Williston-Dinosaur Watershed Fish Mercury Investigation

2016 Report

Prepared for:

Fish and Wildlife Compensation Program, Peace Region
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EXECUTIVE SUMMARY

The Fish and Wildlife Compensation Program (FWCP) – Peace Region carried out a strategic planning process in 2012-13 to review and identify future program priorities and actions in this region. Guided by a Strategic Planning Group (SPG), which included First Nations, academia, agencies, BC Hydro and members of the FWCP-Peace Board, a Basin Action Plan was finalized in 2014. Objective 3a of the FWCP Peace Action Plan is to "*Improve understanding of mercury concentrations, contamination pathways and potential effects on human health and the broader ecosystem*." Initial efforts on this objective were commissioned by FWCP Peace in 2014 and identified the need to obtain updated information on fish mercury concentrations and consumption habits. In 2015, the FWCP-Peace commissioned a multi-year, study to collect fish mercury data from the Parsnip, Peace, Finlay reaches of the reservoir, Dinosaur Reservoir and reference lakes. Results of this investigation will be used to assess the implications for the broader ecosystem and for human health, with the goal of 'updating' the fish consumption advisory, in partnership with health agencies, who are responsible for public health advisories.

Azimuth Consulting Group Partnership began this work in May 2016, assigning the scope of work into five tasks, ranging from First Nations involvement and training, collection of fish muscle samples for mercury analysis from discrete areas of the reservoir and liaison with communities to facilitate creel data collection. A summary of progress made on each task is summarized here, followed by a summary of technical findings related to meristics (length, weight, age), mercury concentrations and stable carbon and nitrogen isotopes in tissues, by fish species, within Williston Reservoir and relative to reference lakes.

Task 1 – *Data Collection Planning*. The 2016 – 2018 sampling program consists of: 1) Core reservoir sampling led by EDI Environmental with assistance by Chu Cho Environmental (CCE) and Northern Spruce; 2) Reference area sampling for lake trout – lake whitefish (led by FLNRO) and bull trout – kokanee complex (led by CCE); 3) Opportunistic, or partnership sampling led by FLNRO, CCE, J. Hagen and Carleton University; and 4) Community-led sampling where fish tissue samples and creel survey information is provided to us directly by participating First Nations communities.

Task 2 – *First Nations Involvement and Training*. Training and participation by First Nations communities and individuals was embedded throughout the program. In 2016, 10 individuals from six communities were trained to collect, handle and store fish tissues for scientific analysis, as well as gathering of 'creel' survey data. These individuals became our 'community champions', with the responsibility of collecting and storing fish tissue samples and gathering creel data on our behalf. Several individuals from Tsay Keh Dene First Nation and McLeod Lake First Nation also participated in each Core reservoir sampling program outlined in Task 1.

Task 3 – *Strategic Sampling*. Three main programs were conducted in 2016. In August, the strategic program was conducted on Parsnip Reach by EDI, CCE and Northern Spruce, gathering tissue samples from 129 fish. Of this, a subset of tissues was analysed from lake trout (42), bull trout (9), lake whitefish (24), mountain whitefish (9), rainbow trout (9) and burbot (1). Fraser Lake (a reference) was sampled in August by FLNRO, capturing 64 fish consisting of lake trout (32), lake whitefish (20), mountain whitefish (8) and burbot (4). In September, Thutade Lake (a reference) was sampled capturing kokanee (12), mountain whitefish (2) and rainbow trout (7).

Task 4 – *Partnership Fish Collection*. Partnership fishing programs resulted in the collection of fish from Finlay Reach (CCE, FLNRO, Hagen) and Dinosaur Reservoir (Carleton University). In total, 56 fish from

Finlay Reach were sampled including 4 lake trout, 13 kokanee (Osilinka River) and 39 bull trout from Ingenika River (10), Davis River (14), Swannell River (7), Chowika River (5) and Osilinka River (3). Some rainbow trout, longnose sucker and mountain whitefish were collected from Dinosaur Reservoir

Task 5 – *Liaison with Health Authorities*. Azimuth has established relationships with the First Nations Health Authority and Northern Health. We have committed to regular updates throughout the project, ultimately leading to addressing the fish consumption advisory on the Williston Reservoir watershed.

Summary of 2016 Results – This is the first of a multi-year study to characterize fish mercury concentrations across a range of species, from different geographic areas within the Williston – Dinosaur watershed, relative to nearby reference area lakes. Data and conclusions presented herein are preliminary and we have not gone into depth to explain reasons behind observed patterns. Data from 2016 are presented in a series of summary tables and graphs, depicting relationships between fish size (length), age (y) and mercury concentration (mg/kg or parts per million) as well as stable carbon (C) and nitrogen (N) isotopes with fish length and mercury. Stable isotopes were combined with mercury data to shed light on individual trophic status (i.e., position on the food web) and nature of fish diet.

As expected, lake trout and bull trout consistently had the highest mercury concentrations, ranging over an order of magnitude, from 0.15 mg/kg up to 1.3 mg/kg, depending on fish size. In general, lake trout had higher mercury concentrations than bull trout, because of larger size and greater age. There was a positive correlation between increasing fish length and mercury concentration in both species. Mercury concentrations for lake trout from Parsnip Reach and Fraser Lake (reference) were similar across the size range of fish examined. Although there was overlap in mercury concentration over all sizes from both environments, mercury in large bull trout from Williston was slightly higher than from Thutade Lake.

Lake whitefish (along with kokanee), are a key food web species and both strongly identify within the pelagic food web in both Williston Reservoir and Fraser Lake (and Thutade for kokanee). This may explain the similarity in mercury concentrations for this species among waterbodies, despite the large inherent differences in fish size between Williston and Fraser. Whereas Fraser Lake whitefish ranged up to 412 mm, nearly all Williston Reservoir whitefish were <300 mm in length. Notwithstanding size differences, mercury concentrations were variable and ranged from 0.05 mg/kg up to 0.33 mg/kg, with no apparent relationship between increasing fish size and mercury concentration. Mercury concentrations in lake whitefish from Williston Reservoir and Fraser Lake were similar.

A small number and narrow size range of kokanee was caught in both Finlay Reach (13) and Thutade Lake (2). Given that this landlocked salmon species seldom exceeds 300 mm in length over a maximum age of 3 – 4 years, small fish were expected. Kokanee had a weak to non-existent length-mercury relationship from both waterbodies with low mercury concentrations overall. Mercury concentration of Thutade kokanee was lower (<0.05 mg/kg) than Finlay Reach kokanee (0.05 – 0.14 mg/kg).

A small number of mountain whitefish (9), rainbow trout (9) and burbot (1) were captured in Parsnip Reach. Mercury concentrations in mountain whitefish and rainbow trout were low (<0.15 mg/kg) and when also present in reference lakes (Thutade and Fraser), mercury concentrations were similar.

In summary, notwithstanding some differences in fish size captured between Williston Reservoir and Fraser and Thutade reference lakes, the range and magnitude of mercury concentrations were similar among Williston Reservoir and reference area lakes for most species. The focus of 2017 work is on Peace Reach, with continuing efforts to fill data gaps in Finlay Reach and Dinosaur Reservoir. A second lake trout – lake whitefish reference lake will also be sampled.

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We have many people to thank – especially our study team members who worked hard on our behalf to collect fish tissue samples from all over Williston Reservoir in 2016. These include Mike Tilson, Kirk Miller, Lindi Anderson, Stephen Friesen, and Marty Izony (Chu Cho Environmental and the Tsay Keh First Nation); Tim Antill and Vicky Smith (Environmental Dynamics Inc. [EDI], Prince George); Cheryl Chingee (Northern Spruce Contracting and the McLeod Lake First Nation); and Fernie Garbitt and Phyllis Gautier (Saulteau First Nation) for diligently collecting creel survey data.

