



Assessing Techniques for Monitoring Lake Trout Abundance

Seed Grant Report - PEA-F23-F-3644

Prepared with financial support of the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations, and public stakeholders.

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Executive Summary

The interactions between lake trout and sympatric species, and growing concern about observed trends in Kokanee and Bull Trout abundance in the Williston Reservoir watershed resulted in the creation of a specific action item in the Peace Region Rivers, Lakes and Reservoirs Action Plan aimed at implementing cost-effective monitoring of Lake Trout. Anecdotal evidence suggests since the mid-2000's there has been an increase in Lake Trout abundance, and a hypothesized commensurate increase in their competitive interactions with conspecifics. As part of an ongoing analysis of limiting factors for adfluvial Bull Trout populations in the Williston Reservoir, a lake trout abundance trend has been identified as an important biotic factor to investigate. A literature review and subsequent one day workshop with regional experts were completed to assess and find consensus on feasible methods that could provide affordable lake trout population monitoring. The workshop attendees created a list of data gaps which prevent meaningful lake trout population abundance monitoring. Without basic population data, effective management actions aimed at promoting the population viability of focal species cannot be devised and the effects of interventions cannot be measured.

We present a combination of stock assessment methods including SPIN and mark-recapture surveys used in tandem to provide data on the Lake Trout populations in the Williston Reservoir. We recommend a staggered approach to feasibility testing given the large size of Williston Reservoir. The bio-sampling associated with capture of pelagic fish species will provide opportunity to support ancillary studies identified in this report. These ancillary studies include genetic population structure, effective number of breeders, population size-at-age, condition factor, diet and niche overlap or competitive interactions with conspecifics. These ancillary studies may prove useful proxies for population status if abundance estimates are shown to have high process error. It is recommended that a multi-year study be implemented aimed at addressing the objectives and data gaps presented in this seed study. We recommend to FWCP that Lake Trout monitoring activities be coordinated with ongoing regional conservation initiatives led by First Nations, BC Hydro, BC, DFO, and concurrently funded FWCP projects.

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1 Introduction

Due to the competitive interactions between char species, a Lake Trout (*Salvelinus namaycush*) abundance trend has been identified as a critical information gap in the Williston Reservoir (Culling et al. 2020; Hagen and Weber 2019). The documented interactions between Lake Trout and sympatric species across their range, and growing concern about observed trends in Kokanee (*Oncorhynchus nerka*) and Bull Trout abundance in the Williston Reservoir watershed resulted in the creation of a specific action item in the Peace Region Rivers, Lakes and Reservoirs Action Plan (PEA.RLR.S02.RI.08; FWCP 2020). In lentic ecosystems Lake Trout are known to competitively exclude Bull Trout over the long-term (i.e., 50 years) however the competitive interactions between the species in the Williston Reservoir are not well understood (Donald and Alger 1993; Mogen and Kaeding 2005). Bull Trout (*Salvelinus confluentus*) is a B.C. blue-listed Species of Concern which currently coexist with Lake Trout within the Williston Reservoir. Mechanisms supporting coexistence are suggested to include space use, life history strategies, diet, and reservoir bathymetry (Guy et al. 2011; Hagen and Weber 2019; Harrison et al. 2020). Anecdotal evidence suggests since the mid-2000's there has been an increase in Lake Trout abundance, and a hypothesized commensurate increase in the potential competitive interactions with conspecifics. As part of an ongoing analysis of limiting factors for adfluvial Bull Trout populations in the Williston Reservoir, a Lake Trout abundance trend has been identified as an important biotic factor to investigate (FWCP 2020; Hagen et al. 2023). Information on the abundance trend of Lake Trout, population structure and the specific competitive interface between Lake Trout and Bull Trout is necessary to implement management actions for both species in the Reservoir. This project aims to identify the methods commonly used throughout BC and North America to assess Lake Trout stock and identify which methods would be deemed suitable for feasibility assessment in the Williston Reservoir.

A regional partnership previously discussed a grant proposal to the Fish and Wildlife Compensation Program (FWCP) to support Lake Trout abundance trend monitoring, but agreed without proper deliberation of the proposed methods there was not confidence in the successful implementation of the project in the Williston Reservoir. Closing the char competitive interaction data gap with an affordable and achievable project will greatly increase our understanding of the how the Williston fisheries community is affected by Lake Trout populations. Funding provided by FWCP allowed Chu Cho Environment to undertake this seed grant study. This seed study builds directly off the work from the Peace Reach Lake Trout Movements Project (PEA-F20-F-2948) and aligns with sub-objective 2 of the Rivers, Lakes and Reservoir Action Plan (PEA.RLR.S02.RI.08; *Understand the relationships between reservoir productivity, kokanee, lake trout and other fish populations, and aquatic and terrestrial food webs*). The first objective of the seed project was to evaluate available abundance monitoring methods and review their applicability in the Reservoir environment. We then sought consensus on monitoring priorities from regional experts. To achieve these objectives, we first conducted a literature review of the methods used in Lake Trout stock assessment with three goals:

