the continuous nature of river flow regimes. Researchers commonly use low-flow indices to study these periods of lowest water level. For instance, previous studies have evaluated changes in the magnitude of low-flows at the regional scale using indices based on the hydrological record (e.g. Q95, 7Q10, 7Q2, and the Q90/Q50 ratio). While these indices are useful for studying trends in low-flow magnitude, the fact that they are based on flow duration exceedance and recurrence intervals implies that these indices are less useful for studying trends in the duration and frequency of low-flow events. Low-flow conditions defined by a flow percentile, such as the Q95, will always occur during 5% of the record. These types of low-flow definitions preclude the possibility for evaluating long-term trends in the frequency and duration of low-flow events. It is however important to determine whether low-flow events are becoming more or less common and whether they are lasting for longer periods under a changed climate regime or altered hydrological conditions and basin land-use changes. In this study, we present low-flow indices that are independent of the flow magnitude record at a site. Instead these are based on channel geometry (e.g. proportions of the wetted perimeter, cross-sectional area, and maximum channel depth), to quantify trends in the frequency and duration of low-flow events. We demonstrate our proposed technique using data from several small streams in southern Ontario, Canada. [296 words]

Presentation type: Poster

P02-H13: Controls on lake chemistry across the Western Boreal Forest: Setting reference conditions

Alexander J.F. Mertens*[1], Kevin Devito[2], David Olefeldt[3]

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Abstract
The Western Boreal Forest (WBF) is experiencing rapid change due to forestry, oil and gas industry, agriculture, and climate change. It is also a massive and diverse region, covering six Canadian ecozones: Boreal Cordillera, Plains and Shield, and Taiga Cordillera, Plains and Shield. This extensive region contains millions of lakes, with its own unique hydrological systems, controls and interactions, and excessive peatland-wetland-pond complexes covering up to 50% of the landscape in certain regions. The response of Western Boreal ponds to future drier conditions, potential water quality impacts influenced by enhanced resource activity and proper watershed management cannot be effectively assessed without a better understanding of the natural variability of pond hydrochemistry. We will therefore assess the baseline hydrochemistry and visualize general patterns across different hydrological controls (e.g. permafrost, geology, topography) and response variables (i.e. nutrients and ion facies). We expect to find ponds located in the Cordillera and along the transition zone of the granite Shield and sedimentary Plains will show our extreme low and high chemistry signatures respectively. The Plains however will experience the largest internal variability, as the greater depth to bedrock allows for more complex groundwater dynamics. By using multivariate and spatial statistics (MRT, PCA, etc.) we will highlight that certain processes and influences can be identified at the regional scale. However, analyses at the subregional and local scale are required to properly capture the processes influencing variability in pond chemistry.

Presentation type: Poster

P03-H13: A Review on Changing Water Temperature in Alpine Basins in the Western Cordillera of Canada and the Implications for Local Fish Populations

Haven Jerreat-Poole,[1*] T. D. Prowse[2] and D. Jelinski[3]

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Abstract
Although freshwater constitutes only 0.01% of the global water budget, it represents an essential component for human society and all biota, including thousands of fish species. Fish, as ectothermic organisms, are significantly affected by the temperature of the external environment. As such, water temperature plays a critical role in the metabolism, migration, motility, reproduction and respiration of these species. Increasingly, studies have linked rising average air temperatures with increases in stream temperature. In particular, mid-latitude, mountainous catchments characterized by seasonal snow-packs have been identified as exhibiting heightened vulnerability to warming temperatures. However, little work has been done within the Western Cordillera of Canada, a region that both meets these criteria and supports various rare and economically important fish populations. This poster synthesizes the current literature exploring these topics, with the intent to provide insight into the various hydrological and hydro-ecological responses to warming climate that have been observed. The ensuing research will then work to determine isotherm shift rates for select basins across western Canada. Subsequently, this information will be used to quantify the potential implications of these temperature changes on key fish species. [184 words]

Presentation Type: Poster

P04-H13: Linking channel morphology and spatio-temporal variability of environmental flow needs in Carnation Creek, B.C.

David A. Reid[1], Stephen Bird[2], and Marwan Hassan[1]

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Abstract
Flow levels in many British Columbia streams are affected by competing water uses and management objectives, such as hydroelectric power generation, flood control, and industrial and agricultural water withdrawals. In these streams, sufficient water should also be available for maintaining properly functioning aquatic ecosystems. However, habitat is not only a function of river discharge; channel morphology, which is variable in space and time, also dictates the character of pools, riffles, and overall habitat complexity and abundance. While significant research has examined how choices of flows affects habitat availability and character, few studies have addressed how spatial and temporal variability in channel morphology influences the quantity and quality of habitat available for a given flow threshold. Using 45 years of channel morphology data in eight study reaches of Carnation Creek, B.C. coupled with 2D hydrodynamic modeling (Nays2DH), we present how changing bed topography, channel form, sediment texture and abundance of wood serve to influence the distribution of flow depths and velocities for 20% of mean annual discharge. Preliminary results indicate that channel morphology is highly variable in some reaches while change little in others, which in turn controls habitat conditions. Findings here will be used to improve the determination of environmental flow needs in coastal British Columbia streams.

Presentation type: Poster