We would like to especially acknowledge the participation by Ian Spendlow and his Forests Lands and Natural Resources Operations (FLNRO) team for their provision of in-kind support collecting fish from Fraser Lake; also by John Hagen (Hagen and Associates) for logistical support and collaboration with FLNRO in fish collections at Fraser Lake and in Finlay Reach. Their contributions to this program were invaluable.

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This report was written by Randy Baker and Gary Mann (Azimuth). Laura Bekar (Azimuth) provided logistical support, data management and quality control throughout the project.

USE & LIMITATIONS OF THIS REPORT

This report has been prepared by Azimuth Consulting Group Partnership (Azimuth) for the use of the Fish and Wildlife Compensation Program – Peace Region (FWCP; the Client).

This report is intended to provide information to FWCP – Peace to assist with making decisions regarding how to respond to the issue of mercury in fish in the Williston Reservoir watershed, including Dinosaur Reservoir. The Client has been party to the development of the scope of work for the subject project and understands its limitations.

The findings contained in this report are based, in part, upon information provided by others, such as tissues, and by analytical laboratories. In preparing this report, Azimuth has assumed that the data or other information provided by others is factual and accurate. If any of the information is inaccurate, site conditions change, new information is discovered, and/or unexpected conditions are encountered in future work, then modifications by Azimuth to the findings, conclusions and recommendations of this report may be necessary.

In addition, the conclusions and recommendations of this report are based upon applicable legislation existing at the time the report was drafted. Changes to legislation, such as an alteration in acceptable limits of dietary exposure to mercury, may alter conclusions and recommendations.

This report is time-sensitive and pertains to a specific site and a specific scope of work. It is not applicable to any other site, development or remediation other than that to which it specifically refers. Any change in the Site, remediation or proposed development may necessitate a supplementary investigation and assessment.

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ACRONYMS & GLOSSARY

CCE	Chu Cho Environmental
CRM	Certified Reference Material
DL	Detection limit
dw	Dry weight
DQO	Data quality objectives
EDI	Environmental Dynamics Inc.
FLNRO	Forests Lands and Natural Resource Operations
FWCP	Fish and Wildlife Compensation Program
Hg	Mercury
MeHg	Methylmercury
MOE	Ministry of Environment
QA/QC	Quality assurance/quality control
RPD	Relative percent difference
SIA	Stable Isotopes Analysis
SINLAB	Stable Isotopes in Nature Laboratory
SOP	Standard Operating Procedures
ww	Wet weight

1. INTRODUCTION

1.1. Background

Williston Reservoir was created in 1968, following construction of the W.A.C. Bennet Dam (**Figure 1-1**). Fish mercury concentrations first appear to have been measured in 1980 (Health and Welfare Canada 1980, as reported in Baker et al. 2002), 12 years after impoundment. Another study was conducted in 1988 (BC Hydro 1989, as reported in Baker et al. 2002), two decades after flooding. Mercury concentrations in bull trout (*Salvelinus confluentus*, a large predator) were elevated, leading to the province issuing a fish consumption advisory in the early 1990s. The "Mercury Warning" in BC's 2015-2017 Freshwater Fishing Regulations Synopsis states that "*Mercury levels in Lake Trout and Bull Trout (Dolly Varden) from Williston Lake and tributaries…may be high. Normal consumption is not a significant hazard to human health, but high consumption may be*."

Prior to the initiation of reconnaissance-level sampling for this initiative in 2015 (see **Section 1.3**), there had been two other studies conducted in the last 15 years. The first was a comprehensive study in Finlay Reach conducted in 2000 that investigated mercury concentrations in water, sediment, invertebrates (zooplankton and benthos), and fish (Baker et al. 2002). While this study concluded that mercury concentrations in surface water, sediment and invertebrates (zooplankton and benthos) were relatively low, mercury concentrations in lake whitefish (*Coregonus clupeaformis*; a food web species) and bull trout (*Salvelinus confluentus*) were slightly higher than one would have expected given the low concentrations in other media. However, mercury concentrations in bull trout had declined since the earlier 1988 study (Baker 2002) while mercury concentrations in lake whitefish were within the range observed for whitefish from non-impounded lakes. The second study, commissioned by the West Moberly First Nation, was conducted in 2012 on the Crooked River, a tributary of the Parsnip River, during a fish camp event. That study indicated that mercury concentrations in bull trout were 'relatively high' (ERM 2015). These data are briefly considered within this current investigation (**Section 3.4.2**).

Dinosaur Reservoir was impounded by the Peace Canyon Dam in 1979 and occupies the former Peace River Canyon immediately downstream of the WAC Bennett Dam and Williston Reservoir. Dinosaur Reservoir is small (20.5 km long), narrow, deep (~200 m), and steep-sided, with limited littoral habitat. There are only two small tributary streams that enter the reservoir (Johnson and Gething Creek), where access is difficult. Productivity is quite low, being driven almost exclusively by inputs from Williston Reservoir. Twenty species of fish have been identified in Dinosaur Reservoir since its formation, the most common of which are rainbow trout (*Oncorhynchus mykiss*), mountain whitefish (*Prosopium williamsoni*), kokanee (*O. nerka*), and lake whitefish (*C. clupeaformis*) (Diversified Environmental and Mainstream Aquatics 2011). As part of the Site C investigation on mercury, Azimuth (2011) examined mercury concentrations in Dinosaur Reservoir and Peace River fish downstream. They found that fish mercury concentrations in both areas were quite low, likely due to the influence of the nutrient poor, oligotrophic (Stockner et al. 2005) Williston Reservoir, immediately upstream.

It is also important to note that there have been large, ongoing ecological changes within Williston Reservoir over the last five decades (e.g., Stockner et al. 2005, Langston 2012), which have the potential to greatly alter the pattern of mercury accumulation by fish. The main change has been a major shift in fish species, with a decline in bull trout and lake whitefish and a corresponding increased abundance of lake trout (*S. namaycush*) and landlocked kokanee (*O. nerka*). This change in the fundamental ecology and food web relationships within the reservoir, as the fish community continues to evolve since its creation, also dictates that more up-to-date information is needed. For example, Langston (2012) observed that of the more than 1 million kokanee spawners estimated in the reservoir were very unevenly distributed, with <1% in Peace Reach, <8% in Parsnip Reach, between 60 – 89% in Omineca Arm, and 2 – 36% in Finlay Reach, depending on the year. It is unclear what role these differences in prey distribution or other ecological factors may have on spatial patterns of mercury concentrations in higher level piscivores such as bull trout and lake trout within the Williston-Dinosaur Watershed.

While fish mercury concentrations are known to increase following reservoir creation, they are known to decrease again in the following two to three decades, typically returning to, or slightly above, pre-inundation concentrations (see **Section 1.4** for an overview). Given the nearly five decades since the impoundment of the Williston Reservoir, we would anticipate that fish mercury concentrations should have returned to, or at least near, pre-flood concentrations. Unfortunately, Williston was created in the decade prior to mercury becoming recognized as a reservoir-related issue, so no baseline fish mercury monitoring was conducted. In these situations, the best approach is to sample other lakes in the region as a point of reference to provide additional context for interpreting data from the Williston-Dinosaur Watershed.