1. Review contemporary methods used to monitor Lake Trout populations in Northern British Columbia
2. Evaluate methods for cost, advantaged and disadvantages, survey requirements and
3. Compare these methods with those used in other jurisdictions across the range of Lake Trout

Then a one-day workshop was hosted by Chu Cho Environmental in which regional experts including BC Ministry of Forests Fish and Wildlife staff, BC Hydro technical scientific staff and researchers at the University of Northern British Columbia could deliberate the logistical considerations of Lake Trout stock assessment in the Williston Reservoir. Attendees were asked to present and review the current knowledge of Williston Reservoir Lake Trout populations and monitoring techniques. The attendees then sought consensus on objectives and the most feasible path forward for Lake Trout population monitoring in the Williston Reservoir.

2 Methods

2.1 Literature Review

A literature review was conducted to collect relevant published and technical literature on Lake Trout stock assessment. The initial focus of the review was on regional work conducted in the Williston Reservoir and the Upper Peace River Basin, then we expanded our search to include a broader regional scope and other jurisdictions in North America. The EcoCat Ecological Reports Catalogue and ResearchGate were used to search and find relevant literature. The literature was reviewed and used in preparation for the workshop, and in evaluation of effective stock assessment techniques.

A bibliography has been presented to identify literature focused on Lake Trout research and assessment methods used throughout North America (Appendix A). The bibliography contains sources from peer reviewed journals and technical literature produced by government agencies from multiple jurisdictions in Canada (i.e., Northwest Territories, Ontario, British Columbia, etc.) and throughout the United States of America (i.e., Colorado; Montana).

2.2 Workshop

On May 9, 2023, Chu Cho Environmental held a workshop in Prince George, BC with the objective of reviewing ongoing and historic projects and seeking clarity on management objectives for each agency and individual in attendance. Presentations were completed on Lake Trout movement, distribution, spawning habitats and regional population monitoring. Following the workshop, a memorandum summary of the meeting minutes was prepared and distributed to the attendees (Appendix B). A list of data gaps was summarized based on the follow-up questions proposed by the attendees.

3 Results and Discussion

3.1 Literature Review

Comprehensive reviews of Lake Trout life history are widely available, but insights into the species ecology have mainly been obtained from surveys conducted outside of British Columbia (Martin and Olver 1980; McPhail 2007; Mills et al. 2002; Riley et al. 2021). The objective of this report was not to present a review of Lake Trout life history but present an overview of methods evaluated for potential use in Lake Trout monitoring in the Williston Reservoir. We encourage readers to explore the relevant literature presented in Appendix A for further information on Lake Trout ecology and stock assessment. Lake Trout occupy a range of lake sizes and typically require an intensive sampling approach to accurately represent a sample population (Sandstrom and Lester 2009). Several stock assessment methods are commonly used in British Columbia and throughout North America including SPIN (Summer Profundal Index Netting), SLIN (Spring Littoral Index Netting) and mark-recapture abundance estimates.

3.1.1 Netting-based Surveys

Gillnetting is a commonly used method to sample fish stocks, including Lake Trout. There are several recognized standard methodologies which utilize gill nets to assess Lake Trout stock including SLIN and SPIN. These surveys involve setting nets at various depths and locations within the waterbody and then retrieving the captured fish. Gillnetting has been used widely to provide accurate estimates of the size, genetic structure and population dynamics of Lake Trout stocks (Giroux 2002). Relative abundance estimation using gill netting provides an index of absolute abundance and is assumed to be directly proportionate to density (Hubert and Fabrizio 2007).

Giroux (2003) completed an assessment of Lake Trout stock and an evaluation of netting and analysis techniques within lakes of the Skeena Region in B.C. In the study, systematic sites were sampled with 45m long sinking monofilament gillnets comprised of three 15 m panels of 1.5", 2" and 2.5" stretch meshes. Nets were set in a perpendicular manner to the shore following the use of a digital depth finder to measure lake depth. Biased netting was also used which included two additional 45 m nets which ganged together to make a 90m net and an 80 m net which was also deployed in one of the studied lakes. The results of the study found the highest producing catch rate per hour of Lake Trout was with the 45 m sinking gill net which produced 0.5 LT/hr and 100 m of net/24hr day or 28.5 LT/100 m net/day). Giroux (2002) found that short-set small mesh netting was effective at capturing Lake Trout when targeted on aggregations of fish, however had a bias to smaller fish size. This evaluation found lower mortality rates of short-set (i.e., 2 hour) small mesh netting provide rationale for its use when live release is required after handling (i.e., mark-recapture abundance estimation).

