

# **Priority Knowledge Gaps and potential DFO-CEA Collaborative Research: Reservoir Science Team**

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At the June 2004 CEA-DFO MOU Research Workshop in St. John's, Newfoundland, eight identified reservoir research priorities were classified as either 'highest' or 'lower' priority, with no relative ranking within categories. After discussion, three broad topics received the highest priority, which were 1) habitat, 2) mitigative measures, and 3) reservoir operation effects. The Reservoir science team was then tasked with identifying specific focused questions that were testable within these three categories.

The report from the Reservoir Science Team will follow a standard format for each research gap as identified at June workshop, as follows:

- outline a very brief rationale behind the prioritization of the knowledge gap
- identify specific, testable questions under each research area
- identify possible approaches in the form of research projects

In addition, recommendations regarding who should undertake this work (utilities, DFO science, consultants, academia, etc.), and an outline of the most important and logical first steps will be presented at the end of this report.

## **1. Habitat**

Understanding more about reservoir habitat was considered the highest priority research gap since very little is known about reservoir habitat, fish interactions with reservoir habitat, and if enhancement of habitat is beneficial. More specifically, the aspects of habitat identified were: 1) improving understanding about the structure and type of habitat available, 2) the role of submerged woody material, 3) fish interaction with habitat, and 4) how habitat creation and improvement could be used to enhance reservoir productivity.

### **1.1 Questions (addresses structure and type of habitat + role of woody material + enhancement of productivity):**

- a) What types of fish habitat are available in reservoirs and how does it influence fish productivity or habitat productive capacity?
  - Is habitat availability dependent on reservoir type (run of river, annual storage, multi-year storage...) and age?
  - How does reservoir productive capacity of habitat (for littoral, pelagic and demersal zone) compare with natural lakes or rivers?
  - What parameters (and sampling strategy) should we use to characterise fish habitat (e.g.: spawning, rearing, feeding) in large reservoir and validate their utilisation?

- b) In big hydroelectric projects, the characterisation of large areas of fish habitat is necessary before (lotic) and after (reservoir) the project. What parameters should be used to establish 'mesohabitats', and what sampling strategy would allow a science based habitat evaluation. Similarly for the validation of their use.
- c) Describe post-flooding processes and timeframes relating to
- Breakdown and movement of submerged timber
  - Replacement of flooded terrestrial vegetation with aquatic macrophytes
  - Evolution of reservoir shorelines.
- d) In regards to reservoir vegetation/forest management
- Will the retention of submerged trees/branches increase or decrease the overall productivity of a new reservoir? ...and ultimately is the removal of woody debris (standing, floating, anchored..) suitable or not for fish, and in what circumstances ?
  - Will wood retention affect the diversity of fish species or fish community structure?
  - What percentage of vegetated (littoral?) area or what type should be left uncleared in the reservoir prior to flooding to provide enhanced structural complexity for fish?

**Possible Approach:**

- The initial step would to conduct a review/survey of existing information on reservoirs in Canada which have some level of habitat and biological data. Include review of Experimental Lakes Area Reservoir Program (ELARP) data + debris management reviews. (Inquire re: other data sources for this information).
- Summarize the spatial and temporal scope of available reservoir habitat (and biological) data, and identify reservoirs where supplementary data should be collected to maximize knowledge gained while minimizing effort and cost.
- Conduct a review of existing structural habitat information on lakes and rivers (ideally coupled with biological data), identify a series of metrics to characterize the systems, and compare to reservoir data above. Are there features of reservoirs that regularly deviate from natural lakes and what are the potential implications of these differences? Since the main difference between lakes and reservoirs is water level management, the review should focus on comparison of littoral habitat structure between lake and reservoir (including drawdown and sub-drawdown zone).
- Compare fish production (or yield) data between reservoirs and lakes or rivers from the same region and with same species assemblage.
- Sample reservoirs of various types and ages (site selection must consider design and statistical analyses to maximize probability of understanding habitat feature(s) of greatest interest) to assess species biodiversity and productivity (e.g. CPUE of suite of gears suitable to habitat type and standardized in effort, index of biomass, Habitat Productivity Index, Index of Biotic Integrity (IBI) (Randal and Minns, J. Great Lakes Res. 28(2)-240-255)). Habitat maps required to include biological data in review above. Data collection would serve to supplement data in above survey and increase potential for both model

development and validation. Level of effort should take into account the amount of pre-existing data plus inter- and intra-annual variation and the stabilization of fish populations following the fill of the reservoir.