Finally, updated information on fish mercury concentrations is only one piece of the puzzle however, with respect to exposure by humans and wildlife to mercury. The other important aspect, for humans, is gaining a better understanding of fish consumption habits, which are normally characterized using creel surveys. Data on type of fish species consumed, geographic location, frequency of consumption (meals per week or month), seasonal patterns and meal size (grams/meal), are poorly known. Thus, determining the implications of exposure to mercury from eating fish caught in the Williston-Dinosaur Watershed requires accurate information on fish mercury concentrations in key species and on local fish consumption habits.

1.2. Objectives

The Fish and Wildlife Compensation Program (FWCP) – Peace Region carried out a strategic planning process in 2012-13 to review and identify future program priorities and actions in this region. This planning process was guided by a Strategic Planning Group (SPG), which included First Nations, academia, agencies, BC Hydro staff, and members of the FWCP-Peace Board. This process resulted in the creation of a Basin Plan and six Action Plans, finalized in 2014, providing guidance on program priorities and direction (**http://fwcp.ca/region/peace-region**).

Objective 3a of the FWCP Peace Reservoirs Action Plan (FWCP 2014) is to "*Improve understanding of mercury concentrations, contamination pathways and potential effects on human health and the broader ecosystem*." Initial efforts on this objective were commissioned by FWCP Peace in 2014 and 2015 (see **Section 1.3** for an overview) and identified the need to obtain updated information on fish mercury concentrations and on fish consumption habits within the watershed. To address these information gaps, the FWCP-Peace commissioned a multi-year directed project to collect fish mercury information from the three major reaches of Williston Reservoir (Parsnip, Peace, Finlay), Dinosaur Reservoir and reference lakes. Azimuth Consulting Group Partnership (Azimuth) was awarded a contract for this work on May 26, 2016.

This report, hereafter referred to as the Williston-Dinosaur Watershed Fish Mercury Investigation, documents:

- The overall scope of work and strategy for study implementation, including details on tasks completed in 2016 (**Section 2**)
- A preliminary assessment of the 2016 results (**Section 3**)
- Implications for follow-up studies (**Section 4**).

Ultimately, this information will be used to assess the implications for the broader ecosystem and for human health. A key outcome anticipated from this FWCP Action Plan study will be to provide updated fish mercury information to health agencies responsible for public health advisories.

1.3. Overview of Previous Related Work

Early in 2014, the FWCP Peace Region Board determined that they wished to address and resolve the issue of the mercury advisory in Williston Reservoir watershed. Azimuth was engaged later in 2014 to conduct an 'Engagement and Consultation' study with the aim of developing a scope of work for next steps, with the following objectives: consult with and identify concerns of First Nations and other stakeholders; identify key issues and data gaps and; based on these findings, propose a scope of work to direct the way forward/next steps to update the fish mercury database for Williston Reservoir watershed and resolve the advisory.

In March 2015, Azimuth issued a report entitled 'Williston Reservoir watershed – Fish mercury consultation and next steps'. The report summarized deliverables from ten discrete tasks including:

1) Outcome of the engagement and consultation process held with members of eight First Nations (Tsay Keh Dene, Saulteau, Nak'azdli, McLeod Lake, Kwadacha, West Moberly, Prophet River, Doig River), Ministry of Environment, BC Hydro and other stakeholders
2) Distribution of a 'mercury fact sheet' that provides an overview of the science of mercury and methylmercury dynamics in lakes and reservoirs;
3) The FWCP-Peace Board and First Nations Working Group was presented to on October 21, 2014, to communicate preliminary findings of the communication and consultation process;
4) Summary of supplementary discussions held with members from several First Nations, BC Hydro and Peace Valley Environmental Association at the Saulteau band office on December 10, 2014
5) A presentation made to Northern Health in Prince George on January 20, 2015, including meeting minutes;
6) A summary of existing, historic fish mercury information from Williston watershed;
7) Data gap summary relating to fish mercury data;
8) Overview of strategy to address a fish mercury consumption advisory in BC;
9) An overview of study design and data requirements (e.g., spatial scope, species, statistical design considerations) from a fish mercury field program; and lastly
10) An outline of the responsibilities and role of First Nations and recreational fishing groups to provide information essential to the success of the field investigation and ultimately, address the fish consumption advisory for Willison Reservoir.

The final section of the Azimuth (2015) report provided a list of recommended next steps to follow for the Board to develop a Scope of Work and Terms of Reference for a fish mercury study.

Later in 2015, Azimuth was commissioned to coordinate a reconnaissance fish mercury sampling program at select locations in the Williston Reservoir watershed. Sampling kits and instructions were provided to groups willing to participate. Bull trout samples were obtained from Forest Lands and Natural Resource Operations (FLNRO) work on the Ingenika River, Davis River and Scott Creek. Archived kokanee (collected by FWCP staff in 2006 and frozen since they were caught) were available from several tributaries to Finlay Reach and Arctic Lake (a small reference lake). Rainbow trout (*Oncorhynchus. mykiss*) samples from Thutade Lake, an upstream reference lake in the headwaters of Finlay River, were collected by Tsay Keh Dene. Samples were analyzed for total mercury, stable isotopes and selenium to help inform which tools might be useful in future studies.

The mercury results from the reconnaissance study were as follows:

- Bull trout mercury concentrations ranged from 0.08 to 0.91 mg/kg wet weight (ww); while sample sizes were too low for definitive conclusions, there was some evidence to suggest that differences among the three locations, with mean mercury concentration of Scott Creek fish (0.52 mg/kg; 590 mm) being higher than for Ingenika River (0.30 mg/kg; 730 mm) and Davis River (0.22 mg/kg; 568 mm).
- Mercury concentration of Finlay River kokanee (n=25) ranged from 0.07 – 0.13 mg/kg ww with a mean of 0.09 mg/kg and no apparent correlation between mercury and fish size. Mercury in Pelly Creek and Germansen River kokanee (n=13) were slightly lower (0.05 – 0.06 mg/kg) and similar to reference area Arctic Lake kokanee (0.05 mg/kg; n=5).
- Mercury concentrations of Thutade Lake rainbow trout (n=10) ranged from 0.03 – 0.09 mg/kg, with a mean of 0.05 mg/kg and a slight positive correlation between fish size and mercury concentration.

These data were used to provide context for 2016 work and have been incorporated into the long-term database that Azimuth is compiling over the course of this work.

1.4. Mercury in the Environment

This section briefly describes some basic information on mercury and methylmercury in the environment to provide the reader with context for this document as well as from a more general perspective.

Like many other elements of a potentially harmful nature, mercury is naturally-occurring and present in low concentrations in all environmental media including air, water, sediment, soil and tissues of all plants and animals. There are a number of forms that mercury can take in environmental media, but the main two forms of concern are inorganic (e.g., elemental mercury adhered to soil or sediment particles and carbon) and methylmercury. Methylmercury ($HgCH_3$) is the 'organic' form of mercury and has much greater toxicity than the inorganic, elemental form (Hg). Methylmercury is the main form of mercury that is found in fish, usually comprising at least 90% of the total concentration (Bloom 1992). This is also the form of mercury for which health guidance has been developed, because exposure by humans and wildlife to methylmercury is almost exclusively via fish consumption (Hall et al. 1997).

The relative amount of methylmercury in environmental media relative to total mercury (i.e., all forms) is different for each media type. In water, the concentration of mercury is usually extremely low and only 1 – 5% of the total is methylmercury. On the other hand, the concentration of mercury in fish muscle is about 10 million times higher than in water and virtually all of it occurs as methylmercury.