SPIN is a standardized Lake Trout assessment method developed by the Ontario Ministry of Natural Resources in 2005 (Sandstrom and Lester 2009; Jessup and Millar 2011). In 2009, Yukon Fish and Wildlife

Branch tested the SPIN methods for assessing Lake Trout populations. This study concluded the method provides distinct advantages for the Yukon fisheries management program compared to existing SLIN methods. The method can monitor changes between years and represents a variety of Lake Trout habitats. It is additionally more robust to seasonal shifts in fish density at a netting site. This approach is commonly used by regional BC Ministry of Forests stock assessment personnel (i.e., Arndt and Morgan 2023). SPIN sampling estimates the distribution and abundance of fish populations by sampling a subset of the total lentic area. SPIN survey requires a minimum of 24 gillnet sets and has a maximum of 140 sets depending on waterbody size. A SPIN survey completed in the Williston Reservoir would require the maximum sets of 140 (Sandstrom and Lester 2009). To accurately distribute nets, a bathymetric map of the studied water body must be obtained. Distributing gill nets proportionally throughout the waterbody to cover all habitat types and life history stages is what makes SPIN effective.

Hansen (2018) presented the results of summer profundal index netting for tracking trends in Lake Trout abundance in lakes and reservoirs of Colorado. Within the study, standardized gillnets were used to capture Lake Trout and estimate Lake Trout density (number/ha) in Blue Mesa Reservoir. To account for potential differences in Lake Trout habitat, sampling was conducted when water surface temperature measurements exceeded 18 °C and nets were set for two hours during daylight from July 9th to 12th. Overall, sampling was completed over the course of four days which involved 95 net sets capturing a total of 313 Lake Trout ranging from 210 mm to 862 mm. Lake Trout were most prevalent in 20-30 and 30-40 m depths.

While being an effective and widely used technique in large waterbodies across North America, the implementation of netting-based surveys in the Williston Reservoir presents unique difficulties. This is due to the large size of the waterbody (1779 km²; Stockner et al. 2005) and the widespread benthic hazards caused by the previously forested landscape which was flooded to create the reservoir. Despite these issues, previous research has identified locations in the Peace Reach of the reservoir where profundal net deployments may be feasible (Culling et al. 2020; Ted Euchner pers. comm.). With the use of marine navigational technology, netting sites without the risk of benthic entanglement could be identified. The availability of sites like those previously identified in the Peace Reach may however be limited. The minimum sample size requirements of a SPIN survey would need to be evaluated before implementation in the Williston Reservoir.

3.1.2 Mark recapture

Mark-recapture abundance estimates are used to estimate absolute abundance (Gresswell et al. 1997). In Lake Trout stock assessment mark-recapture estimates are often used in tandem with a relative abundance method like SPIN (Hansen et al. 2016). Fish are captured and marked with small tags. The tagged fish are then released back into the system, and subsequent recaptures of tagged fish are used to estimate population size. Once a reliable trend of population estimates is gathered (three generations; COSEWIC 2012), population trend or growth rate can be estimated.

This method can provide accurate population estimates; however, various assumptions need to be met through careful study design. Extensions to the basic estimation methods can be made to overcome

assumption violations, but even if overcome, a relatively large sample size of recaptures is required (i.e., >25). This has proven difficult to accomplish in large waterbodies. Mark-recapture efforts are most effective where fish aggregate in high densities, and there are multiple opportunities to recapture tagged fish. This method could be implemented on previously identified spawning shoals in the Williston Reservoir where large aggregations of Lake Trout have been observed. However, in other jurisdictions in British Columbia, practitioners have advised that attaining the required minimum sample size to produce an accurate abundance estimate has still been a challenge. This could be caused by logistical issues as well as Lake Trout ecology and movement (i.e., skip spawning, unidentified spawning locations). Due to the difficulty of attaining accurate population estimates through mark-recapture sampling, this technique is often used in conjunction with netting-based surveys which can distribute tags more widely in a population and provide ample opportunity for recapture due to their intensive, repeated sampling requirements.

3.1.3 Environmental DNA (eDNA)

Environmental DNA (eDNA) has the ability to identify the presence or absence, and given enough sampling sites, distribution of aquatic species (Fukuzawa et al. 2023). Mucus, feces, urine, gametes, and skin cells shed by an animal within a waterbody (eDNA) are used to detect presence or absence at a sampled site (Valdivia-Carrillo et al. 2019; Rourke et al. 2021). DNA particles within a water column can be detectable for up to 60 days which allows for accurate representation of a population at temporal scale (Rourke et al. 2021). In recent studies, eDNA has been used to monitor the spatio-temporal activity of spawning fish in a lentic ecosystem (Di Muri et al. 2022).

