NSERC HydroNet Component 2.2: Predicting the Entrainment Vulnerability of Fish in Hydropower Reservoirs

Rationale: Fish entrainment is the process where fish are non-volitionally and coincidentally displaced from reservoirs with water diversions through turbines or other water release structures at dams. Adult fish entrainment could represent significant losses to a population and be particularly detrimental to species that are already imperilled, such as bull trout (*Salvelinus confluentus*). Few evaluations have been conducted on the entrainment vulnerability of adult fish that inhabit hydropower reservoirs. By integrating hydrodynamic and thermal properties of a large hydropower reservoir with the movement of important adult fish species, it will be possible to develop a generalized framework for assessing fish entrainment and ultimately produce the information needed to direct well informed management programs.

Description: Theme 2.2 has four general objectives that each addresses fish entrainment vulnerability in a hydropower reservoir. These objectives are to examine the hydraulic properties of the forebay at different dam sites, use coarse- and fine-scale biotelemetry to study the spatial ecology of bull trout and burbot (*Lota lota*) over multiple seasons, identify reservoir thermal properties throughout the year, and recommend mitigative measures to reduce entrainment vulnerability and entrainment rate. The following describe these objectives in more detail:

- **Developing a model of entrainment vulnerability based on hydraulic conditions and forebay geometry:** (*Lead: David Zhu, University of Alberta; Collaborators: David Patterson, DFO-Pacific; Alf Leake, BC Hydro; Paul Higgins, BC Hydro*). The specific objectives of this component are to generalize the knowledge of intake-induced flow hydraulics for different sites, under various temperature stratification regimes and reservoir levels, and different hydropower operations.
- **Strategies to reduce entrainment vulnerability based on the behaviour and thermal requirements of fish:** (*Leads: Steven Cooke, Carleton University; Michael Power, University of Waterloo; Collaborators: Alf Leake, BC Hydro; Paul Higgins, BC Hydro*). The specific objectives of this component are to determine the biotic characteristics that influence the entrainment vulnerability of bull trout and burbot by using acoustic biotelemetry to track behaviour such as depth distribution, temperature selection and movement throughout a reservoir (Kinbasket Reservoir, BC), including sub-meter tracking in front of the dam face (Mica Dam).
- **Thermal aspects of fish entrainment vulnerability in Kinbasket reservoir with relevance to other large hydropower facilities in Canada:** (*Leads: David Patterson, DFO; Steven Cooke, Carleton University; Collaborators: Mike Power, University of Waterloo; David Zhu, University of Alberta; Alf Leake, BC Hydro*). The specific objectives of this project will determine how reservoir thermal properties vary seasonally and with respect to hydropower operations to influence entrainment vulnerability for a variety of key fish species
- **The mitigative measures for reducing entrainment vulnerability to key fish species:** (*Leads : David Zhu, University of Alberta; Steven Cooke, Carleton University; Michael Power, University of Waterloo; Collaborators : David Patterson, DFO-Pacific; Alf Leake, BC Hydro; Paul Higgins, BC Hydro*). The specific objectives of this component are to determine how physical mitigation alternatives (such as barrier nets, thermal curtains, etc.) affect upstream flow fields and how various mitigation options perform under various hydraulic and operation conditions

List of current student related projects:

- *Hydraulics of Hugh Keenleyside dam* – Beth Robertson (M.Sc. Alberta)
- *Field investigation of forebay hydraulics at Columbia River hydropower facilities* – Mat Langford (Ph.D. Alberta)
- *Effect of thermal stratification on hydropower intake induced flow-field* – Rashedul Islam (Ph.D. Alberta)
- *Biotic and abiotic aspects of entrainment risk in bull trout* (Salvelinus confluentus) *in Kinbasket Reservoir* – Lee Gutowsky (Ph.D. Carleton)
- *The thermal and spatial ecology, and associated entrainment risk of burbot* (Lota lota) *in a large hydropower reservoir in British Columbia, Canada* – Philip Harrison (Ph.D. Waterloo)
- *Entrainment risk of burbot* (Lota lota) *and bull trout* (Salvelinus confluentus) *in a large hydropower reservoir* – Eduardo Martins (Post-doc Carleton)

Outcomes /Deliverables:

- Determine entrainment vulnerability and rates in relation to thermal properties and intake-induced flow dynamics
- Develop suitable mitigative options for reducing vulnerability to entrainment

Benefits from this research:

The integrative approach used in this component will provide a better understanding of the spatial ecology of bull trout and burbot, as well as the biotic and abiotic factors influencing their entrainment vulnerability, and deliver the tools for assessing and mitigating entrainment of fish in other reservoirs in Canada and abroad.