Ingested methylmercury is easily incorporated and stored into biological tissues, mostly in muscle. How much is acquired can be greater than the amount that is depurated, depending on how much fish is consumed and how frequently. This can result in a net accumulation of mercury. Furthermore, the concentration of methylmercury in animal tissue increases with progressively higher steps in the food web, a process known as biomagnification. This process occurs in both terrestrial and aquatic ecosystems but is more results in higher concentrations in aquatic species because of the multiple steps in the food web, many of which are carnivorous (e.g., many sequential steps where invertebrate and vertebrate animals are consumed, culminating with fish). It is for this reason that in natural freshwater lakes and reservoirs, fish have higher mercury concentrations than almost all other animals. Thus, fish consumption is the primary means of exposure of humans and fish-eating birds and mammals to methylmercury. Furthermore, carnivorous fish such as bull trout, lake trout and northern pike (and tinned tuna) have higher mercury concentrations than omnivorous species including whitefish, rainbow trout and others.

The relationship between the creation of new reservoirs and the phenomenon of increased methylmercury concentrations in fish has been well studied, with many examples within Canada, especially in Manitoba (e.g., Bodaly et al. 1997, Bodaly et al. 1984) and Quebec (e.g., Schetagne et al. 2003). Over time, inorganic mercury is captured from the atmosphere and incorporated into the leaves and needles of plants. Over decades or centuries as this material falls to the ground and accumulates to form terrestrial soil, the atmospheric mercury also accumulates here, where it is sequestered by carbon. When terrestrial soils are flooded, this organic soil is rapidly decomposed by bacteria. As part of this bacterial decomposition process, a specific group of bacteria transform or "methylate" some of the inorganic mercury in the soil into organic or methylmercury. Now that methylmercury has been created and incorporated into the base of the food web, it is accumulated and concentrated at each increasing step up the food web, to reach highest concentrations in carnivorous fish.

This methylation process is most rapid during the first few years after reservoir creation, before slowly diminishing. Data from all Canadian reservoirs agree in the general pattern of changes in fish mercury concentration over time. Mercury in adults of large, predatory species increases rapidly, with peak concentrations between three and eight years after impoundment. Once peaks are achieved, concentrations slowly decline, eventually returning to near pre-impoundment (or baseline) concentrations between 20 and 25 years after reservoir creation (Schetagne et al. 2003, Bodaly et al. 2007, Munthe et al. 2007). Given that Williston Reservoir was created in 1968, nearly 50 years ago, we would expect that mercury concentrations will have stabilized at a new baseline. Given that there are no pre-development data, there is no way of knowing how current day concentrations compare. However, gathering data from nearby reference lakes will put mercury concentrations from Williston fish into perspective.

It is important to note that there is no mercury concentration that represents a 'threshold' above which risks may be posed to humans or to wildlife. Thus, there are no red lines that appear on graphs in this report, that might suggest either safe or unsafe concentrations. Like all other contaminants in the environment, it is the 'dose that is the poison'. Exposure to mercury occurs almost exclusively via diet (primarily fish) and the 'dose' is a function of a combination of frequency of fish consumption, meal size (gm), body weight (kg) and gender/age, in addition to the fish mercury concentration, which varies by species and fish size. This dose is unique to every person and there are commonly used guidelines in Canada (and other countries) that can be used to determine what is acceptable on an individual basis.

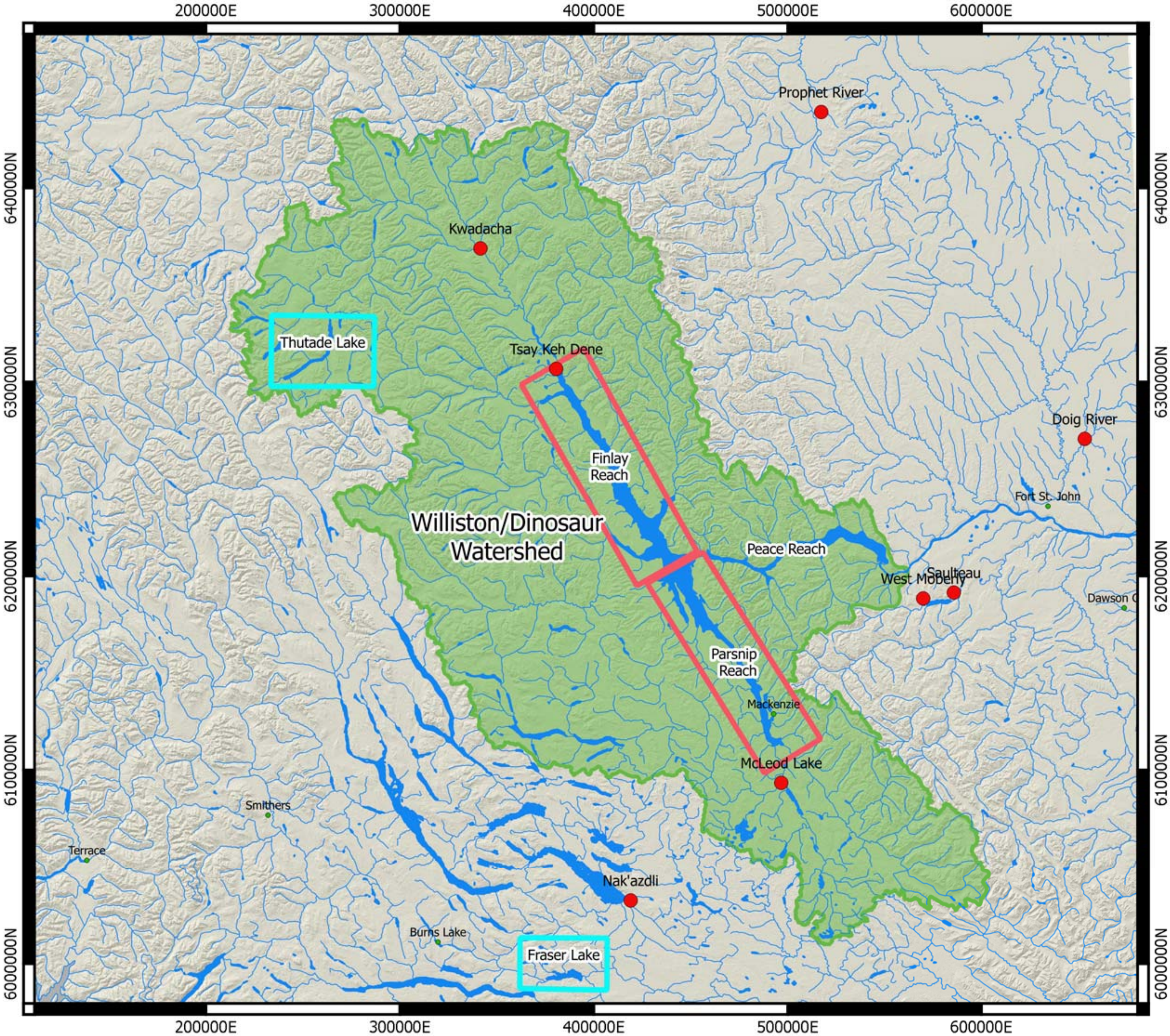


Figure 1-1. Main sampling areas for Williston-Dinosaur Watershed Fish Mercury Investigation, 2016.