There are several abiotic and biotic factors that impact eDNA concentrations including the size of the water body, stress, metabolism and size, distribution and density, feeding and diet, reproduction and migration, water flow, water temperature, water depth, eDNA decay, and spatial and temporal scales represented by eDNA sampling (Rourke et al. 2021). Environmental DNA offers a low-cost and logistically feasible method for estimating the distribution of Lake Trout across the Williston Reservoir. Lake trout distribution in the Finlay and Parsnip reaches of the Williston Reservoir should be more accurately mapped using eDNA sampling. The recent development of a Lake Trout specific assay by the FWCP funded project Williston Reservoir Fish Ecology Assessed Using eDNA (PEA-F22-F-3404) provided rationale for the use of eDNA to map distribution of fish species across this large waterbody.

3.1.4 Assessments Completed in the Williston Reservoir

The majority of the research on Lake Trout ecology and stock assessment has taken place outside of the jurisdiction of British Columbia. However, some important assessments of Lake Trout movement have been completed in the Williston Reservoir.

Culling et al. (2020) completed an investigation into Lake Trout movement ecology using an acoustic telemetry array which was active in the Williston Reservoir from 2015-2019. In this study, Lake Trout were captured for acoustic transmitter implantation by angling. Results of this study have identified the most

common Lake Trout movement patterns in the Peace Reach of the reservoir. Lake Trout captured in the Peace Reach tended to move westward during the spring and summer and returned eastward towards the forebay and W.A.C. Bennett Dam in the fall and winter. These movement patterns coincide with congregations at identified spawning shoals in the reservoir. This study and subsequent peer-reviewed publications which resulted from it provide the seminal works on Lake Trout ecology in the Williston Reservoir. These works have formed a strong information base from which regional stakeholders can pursue further information gaps. Without this basic population data, effective management actions (conservation or suppression) cannot be devised, and their effects cannot be monitored meaningfully.

Harrison et al. (2020) quantified entrainment risk for Lake Trout and Bull Trout based on the telemetry data collected by Culling et al. (2020). They found low entrainment rates for both species, however species-specific movement ecology, including longer forebay (near dam) residency for Lake Trout increased entrainment vulnerability (i.e., more exposure to turbines). The study also revealed a difference in depth use between the two species. Bull trout movement patterns observed in other reservoirs (Kinbasket Reservoir; Martins et al. 2013) where they held the top pelagic predator status were not replicated here. Bull trout movement behaviours in the Williston Reservoir could therefore be affected by competitive interactions with Lake Trout. The authors recommended further research into diet, space-use and niche overlap between these two species in the Williston Reservoir.

3.2 Workshop Outcomes

The workshop provided an opportunity for attendees to review and discuss contemporary Lake Trout monitoring and research in the Williston Reservoir, Omineca, Peace and Skeena regions. Presentations were provided by Chu Cho Environmental staff, members of the research team from Culling et al. (2020), BC Ministry of Forests technical staff, independent biologists, and researchers from the University of Northern British Columbia. A summary of the meeting minutes is available in Appendix B.

Consensus on a definitive study design for monitoring Lake Trout abundance was not reached in the workshop. This was the result of lengthy discussions identifying that population-level estimates of abundance trend may not be an immediate requirement, and feasibility testing of abundance monitoring methods is needed. While being a high priority in the near-term (3-5 years), workshop attendees agreed that ancillary studies may be more important which provide insight into Lake Trout population genetic structure, effective number of breeders, population size-at-age, condition factor, diet and niche overlap or competitive interactions with conspecifics. These ancillary studies should also be designed to determine the specific competitive interface between char species. The workshop did not provide certainty that stock abundance time series would answer the question of whether increasing Lake Trout population abundance is negatively impacting Bull Trout (the previously identified priority objective of Lake Trout monitoring; Hagen and Weber 2019). In response to this there was agreement that population-level estimates have higher process error than the ancillary studies listed above and monitoring changes in population dynamics inferred from ancillary studies may have more merit in the long-term when conducted in coordination with stock assessment. Ancillary studies would provide further understanding of the ecology of Lake Trout in the reservoir which is necessary for the analysis of limiting factors for other focal species. Workshop attendees agreed that

conducting ancillary studies requires fish collection, which would facilitate feasibility testing of abundance monitoring techniques including SPIN and mark-recapture.

The workshop attendees created a list of data gaps which are necessary to support cost-effective Lake Trout stock abundance monitoring (Table 1). This list is a condensed version of the follow-up questions posed by workshop attendees (Appendix B). Regional stakeholders need to develop projects which collect the required information on population structure, dynamics and abundance prior to the implementation of management actions which will support the population viability of focal species. By completing ancillary studies and feasibility testing of abundance monitoring techniques described in this report, monitoring can begin to address *Action #8 Develop cost-effective lake trout monitoring* of the Peace Region Rivers, Lakes and Reservoir Action Plan (FWCP 2020).