- Plan a detailed study of upcoming reservoir creations – potential to use a model based on information survey/summary to predict outcome *a priori* to gauge potential to detect an effect. Some harvesting required – design study with categories of clearing intensity (high/low) and predict resulting effect on fish community. Study for subsequent years to test prediction.

### **1.2 Question (addresses fish interaction with habitat):**

- a) What are the fish habitat requirements in reservoirs and do requirements differ from natural lake systems? Are limiting factors for fish production the same in reservoirs and in natural lakes/streams?

#### **Possible Approach:**

Habitat requirements will vary by species and will therefore depend on the composition of the fish community and fisheries management objectives for the reservoir. The dominant recreational fish species indigenous to the area would be the species of study and would vary by reservoir.

- Use existing literature (e.g. Bradbury et al., Portt et al., and Richardson et al.) to outline habitat requirements by species as determined in natural lakes. Prioritize those features in terms of perceived level of importance and compare with habitat availability and utilization in reservoirs (mine data from utilities, mainly available for new projects). If possible, compare natural range in habitat use, standing crop, and biomass of fish in natural lakes (of similar latitude) to reservoir data. N.B. data on standing crop/biomass are probably not very abundant for reservoirs. We might probably then need to compare CPUE or harvest/yield data.
- E.g. northern pike. Assessment of the habitat use (e.g. submerged wood for spawning vs. floodplain vegetation). Or e.g. Brook trout. Assessment of habitat use (e.g. spawning/rearing/adult habitat) in reservoirs, compared to habitat use in lakes?
  - Variety of methods available including:
    - First step would be to review existing radio telemetry studies conducted in reservoirs to determine availability of data on habitat utilization by various fish species.
    - Use radio or acoustic telemetry, habitat datalogging telemetry tags (temperature/depth/location info datalogged every 15s. Multiple antennae and receivers can allow for detailed habitat use info).
    - Visual survey assessments (distance sampling via. snorkelling or underwater camera. Moment in time, small area surveyed, habitat feature specific).
    - Net capture data (short sets required, not as robust – integrate over time, habitat types may be blended).

- Integrate results of these studies into habitat utilization indices for natural lakes and reservoirs. Compare and contrast as appropriate

### 1.3 Question (addresses habitat creation or enhancement)

- a) Can productivity of existing reservoirs be increased by the enhancement of structural complexity in the nearshore area of the reservoir?

#### Possible Approach:

- Review literature, and conduct a data/information mining exercise research or monitoring conducted in Canadian reservoirs (utilities, resource management agencies) on the effectiveness of habitat enhancements in reservoirs.
- Would require multiple reservoirs with very little habitat structure in the littoral zone coupled with extensive biological data (to minimize the need for pre-treatment data collection). Design a study where habitat is enhanced in some reservoirs, while others would remain as a control in a BACI (Before-After-Control-Impact) design. Monitor response of fish community over years to determine if physical habitat enhancement had an effect on fish populations. For efficiency and cost savings, it should be investigated if this idea could be accomplished at a smaller scale e.g. ELARP.

## 2. Mitigative Measures

Knowledge surrounding the most effective techniques to mitigate against the impacts of reservoir creation and operation exists, but feasibility and applicability of techniques warrants further research. The top areas identified at the workshop for research were how to effectively mitigate for erosion, mercury, and habitat?

#### Possible Approach:

##### Habitat Mitigation

- The initial step would to conduct a review/survey of existing information on the monitoring of the ecological benefits of mitigative measures. Obtain and update report on review of existing mitigative measures for habitat conducted for CEA (by Acres approximately 10 years ago).
- Compare the environmental impacts (i.e. do an EA) of cleared versus non-cleared reservoirs with respect to erosion, water quality, habitat, mercury.