Version Date: 28 March 2017

Legend

FN Communities

Reservoir Sampling

Reference Lakes 2017

Watershed Boundary

0 50 100 km

Data Sources

NRC - DEM, topo layers
GeoBC - Place names
Azimuth - station locations

Projection: UTM 10 NAD83

Williston-Dinosaur Watershed Fish Mercury Investigation

AZIMUTH

2. SCOPE OF WORK DOCUMENTATION

The scope of work contained several specific actions that we have grouped into five main tasks:

1. Develop a comprehensive plan to collect sufficient tissue samples to update the fish mercury advisory – This task was fully addressed by our proposal to complete the work. As per the terms of reference, the primary focus in 2016 was on Parsnip Reach, however, data were gathered elsewhere, across the watershed, as described in n **Section 3.0**.
2. Describe First Nations involvement and training (see **Section 2.2** for details) – Subtasks included:
   - Plan and budget for First Nations engagement to share in the mercury study, solicit participation in targeted and opportunistic sample collection and gather information on fish consumption.
   - Supply interested First Nations with 'fish sampling kits' containing all supplies needed for collection and preservation of fish tissues.
   - Train First Nations representatives on the proper handling, harvesting and storage of tissue samples.
   - Fund First Nations member efforts to collect fish as part of the 'targeted' fish sampling program (as part of Task 1) as well as opportunistically during community harvest events.
3. Scientific Study Implementation –This task focuses on Parsnip Reach and key reference lakes in 2016 (see **Section 3.0**). Target fish species and sample size are identified, as well as protocols for data analysis and reporting. Subtasks included:
   - Sample bull trout (*S. confluentus*) and lake trout (*S. namaycush*) from reference area(s) as well as other target species (e.g., lake whitefish [*C. clupeaformis*] and kokanee [*O. nerka*]) should the opportunity present itself. Liaise with Ministry of Forests, Lands and Resource Operations (FLNRO) ahead of sampling.
   - Coordinate gathering of and testing of tissues by the study team and those contributed by First Nations members and other opportunistic sampling events. Azimuth worked with other contractors, academia and government biologists to achieve this goal.
   - Conduct a creel survey to gather information on fish consumption patterns (e.g., locations, species, serving size, and serving frequency) to understand dietary exposure to mercury via fish consumption within the study area.
4. Ancillary tasks – the elements of this task (see **Section** Error! Reference source not found. for m ore details):
   - Continue to build on relationships established in 2015 to opportunistically collect samples (e.g., FLNRO).
   - Organize the collection, storage and analysis of fish tissue samples collected from all sources, including First Nations community representatives.
   - Apply for and receive a scientific collection permit that allows for regional sampling.
5. Work with the FWCP-Peace program manager to engage with Northern Health and the First Nations Health Authority. Keep them apprised of project related developments. Plan for a face-to-face meeting in 2017.

2.1. Overview of Plan for FWCP Action Plan Study

The project requires the collection and analysis of fish tissues for mercury concentration (over a maximum three-year period) from key species from the three major reaches of Williston Reservoir (Parsnip, Finlay, Peace and their main tributaries), Dinosaur Reservoir and reference lakes. As described in **Section 1.1,** data on fish mercury concentrations in the Williston-Dinosaur Watershed are limited (Azimuth 2015, 2016). Also, there have been many changes in reservoir ecology and fish population structure over this time, such as the large increase in the abundance of kokanee (Langston 2012). Altered food webs, changes in dietary relationships and possible geographic differences in mercury concentration of prey species will influence exposure to and bioaccumulation of mercury by fish and other organisms (as describe in **Section 1.4**). Thus, an understanding of ecology (life history, diet and trophic relationships) is also a vital component to this study.

To help address this, we also collected duplicate tissue samples (from most fish) for analysis of stable Carbon (C) and Nitrogen (N) isotopes. While this study element was not requested for, we strongly felt that the added value was worth the additional cost. Stable C and N isotopes will tell us about dietary relationships among fish species and help us understand the pathway of mercury exposure between species. This may also assist us in understanding the possible nature of geographic differences within the reservoir system and its key tributaries, if any.

Williston Reservoir is a large, complex aquatic system. Given its large size, it is reasonable to assume that different patterns of mercury concentrations could occur in the same species in different areas. Consequently, the entire reservoir and its tributaries were not considered one large, homogeneous environment. Fish may inhabit the reservoir proper, or may spend different amounts of time in or near stream mouths, migrate up rivers seasonally for food or for spawning, or may persist primarily within tributary streams themselves, only occasionally venturing into the reservoir. Because bioaccumulation of methylmercury is exclusively driven by diet (Hall et al. 1997), the location of the source of nutrients consumed over the life of the fish ultimately dictates its mercury concentration. Thus, we also set out to explore the importance of geography as a key component of this project. At this stage, we focused on select within-reach (i.e., comparing mercury concentrations among tributary streams within a reach) and among-reach (i.e., comparing Parsnip, Finlay and Peace) comparisons to gauge the importance of this factor.

Our plan for the FWCP Action Plan study is centered around four distinct sampling strategies, as follows:

1. *Core Reservoir Sampling* – Parsnip Reach was targeted in 2016. Opportunistic sampling of Finlay Reach took place in 2016, leveraging some partnership relationships. Sampling of Peace Reach, Parsnip Reach, Dinosaur Reservoir and possibly filling data gaps, are planned for 2017 – 2018. Further details are provided in **Section 2.3.1**.
2. *Reference Area Sampling* – We targeted two reference areas in 2016. A lake trout – lake whitefish system at Fraser Lake (Figure 1-1**Figure 1-1**) and a bull trout – kokanee complex in Thutade Lake in the upper Finlay River, above an impassable falls (i.e., no connectivity for fish from the reservoir). Sampling of Fraser Lake was an in-kind effort undertaken by Ian Spendlow and his team (FLNRO, including John Hagen of Hagen and Associates) on our behalf, while sampling of Thutade Lake was undertaken by Chu Cho Environmental.

3. *Partnership Program Sampling* – Targeted opportunistic sampling occurred in partnership with Ian Spendlow (FLNRO), John Hagen (Hagen and Associates) and Chu Cho Environmental (CCE), based in Tsay Keh Dene. These programs targeted bull trout in tributaries to Finlay Reach (FLNRO/Hagen) and in the reservoir itself (CCE). We were also able to acquire a limited number of fish samples from Dinosaur Reservoir in a collaborative program with Carleton University, Ottawa. There was minimal labour / disbursement cost for the collection of these samples. Details are provided in **Section 2.3.3**.
4. *Community-Led Sampling* – This strategy was truly opportunistic and was intended to be flexible and responsive/driven by community desires. We had hoped to acquire tissues from a possible range of events targeting food fisheries (e.g., Crooked River or others), local water bodies (e.g., McLeod Lake, Moberly Lake), fishing derbies (e.g., out of McKenzie) and other samples delivered to or acquired by our community partners in Tsay Keh Dene, McLeod Lake, Saulteau and West Moberly (CCE, 4 Evergreen and Northern Spruce) as a start. Further details on the success/challenges of this program are provided in **Section 2.3.3**.

Together, these four strategies were implemented in 2016 under the direction of Azimuth and executed by our study partners. We intend to build on and improve these aspects of sampling in 2017/2018.

Aspects of the program that were not required as part of the contract, but were executed in our study, include the following:

- We collected duplicate tissue samples from about 70% of fish collected for analysis of stable C and N isotopes. These were submitted to the University of New Brunswick SINLAB facility. This study element was an option in our proposal, so analytical costs were not included in the original budget. Pursuit of this option was discussed with the FWCP-Peace Region Manager and additional funds were approved by the FWCP-Peace Board to cover these extra costs.
- Fish age structures were collected from about 25% of all fish sampled. This study element was an option in our proposal, so analytical costs were also not included in the original budget. These were sent to North/South Consultants for ageing. Costs for adding this element were included in the additional funding discussed above.
- Analyses of selenium and total metals were also presented as options in our proposal. Consequently, several fish tissue samples were archived at ALS Environmental (Burnaby, BC) for analysis of selenium or total metals. Recent research has shown that selenium plays a role in reducing mercury toxicity, when it is present in higher abundance than mercury in fish tissue. While these samples were not analyzed in 2016, we will collect and archive tissue samples for selenium/metals analysis in 2017.