Table 1. Data Gaps affecting understanding of Lake Trout ecology and competitive interactions in the Williston Reservoir.

ID	Data Gap	Information Type	Suggested Studies	Supporting Literature	Immediacy
1.1	Lake Trout Population Structure	Genetics	Investigate population structure and origin; Identify and map additional spawning habitats	Langston and Murphy 2008; Culling et al. 2020	High
1.2	Competitive Interface	Species Interactions	Diet overlap review and analysis across life history stages	Hagen and Weber 2019; Guy et al. 2011; Hagen et al. 2023	High
1.3	Abundance Survey Feasibility	Logistical Considerations	Reconnaissance and identification of netting sites with no benthic hazards; Power analysis to determine minimum sample size requirements	Culling et al. 2020; Hansen 2018; Sandstrom and Lester 2009	Moderate
1.4	Space Use and overlap with conspecifics	Distribution and Movement Ecology	Further analysis of existing movement data for Bull Trout and Lake Trout; eDNA distribution assessments	Culling et al. 2020; Harrison et al. 2020; PEA-F22-F-3404	Low

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The workshop attendees agreed on the scope of an initiative which could address Lake Trout data gaps. Given the ongoing investments by FWCP in the Williston Reservoir watershed, BC Hydro investment in fisheries monitoring during the flooding of Site C reservoir and concurrent Fisheries Entrainment Strategy (FES) mitigation and enhancement recommendations for the Williston, there is a need for ongoing monitoring of the pelagic fisheries community. In addition, the Environmental Stewardship Initiatives between the BC Government and First Nations, and COSEWIC review of Western Arctic Bull Trout conservation status provide an urgency to continue the baseline monitoring of a potentially evolving ecological community in the Williston Reservoir. Coordination between these ongoing initiatives will be required to attain the support needed to address the data gaps presented in Table 1. Three objectives emerged from the workshop including:

1. Identifying the competitive interface between Lake Trout and Bull Trout
2. Define population structure and origin of Lake Trout
3. Test feasibility of abundance estimation techniques, providing opportunity for bio-sampling of the fish community

Addressing these objectives should be completed in coordination with continued analysis of existing data including that of Culling et al. (2020) and the recently completed Pelagic Fish Survey (PEA-F22-F-3587-DCA). Additionally, effort should be placed on simulation analyses of the proposed abundance estimation methods reviewed in this seed project. This will allow project proponents to determine minimum sample size requirements in a situation where sampling sites may be limited due to logistical constraints.

4 Summary and Recommendations

Implementation of monitoring programs on the Williston Reservoir poses challenging logistical constraints. Feasibility testing of abundance estimation techniques is required given the complexity and scale of the reservoir environment. The methods presented in this report appear suitable for assessing Lake Trout stocks in the Williston Reservoir. However, the effectiveness of each method may vary depending on the specific characteristics of the reservoir, such as debris, bathymetry and water quality. Verification of minimum sample size requirements for abundance estimation should be conducted and the level of process error in abundance estimates must be considered relative to the objectives of a proposed project. If a primary goal of Lake Trout monitoring is to determine the effect of competitive interactions with Bull Trout, additional studies should be conducted in conjunction with abundance estimation to ensure a complete picture is presented following significant investment in population monitoring. The bio-sampling and surveying associated with fish capture required for abundance estimation provides samples which will support ancillary studies (e.g., genetic population structure, identification of additional spawning habitat, ageing, condition factor and niche overlap with conspecifics; Table 1). These ancillary studies will produce critical information on Lake Trout population status. A rigorous, replicable sampling design can allow for long-term monitoring of Lake Trout population status (which includes more components than abundance estimation; Table 1) and will provide more insight into competitive interactions and potential management actions than abundance estimation alone.

It may be necessary to use a combination of methods to obtain a comprehensive understanding of the Lake Trout stocks in the Williston Reservoir. SPIN sampling focused on Lake Trout in the Williston Reservoir may be a useful method for estimating relative population abundance and distribution. The spatial scope of surveys must be considered given the widespread locations of Bull Trout abundance monitoring and the interest in determining the competitive interface between these species. SPIN surveys provide a spatially appropriate estimation of fish density for use in an analysis of limiting factors for Bull Trout (Hagen et al. 2023). However, feasibility testing is needed to assess the suitability of this method in the Williston Reservoir. Site reconnaissance and use of marine navigational technology should be used to identify suitable netting sites across a spatial scale appropriate for the SPIN design. It is also recommended that mark-recapture estimation be tested using marks deployed during SPIN surveys. Recapture events are possible during Lake Trout spawning aggregations, at which time mapping of spawning shoals should be completed. Deployment of marks over spatially distributed SPIN sampling sites would provide a good sample of the population and information on spawning fidelity and fish distribution if recapture rates are suitable. Standardized SPIN and mark-recapture sampling in the Williston Reservoir will provide the value of a consistent sampling design under which estimates of relative abundance can be evaluated. In addition, standardized sampling locations provide the ability to regularly gather samples needed to address the data gaps outlined in Table 1. Index sampling therefore allows for the evaluation of abundance trend estimation as well as providing samples needed to address ancillary studies and proxies for population status which include condition factor, size-at-age, diet and niche overlap and genetic population structure.