##### Mercury Mitigation

- There is currently a debate regarding the relative contribution of organic matter leading to mercury methylation vs. inorganic mercury present in the system in order to make a good prediction of MeHg following the creation of reservoir. (a good prediction is necessary to account for the provisions for 'healthy fish, safe for human consumption' in the Policy for the Management of Fish Habitat).
  - Consult with Drew Bodaly
  - Engage a consultant to conduct a comprehensive literature review and prepare a synthesis for discussion by the reservoir team. The reservoir

team should then attempt to reach consensus on the issue and proceed accordingly.

- Investigate Selenium addition as a mitigative measure in northern reservoirs by conducting experiments at a small scale in existing reservoirs.

#### Erosion Mitigation

- Does leaving vegetation in the drawdown zone mitigate effectively against erosion, or is the best form of mitigation against erosion involve manipulation of timing and magnitude of drawdown events?
  - This question could be addressed via a survey of existing reservoirs and/or areas of reservoirs that have some cleared/uncleared areas, or are operated to control for erosion.
  - Evaluate the role of selective clearing (e.g. large trees only) in the drawdown zone.
  - Is a high rate of erosion preferable to a slower more incremental rate of erosion to reach a steady state?
  - If mitigation is not feasible or accepted techniques are not applicable then what types of compensation may be appropriate?

### 3. Reservoir Operation Effects

The effects of reservoir drawdown (timing, magnitude), and operational effects on erosion were identified as the highest priorities in relation to reservoir operations.

#### 3.1. Questions

- a. Can water levels in reservoirs be operated in such a way to effectively mitigate against erosion?
- b. What are the effects of drawdown on populations of various fish species in a reservoir?
- c. Can the timing of drawdown be adjusted to reduce or eliminate the effects on shoreline/tributary spawners?
- d. Can the timing, magnitude and duration of water level fluctuations be adjusted to increase littoral production?
- e. Should reservoirs be moving towards a ‘natural level regime’ paradigm analogous to downstream flow? (if yes, specific question guidance may be available from the flow management research group).

#### Possible approach:

- Conduct an information mining exercise to investigate how altering operations has worked to achieve the target objective.

- Investigate the factors controlling erosion on reservoirs (geological/edaphic factors, reservoir age, operational regimes, etc). If adequate data do not exist, a study could be initiated to specifically measure the level of erosion under various operational regimes.
- Reservoirs with specific littoral spawning fish populations (both spring, e.g. pike, and fall spawners e.g. lake trout or whitefish), preferably with years of population monitoring data under existing operations, would adjust operations to see if the populations benefit from operational changes. Would require data collection on multiple reservoirs that both adjust or maintain operational regimes (experimental and ‘control’ systems).
- Sample reservoirs during various levels of drawdown - benthic sampling within the littoral zone combined with an assessment of shoreline vegetation would probably be adequate.

#### **4. Recommendations**

- The logical first step to move this research forward would be to conduct a comprehensive “data mining” exercise in which all possible sources of data should be examined. A large amount of data have been collected over the years by DFO, academia and the Utilities which should be explored to determine if a re-analysis of existing data is appropriate and which would save time and effort (not to mention \$) of collecting new data.
  - Data collections and reviews may best be contracted to a consultant (bilingual capabilities, preferably with regional offices), subject to guidance and review by a joint DFO-CEA steering committee. Steering committee should include current Reservoir Science Team, but also be expanded to include members from all utilities to facilitate information collection.
  - Ballpark estimate of cost \$50-100K. Must identify source of funds to initiate process.
  - Once funds agreed upon, the Steering Committee will prepare a Terms of Reference and we will negotiate with consulting firm(s) as appropriate.
- Have CEA and DFO members identify which specific research questions are of concern to them, and if they would be willing to enter into a collaborative agreement with the other party(ies) to undertake the research. Research projects requiring data collection should be jointly conducted by CEA members and DFO science to reduce costs, increase scientific rigour, and defensibility and acceptability of results.