A more detailed description of the study design and approach to strategic and opportunistic sampling of the 2016 study area is provided in **Section 2.3**, with a results summary in **Section 3.0**.

2.2. First Nations Involvement and Training

This FWCP Action Plan study was designed to include and collaborate with the eight First Nations communities as part of the First Nations Working Group on this project. To that end, a substantial component of the program was explicitly dedicated to providing opportunities for First Nations to directly participate in this study. Several individuals from various First Nations communities collected fish tissue samples during each of the fish collection programs in 2016:

- Participating in a one-day fish mercury sampling training course delivered by Azimuth in Mackenzie prior to 2016 activities. Members from six First Nations received this training.
- Participating in fish mercury sampling activities from all target areas.
- Acting as 'Community Coordinators' within six of eight participating First Nations to opportunistically gather fish tissue samples during community led fishing activities.
- Acting as the community representative charged with gathering fish tissue samples and fish consumption information (i.e., creel survey) within their communities during course of the summer.

In addition to the direct involvement described above, collaborative efforts among Azimuth, the FWCP Peace Region Manager and the First Nations Working Group ensured that communities were alerted to opportunities to participate in the study (e.g., in fish sampling efforts or in providing information on fish consumption habits via the creel survey) and kept up to date on how the study was progressing through regular email communication

2.2.1. First Nations Engagement and Communication

While Azimuth had the responsibility of project and data management, all field collection activities were undertaken by our project partners, Environmental Dynamics Inc. (EDI), Prince George and Chu Cho Environmental (CCE), a wholly-owned First Nations consulting company based in Prince George and operating out of Tsay Keh Dene. We also partnered with two other First Nations owned companies (subcontracted to EDI). Northern Spruce Contracting Ltd., a McLeod Lake based First Nations contracting company with experience in fisheries research and 4 Evergreen Resources LP, a West Moberly based First Nations contracting company with experience working in the region.

Chu Cho Environmental was instrumental in collecting fish, participating in the targeted Parsnip Reach sampling event, opportunistic sampling on Finlay Reach, and the reference area sampling in Thutade Lake. There were two components to their work in Finlay Reach – opportunistic during routine dust monitoring on behalf of BC Hydro while on the reservoir and strategic targeting of tributary stream mouths along the reach. Strategic sampling of Thutade Lake to acquire bull trout, kokanee and rainbow trout (*O. mykiss*).

Environmental Dynamics Inc. (EDI) conducted the strategic 5-day survey of Parsnip Reach in collaboration with CCE, who provided a boat and operator and with members from McLeod Lake and Tsay Keh Dene. These individuals become well acquainted with the project and procedures followed to capture, process, log, and store fish tissue samples in a quantitative program.

EDI also conducted all fish sampling during the annual fishing derby on Parsnip Reach, sponsored by Duz Cho Logging. Azimuth assisted Duz Cho, acting as the recipient and adjudicator of fish size to determine the derby winner. Tissue samples and age structures were collected and submitted for mercury and stable isotope analysis and ageing.

John Hagen (Hagen and Associates), with First Nations assistants collected bull trout samples on our behalf in the Davis and Ingenika rivers, as part of Ian Spendlow's program (FLNRO).

Photo of a Davis River bull trout sampled using the project-supplied biopsy tools.

2.2.2. Supply Fish Sampling Kits

Fish sampling kits ("fish kits") were assembled to include all necessary equipment for scientific sampling. These kits were supplied to at least one representative from each of the six First Nations who attended the training session in Mackenzie on July 8, 2016. First Nations that received the fish kits included Doig River, Prophet River, McLeod Lake, Saulteau, Tsay Keh Dene and Nak'azdli. Additional sampling consumables were provided to supplement fish kits originally provided as part of the 2015 reconnaissance studies.

2.2.3. Training of First Nations in Tissue Collection for Scientific Purposes

A one-day training session was held in Mackenzie on July 8, 2016. Ten individuals from six First Nations (Doig River, Prophet River, McLeod Lake, Saulteau, Tsay Keh and Nak'azdli) attended. Attendees were trained to harvest fish tissue samples using traditional 'fillet' style and non-destructive 'biopsy' techniques from live fish using the fish kit materials. Training took place at the Morfee Lake park, just outside of town and was also attended by Environmental Dynamics and CCE. In addition, we conducted training on the objectives and methods of how to collect creel survey information from community members.

To facilitate the collection of fish tissues and creel survey information, each First Nation was provided with the Fish Kits and Standard Operating Procedures (SOP) documents developed for this project, to assist them with fish tissue collections and gathering creel survey information. These documents are provided in **Appendix A**.

Each of the people attending the training were acknowledged to be the Community Coordinators who would 'champion' the project and whose responsibility it was to gather fish tissue samples and creel information over the course of the summer.

2.3. Sampling Programs

This section addresses the implementation of the sampling component of this FWCP Action Plan study. The investigation targets lake trout, bull trout, lake whitefish, and kokanee, but also includes allowances for less intense sampling of other fish species (e.g., mountain whitefish, burbot and others). The basic methodology of the 2016 study followed the protocols laid out by Azimuth (2015) and is summarized below.

There is a well-known positive correlation between increasing size and age of fish and mercury concentration. This relationship is particularly strong for piscivorous species such as lake trout and bull trout and weaker for omnivorous species such as lake and mountain whitefish. This relationship may be very weak or not statistically significant for insectivorous (e.g., rainbow trout), planktivorous (e.g., kokanee) or lower trophic level species (e.g., peamouth, sucker) that consume low mercury prey.

In order to determine this relationship, it is necessary to collect a sufficiently large sample size (usually >25 – 35 fish) spread across as wide a size range as possible, from small (150 mm) to large fish (>800 mm) depending on the species. If this sample size and size distribution is acquired, a statistical relationship can be developed correlating fish size (length, weight), age (y) and mercury concentration (mg/kg or ppm). This study design has been used by Azimuth in BC in a variety of other fish mercury studies in British Columbia lakes and rivers (Pinchi Lake, Stuart Lake, Tezzeron Lake, Francois Lake, Seton Lake, Bridge River, Peace River) and reservoirs (Dinosaur, Carpenter, Downton, Falls River and others). This approach has also been used in Manitoba (e.g., Bodaly et al. 2007) and Quebec reservoirs (e.g., Schetagne et al. 2003).

While statistical testing for potential spatial or temporal differences in fish mercury concentrations are conducted using the size-mercury relationships directly, the results are often reported for a single fish size to facilitate communicating the results in a consistent way. The size chosen for each species is called the "standardized" size, and are usually consistent among studies (i.e., the standardized size for lake whitefish that is commonly used is 350 mm, 550 mm for bull trout and 600 mm for lake trout). These sizes are typically close to the size of fish most commonly consumed by people. Standardized sizes will be used in this study to report fish mercury concentrations when comparing among species, or when assessing spatial (e.g., between reaches of reaches and reference lakes) or temporal (e.g., 2000 vs 2016 data for Finlay Reach) trends.

In cases where it is unlikely that the whole size range of a fish species will be sampled (e.g., opportunistic or community sampling), we are implementing a strategy of trying to collect about 10 fish per species from within +/- 50 mm of the respective standardized size (e.g., 10 bull trout between 500 and 600 mm). This strategy reduces potential size-related bias in characterizing fish mercury concentrations and was used in 2016 for bull trout collections from several tributary streams in Finlay Reach. While not as informative as characterizing the whole size-mercury relationship, it can be a cost-effective way of gaining insights into potential spatial differences in fish mercury concentrations.