It is recommended that a multi-year study be implemented aimed at addressing the data gaps presented in this seed study and evaluating the efficacy of abundance estimation techniques. SPIN survey

site reconnaissance and feasibility testing should be divided up by reservoir reach over subsequent years (3) to overcome logistical difficulties of operating on such a large waterbody. During index netting effort bio-sampling and marking should be conducted to provide samples needed to address the data gaps outline in Table 1. Recapture effort should be conducted at spawning aggregations in conjunction with mapping of spawning shoals using marine navigational technology. Mapping spawning shoals and cataloguing site characteristics will aid in the search for unidentified spawning shoals and assist in the determination of population structure (Table 1; 1.1).

Coalescence between ongoing monitoring programs under restricted funding availability will be a critical step in addressing the data gaps presented in Table 1. Fortunately, the workshop confirmed there are multiple different stakeholders with an aligned interest in the prioritization and implementation of Lake Trout monitoring in the Williston Reservoir watershed. We recommend to FWCP that Lake Trout monitoring activities be coordinated with other ongoing regional initiatives led by First Nations, BC Hydro, the provincial government and Fisheries and Oceans Canada, and concurrently funded FWCP projects. Urgency is placed on the implementation of Lake Trout monitoring feasibility by the momentum of concurrent studies on other focal species in the reservoir. A project based on the recommendations in this report will support FWCP priority actions, as well as the requirements of other agencies interested in the stewardship of fisheries resources in the Williston Reservoir. Without basic population data, effective management actions aimed at promoting the population viability of focal species cannot be devised and the effects of interventions cannot be measured.

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Appendix B – Workshop Summary Notes

Summary Notes Assessing Techniques for Monitoring Lake Trout Abundance Technical Workshop 2023-05-09

Table B1. List of workshop attendees.

Attendee	Association
Stew Pearce	Chu Cho Environmental
Bryce O'Connor	Chu Cho Environmental
Nathan French	Chu Cho Environmental
Dan Krivenko	Chu Cho Environmental
Ray Pillipow	BC Ministry of Forests
Joe De Gisi	BC Ministry of Forests
Tyler Weir	BC Ministry of Forests
David Johner	BC Ministry of Forests
Taylor Ward	BC Hydro
James Morgan	BC Ministry of Forests
John Hagen	JH and Associates
Ted Euchner	Diversified Environmental Services
Randy Zemlak	BC Hydro
Mike McArthur	BC Hydro
Dr. Mark Shrimpton	University of Northern British Columbia
Andrew McDermot-Fouts	University of Northern British Columbia

Objectives:

1. Review available and ongoing research of Lake Trout in the Williston Reservoir
2. Reach consensus on recommendation for a feasible, affordable study which can monitor Lake Trout abundance
3. Create space for open discussion and creative ideas

Purpose:

Gain an understanding of Lake Trout (LT) abundance and population dynamics prior to management decision making. Lack of direct LT management or monitoring in Williston Reservoir precludes ability to enact possible conservation actions.

9:15 Attendee Introductions

- Comment from BC Hydro on Fisheries Entrainment Strategy (FES) – Looking at mitigation and offsetting for entrainment in Williston of fish species. How can LT abundance monitoring be coordinated and find mutual benefits with FES and associated monitoring requirements?

9:30 Background on LT/BT from Chu Cho Environmental (CCE)