A brief outline of the study design approach is as follows:

- Strategic 2016 sampling focused on Parsnip Reach and two reference lakes: Fraser Lake, led by FLNRO and Thutade Lake, led by CCE. Opportunistic sampling of Finlay Reach (CCE, FLNRO, Hagen) and Dinosaur Reservoir (Taylor Ward, Carleton University, Ottawa).

- Principal study design followed the approach stipulated in Azimuth (2015) protocols where we attempted capture of 24 – 36 fish, over a range of sizes for each target species. Fewer fish are needed for species with a smaller overall size range (e.g., kokanee, mountain whitefish). Non-destructive biopsy sampling was preferentially applied to bull trout and lake trout. Whitefish and kokanee do not survive capture and handling well, so these were destructively sampled.
- In addition to mercury, Azimuth et al. collected duplicate tissue samples from a subset of tissues for analysis of stable Carbon (C) and Nitrogen (N) isotope data by SINLAB at the University of New Brunswick. These isotope ratios assist in determining trophic structure and provide insight on food web relationships among fish species. Normally, benthic invertebrates and zooplankton from reservoir stations are also collected to establish the 'baseline' C/N signature.
- Selenium or other metals were not measured in fish tissue in 2016. Some samples were archived in 2016 and this program element will likely be expanded in 2017.
- Ageing structures (otoliths) were acquired from a subset of fish – mostly from lethally sampled fish from the Mackenzie fishing derby. FLNRO also provided ageing structures for lake trout from Fraser Lake. Although outside the scope of work, all collected structures were aged by North/South Consultants, Winnipeg.
- The study team systematically sampled fish from Parsnip Reach (**Figure 2-1**) using short-set gill nets and angling. Gill netting used methods, like those employed by the Summer Profundal Index Netting or SPIN programs. SPIN uses 64 m monofilament gill nets made up of 8 panels of 57, 64, 70, 76, 89, 102, 114, and 127 mm mesh sizes, set for 2 hours. Net sets were adjusted according to results, with nets left in at increasingly longer durations when few fish were captured, while attempting to minimize mortality. The CCE boat electro-fisher was also used to target the lower reaches of the larger tributary rivers in shallow waters.

A more fulsome description of the methods employed during the strategic Parsnip Reach gillnetting effort (5 days), Finlay Reach opportunistic sampling (sporadic over months) and reference area sampling in Fraser Lake (FLNRO) and Thutade Lake (CCE) are described briefly in the following sections.

2.3.1. Strategic Program – Parsnip Reach

The goal of the Parsnip Reach Sampling Program, in conformance with the Azimuth (2015) protocols was to acquire 24 – 36 fish, over a range of sizes for four target species; lake trout, bull trout, whitefish and kokanee. Five days were allocated to the strategic Parsnip survey in the budget and this effort took place immediately after the August 20 – 21 Mackenzie fishing derby between August 22 and 26, 2016 inclusive. A full report from EDI describing the methods and basic fish capture statistics is provided in **Appendix B**. The text below is a brief summary of what is contained there. EDI received a scientific collection permit (*PG16-232536*) on June 10, 2016. This permit applied to all tributary streams connected with Parsnip Reach, as well as the reach itself and to Thutade Lake. A copy of the permit is provided in **Appendix C**.

Strategic Survey – The crew consisted of EDI, Northern Spruce and CCE. The principal fish capture method was pelagic monofilament gill net sets of 64 m length. Gill nets made up of 8 panels of 57, 64, 70, 76, 89, 102, 114, and 127 mm mesh sizes were used, similar to the SPIN nets used on Fraser Lake for the reference area (see **Section 2.3.2**). Nets were set at depths ranging from 5 to 20 m depth. Littoral, nearshore (<10 m) sets were also made using 16 m nets with 34 mm mesh panels. Gill nets were initially set for 2 hour durations; however soak times were generally extended later in the program to improve catch success. Angling/trolling was also used opportunistically between sets.

Fourteen gill net locations were established, primarily within the vicinity of the Nation River and Cut Thumb Bay, midway up the Parsnip Reach (**Figure 2-1, Appendix B**). The area around the confluence of the Parsnip River was investigated on Day 1, but the general area was relatively shallow with numerous submerged stumps and was not considered a good sampling location, particularly for lake trout. Sampling near Mackenzie was considered, but test sets captured non-target 'coarse' fish species (e.g., suckers, chub). The area around the Nation River and Cut Thumb Bay was targeted, based on comments from local residents at the fishing derby, early success at this location at the start of the program and the perceived likelihood of capturing kokanee moving into the Nation River system to spawn.

Fish handling and tissue sampling methods followed those identified in the Azimuth *Fish Tissue Collection & Recording Procedures* (2016) document (**Appendix A**). Non-destructive biopsy sampling was used for bull trout and lake trout; while lethal sampling was used for the other target species. Fillet samples were collected from rainbow trout, lake whitefish, mountain whitefish (*Prosopium williamsoni*), and burbot (*Lota lota*).

In addition, we collected whole body northern pikeminnow (*Ptychocheilus oregonensis*) and peamouth chub (*Mylocheilus caurinus*) for Carleton University. These fish are being analysed by Carleton University for genetics purposes. A tissue sample was collected and archived in the event there is a desire to explore mercury concentrations in other, lower food web species.

Tissue was collected from a total of 129 fish from the Parsnip Reach during the dedicated sampling program (**Appendix B**), consisting of 56 lake and mountain whitefish, 19 lake trout, 12 bull trout, 8 rainbow trout and 1 burbot. Non-target pikeminnow (13) and peamouth (20) were retained for use by Carleton University. Although kokanee were a target species, none were encountered. Note that not all of these fish were analysed for mercury, because of an abundance of fish within some size categories.

Despite 5 days on the water, we did not fulfill all numbers within the desired size intervals. Certain size classes were disproportionally abundant for lake trout (i.e., mostly large >700 mm) and whitefish (200 – 299 mm). This pattern was especially true from the fishing derby catch, where nearly all lake trout captured were quite large, which is not unexpected given the objective of the derby (biggest fish wins!).

Tissues were couriered to Azimuth for storage and handling prior to delivery of tissues to ALS Environmental, Burnaby for mercury analysis and to SINLAB at the University of New Brunswick, Fredericton for stable C and N analysis.

Fishing Derby – To augment fish for the Parsnip survey, EDI attended the Mackenzie fishing derby on August 20 and 21, 2016. More than 50 lake trout, many of them large fish, were weighted, measured, processed (filleted, age structure removed) and sampled for tissue. We also processed 1 bull trout and 1 burbot. These samples were also delivered to Azimuth with the Parsnip Reach fish. Not all fish from both efforts were analysed. Azimuth randomly selected fish from among these groups to represent the desired size classes. The remaining tissue samples are in archive at ALS, Burnaby.

2.3.2. Reference Area Fish Tissue Collections

Reference areas are defined as "pristine control locations unaffected by reservoir creation, and in areas of similar geology and geography." The Williston – Peace watershed is huge and finding a good reference area for bull trout – kokanee complex has been difficult. On the other hand, there are many nearby lakes with similar geography that provide good candidates for lake trout – lake whitefish complexes. We identified two candidate reference areas – Fraser Lake (lake trout – whitefish) and Thutade Lake (bull trout – kokanee) (**Figure 1-1**).