- Adfluvial Bull Trout (BT) often experience competitive exclusion by LT when rearing in the same waterbodies. Index sections surveyed (Scott, Point, Mininchinka, Davis River etc.) to count redds and quantify trends in redd abundance. In 2023, CCE plans on expanding to 8 index sites. Finlay Reach is a strong hold for BT abundance, index sections in Parsnip and Peace Reaches suggest populations are in decline.
- Peace Reach redd surveys - 2016-2017 and in 2019 – didn't find high density of BT spawning, although no baseline data exists to compare to. Numbers were variable and current status unknown due to lack of historical data.
- Comment from Randy Zemlak – Anecdotally LT abundance increasing since mid 2000s – angler reports. This suggests we are only in the middle of potential community transition (to LT dominance)
- CCE and TKD interests:
 1. Provide data to evaluate LT as a limiting factor for BT. Understanding how LT impact BT in the reservoir. The goal is to understand abundance and dynamics prior to evaluating need for suppression or conservation actions.
 2. Provides continued opportunity for monitoring mercury levels in fish tissue
- Methods review - SPIN typically preferred for abundance monitoring and effectiveness however, SPIN is difficult in the reservoir due to debris on lakebed. Potential to lose lots of nets. SPIN and mark-recapture seem to be most effective and widely used in tandem. Logistics of minimum sampling effort for SPIN on large waterbodies and difficult bathymetry of reservoir make implementation difficult.
- Literature on BT/LT interactions seems sparse but there are some works through which we can learn more – Ferguson et al., Flathead Lake, Quesnel Lake telemetry

10:00 – Spatial ecology of Bull Trout and Lake Trout in Williston Reservoir

Taylor Ward

- Utilizing acoustic telemetry data to identify fish use in forebay and Peace Reach
- Hydrophone Array: 9 receivers near Bennet dam, gates throughout peace reach. Tags detected up to 2km away from receivers.
- Difficulty recovering receivers due to ice, debris, trees
- Results of tagging and surveys: tags provide pressure reading relating to depths of occupancy
- BT and LT occupy various depths throughout the year. BT occupy high areas in the water column in spring and summer while LT move deeper into the water column into the summer season.
- BT generally occupy shallower depths (littoral/creek mouths) than LT but varies based on season. Summer months had highest variation and difference in space use. Winter had more space/depth overlap
- Consistent seasonal trends for LT when compared to BT. Movement towards forebay in winter then spring begin westward movement out to Parsnip and Finlay Reaches in the summer. Congregation near Selwyn spawning zone for LT in fall (finlay forks area)

Comments:

- Do BT use reservoir for migration rather than feeding and foraging like we suspect? Movements directionally between spawning areas and littoral foraging areas or kokanee feeding opportunities – are BT using cold-water influence of river mouths to withstand high surface water temps if spending time in shallower water? How can BT be so near surface when summer surface temps are 18°C+. Future of this dataset should be further investigation into BT movement

- This dataset has a lot of potential for further analysis and investigation of BT/LT overlap or looking into fish distribution – map of LT occupancy predicted by depth? Good opportunity for grad students to generate inference in BT/LT overlap without funding expensive fieldwork – potentially more inference into competition than a time series of LT abundance provides.
- Telemetry data from other reservoirs and lakes in BC – could be combined in meta-analysis and more inference could be made into BT depth and space use, especially where competitors are present

11:15 – Peace Reach Lake Trout Movements – FWCP Project 2016-2019

Ted Euchner

Project Objectives:

- Include identifying seasonal movements outside of Peace Reach and identification of spawning habitat. Previously no spawning zones or pre-spawn aggregations known for Williston LT
- Lots of time spent around Wicked River and Mt. Selwyn
- Angled for fish – using downriggers, and vertical jigging then tagged with hydroacoustic tags
- Always caught fish on sandy gravelly shore areas on Eastern half of reservoir, never caught over trees (not using treed areas, or just not efficient at angling in those drowned forests?)
- Hydrophones were set up at choke points on a fixed line anchored from bottom – accessible in spring. Occasionally placed temporarily to monitor presence of tagged fish

Results:

- Lake Trout leave peace reach and return in fall and near forebay in winter
- Most fish move westerly in summer – dominant movement pattern
- Congregation of LT in Zone 9 in the fall (Selwyn spawning shoal)
- Fish moved from peace reach into Finlay and Parsnip – no patterns in movement in Finlay, Parsnip congregations in Nation River arm and Nation lower falls – suspected spawning?
- Base of Selwyn – area of significance for LT spawning – only documented spawning shoal
- Fish caught by trolling 8-30m above bottom during the day (females)
- Males were caught almost exclusively on the bottom during trolling
- Spawning zones: Selwyn: cobbles falling into the reservoir from mountainside. Only area which wasn't covered in silt – most of reservoir does not provide spawning habitat
- Selwyn most important spawning feature. Spawning related to inflow of water? Wave action? Fresh cobbles from mountain slides?

Comments:

- Data gap - juvenile rearing areas (inlets? – overlap with BT)
- Work needed on various life history stages of LT
- Distribution work for pigmy whitefish - relationship between pigmy whitefish and Lake Trout: Key prey species of lake Trout in smaller lakes
- SPIN – Time series required if LT abundance is increasing
- Before establishing methods for times series how can ancillary studies provide ability to close data gap on BT/LT interactions? – Diet or SIA niche overlap, condition factor. Also how can these studies improve times series development as new information becomes available. Sometimes these ancillary studies can reveal that time series may not be as valid or accurate as you believe.
- Genetics of LT – help us understand extent of unknown spawning locations if we see different genetic signatures in samples? Also help us determine origin of LT populations – stocked or natural recruits from inundated lakes
- Lots of LT found were in areas where a “Spine” between two inundated rivers exist. No trees and little for nets to snag on – There is potential to create a shortlist of areas where SPIN index sites could be established based on where Ted and Diversified were capturing fish without snagging downriggers

Assessing Techniques for Monitoring Lake Trout Abundance

- Strong hold of BT abundance in Finlay reach with very little LT present – too shallow?
- Understanding even a snapshot of LT abundance by pursuing SPIN or mark-recap could be valuable data – baseline
- How can SPIN index netting reveal more spatial variation in LT abundance? – more widely distributed than mark-recap focused on spawning shoals

13:00 - Lake Trout in Northeast BC

James Morgan

Williston Creel Survey 2021

- 4000 angler days, 155 boat days, 17600 rod hours were estimated
- 75% rod hours directed at Lake Trout
- Out of 2433 LT caught, 409 were kept
- Most anglers were out of compliance
- Mainly targeting LT in Williston
- 16.8% LT harvested

Comments:

- Suspected whitefish and juvenile late trout are competitive?
- Mark recapture can be effective during ice fishing angling activities on Parsnip Reach
- What can we learn from the NE about space and habitat use in smaller lakes?
- Fishing mortality and angler effort a priority for the Ministry and should be wrapped into project to advise management – can increase angler harvest mitigate BT/LT interactions?
- Effort required for SPIN on small (relative) lakes makes SPIN seem not realistic on Williston – Steve Sandstrom email Williston would be largest SPIN ever implemented in North America

13:40 - Piloting eDNA in the Williston Reservoir

Andrew McDermot-Fouts

Introduction:

- Environmental DNA (eDNA) is detectable below thermocline when the lake is stratified, and eDNA below thermocline more stable and less widely distributed than in surface layers
- During mixed events, eDNA is homogenous throughout water column

Objectives:

1. Identify and develop and then validate eDNA assays for the pelagic fish species in the WR
2. Investigate the relationship between vertical distribution of eDNA and gill net catch results
3. Make recommendations for use in Williston Reservoir

Results:

- Agreements between gill netting results and presence, absence of eDNA sampling
- more eDNA results near surface of water due to more feeding and activity
- eDNA has higher production and higher detection probability above the thermocline than below
- Novel Lake trout assay created which can differentiate BT and LT

Recommendations:

- Higher volume of water to sample: tow nets captured more coarse particles of fish but were able to run more water through the filters – to identify cryptic species

- No positive detection of LT, needs more verification at sites with known LT presence
- Sampling below thermocline will have higher spatial accuracy but lowest probability of detection. During mixing, in spring and fall there is more probability of detection but distribution of eDNA will be more widespread
- Should pair eDNA sampling with traditional stock assessment - SPIN netting

14:15 - Questions for Follow-up Studies/Project Scoping

1. What habitat types do the LT juvenile occupy?
2. LT spawning shoals? How many in addition to Selwyn and potential Nation. Mapping shoal extent using boat navigation tech? Divers?
3. Is LT movement between reaches tied to Kokanee movement and abundance?
4. What specifically is the BT/LT competitive interface?
5. What is the role of prey fish type, size and abundance in mediating LT/BT competition?
6. If BT are more migratory – moving between point locations in reservoir – how can this facilitate coexistence/ different niche or space use?
7. How does vertical distribution segregation b/w BT and LT affect competition between species if BT are in shallower (warmer?) do they have disadvantage metabolically?
8. Is LT distribution driven by depth/temp and what are there preferences?
9. What are the goals and objectives of LT monitoring?
10. What limits LT spawning habitat suitability?
11. Is there one panmictic population given few spawning areas?
12. What are the genetic origins of LT in the reservoir? Stocked or naturally recruited from inundated lakes?
13. Could stocks be managed/monitored by “Core Areas” based on genetic results?
14. How does annual draw down of the reservoir impact occupancy and migration of LT?
15. Can suitable SPIN index sites be established where there are very few benthic hazards?

14:15 - Action Items

1. Follow-up with meeting summary and distribute to attendees.
2. Work with Ted Euchner to create list of SPIN set sites for feasibility project – can we cut out a smaller zone of the Peace Reach within which to attempt SPIN sampling while identifying index sites in other reaches?
3. Reach out to Scott Milne to assess technological capabilities to map out known spawning shoals or identify unknown spawning shoals.
4. Create list of ancillary studies in addition to assessment of abundance monitoring methods which can provide information to support abundance monitoring and BT competition data gap – population dynamics, genetics, competition and niche overlap.