Fraser Lake (54 km^2, 30 m max depth) is at a very similar elevation as Williston Reservoir (within 30 m), within the same geoclimatic zone and latitude, but flows to the Fraser River. The lake was being targeted by FLNRO's efforts to monitor lake trout populations in the Omineca Region and Ian Spendlow (FLNRO) agreed to provide us with fish tissue samples from lake trout and lake whitefish. Methods for the stratified random gill net assessment followed the protocol outlined in Sandstrom and Lester (2009). SPIN sampling was conducted from August 3rd through August 8th, 2016. A total of 80 short-duration (2 hour) daytime gillnet sets were completed.

A total of 56 lake trout were captured with an average fork length of 552 mm (range 321-757 mm), of which 32 were lethally sampled and tissue samples harvested according to Azimuth (2015) protocols provided to FLNRO. Routine collection of age structures (otoliths), sex/maturity, length and weight was recorded from all fish samples. In addition, 20 lake whitefish were captured across the desired size range and provided to Azimuth. All tissue samples were received frozen and in good condition at the end of September. Fish tissue samples were checked against fish collection data sheets for Quality Assurance, data were entered digitally into excel and tissue samples were divided in half (i.e., for mercury and stable C/N analysis) and placed into separate Zip-Loc bags. In addition to the target species, we also received fillet samples from four burbot and eight mountain whitefish.

Thutade Lake (~ 50 km^2) situated in the headwaters of the Finlay River system (**Figure 1-1**) was the second reference area chosen, targeting bull trout and kokanee. It is isolated from the reservoir by the impassable Cascadero Falls. Although several hundred meters higher in elevation than Williston, it is obviously situated within the same watershed as Williston, which is an advantage, yet physically isolated from the upstream migration of fish from the reservoir. In addition, there are several years of recent fisheries data on this watershed related to baseline studies for the Kemess Mine expansion (Hatfield and Bustard 2017). Bull trout and kokanee tissue samples were collected in 2014 and 2015 by John Hagen, one of our study partners. Like Williston Reservoir, bull trout attain sizes of >800 mm in this lake, on a diet in which kokanee are a key component.

Thutade Lake was sampled on July 1, 2016 by CCE. A limited number of fish were captured using SPIN nets and angling, consisting of 7 rainbow trout (300 – 350 mm), 12 kokanee (205 mm – 240 mm) and 2 mountain whitefish (250 mm, 265 mm). The length frequency distribution was restricted to fish of a very similar size for each species. No bull trout were captured in 2016.

2.3.3. Opportunistic Sampling Efforts

Although the request for proposal stipulated that 2016 was primarily dedicated to Parsnip Reach, we sought opportunities to acquire fish tissue samples from elsewhere within the watershed, principally from leveraging off other working being conducted by our study team partners. As noted above, while CCE was engaged in other activities on Finlay Reach they captured and sampled fish on our behalf. During the summer, the following fish samples were collected on our behalf at the locations indicated in **Figure 2-2**. These were bull trout from Davis River (14), Chowika River (5), Swannell River (7), Ingenika River (10) an Osilinka River (3). In addition, several fish of other species were collected including 2 lake whitefish and 13 kokanee from Osilinka and 4 lake trout from Omineca.

In addition to fish from Finlay Reach, a small number of fish from Dinosaur Reservoir (**Figure 1-1**) near Johnson Creek were provided to Azimuth by Taylor Ward as part of his M.Sc. research at Carleton University. Tissues were limited to two lake whitefish, three mountain whitefish and six rainbow trout. We provided him with 20 peamouth and 9 longnose sucker (*Catostomus catostomus*) from southern Parsnip Reach, for archival and possible analysis for mercury.

2.3.4. Creel Survey Results

Creel survey information documenting locations fished, preferred (and non-preferred) species, approximate timing and frequency of fishing, and meal size data were gathered from some members of the Tsay Keh Dene and the Saulteau / West Moberly First Nations. Raw data were received from the communities and were used to generate general trends in fish consumption patterns and locations.

In Tsay Keh Dene, eight people were interviewed on 21 September by the CCE community representative. The species reported most being consumed were bull trout (all people), with a couple of people indicating they ate rainbow trout and burbot. One individual consumed steelhead and spring salmon, but these were from the Pacific drainage. The most common locations indicated fish were captured from Pesika Creek, a lower tributary to the Finlay River and the Chowika and Mesilinka rivers. The frequency of fish consumption would be regarded as infrequent, with most people indicating episodic consumption with large meals being consumed within the week of fish capture. To get a better picture of consumption patterns here, we need to speak to more people and get more detailed information, if possible. We do not know if non-fish eaters were included in this log.

In the Saulteau and West Moberly First Nations communities, our representative here interviewed 13 people. According to records, the most commonly consumed fish species was 'jackfish' or northern pike (*Esox lucius*) with 10 of 13 people indicating that they consumed this species, mostly taken from Moberly Lake. The next most frequently consumed fish species were ling or burbot (7 people), lake whitefish (5 people), lake trout (5 people), rainbow trout (4 people), Arctic grayling (2 people) and 'sucker' (1 person). Two people also indicated that they consumed store bought tuna and halibut.

Fish were captured from a wide variety of locations, with Moberly Lake being most frequently mentioned. Following this, the most commonly mentioned fishing locations / lakes were Jackfish Lake, the Pine River (a large tributary to the Peace), Charlie Lake (a moderate size lake 8 km west of Ft. St. John), Cameron Lake (flows south into Moberly Lake), Carbon Lake (outflow to Carbon Creek and then north to Peace Reach), and Boucher Lake (a small headwater lake on the north fork of the Moberly River). A few respondents indicated that they also fished on Williston and Dinosaur Reservoirs. On the other hand, at least one respondent indicated that they would eat 'nothing attached to Williston Reservoir'. Thus, most of the fishing locations are fairly local and for the most part, connected to the Moberly River watershed or Peace River/Peace Reach.

With respect to the number of fish captured per year, there was a wide range reported, but there was a consistent response with respect to the frequency of consumption in terms of meals per week. The number of fish captured annually ranged from a low of 10 – 15 with most reporting between 40 and 100 fish per year. Three respondents reported capturing more (175, 200, 285), however these people also reported sharing these fish with family members within the community.

In general, the majority of people who were interviewed reported eating fish about once per week (8/13). Only two people reported eating fish twice a week, while one person reported eating fish about once per month. Two people mentioned that their fish consumption was more 'episodic' and would occur during a fishing event when a large amount would be consumed, but not regularly. Thus, the frequency of consumption seemed to be on average about one meal per week with a seasonal pattern.

Most people reported fishing on a seasonal basis, with most fish captured during open water (May to September). Five of 13 respondents reported that they fish under the ice in January/February and mostly for ling cod.

Further creel data will be collected in 2017 and 2018 to better understand fish consumption patterns. At this time, it appears that in at least two communities, fish are consumed about once a week and mostly during the open water season – although some winter fishing occurs. There is a diverse range of species, depending on the community but relatively few fish are taken directly from Williston Reservoir itself. Whether this is due to its perception as having fish with high mercury concentrations, or difficulty accessing and traveling on the reservoir, is not known.

Table 2-1. Detailed (top: by species, waterbody, reach, area, and program) and summary (bottom: by program) sources of fish tissue samples for 2016.

Year	Species	Waterbody	Reach	Area	Program	N
2016	LKTR	Williston Res	Parsnip Rch	Parsnip Rch	Parsnip Derby	48
2016	LKTR	Williston Res	Parsnip Rch	Parsnip Rch	Targeted	19
2016	LKTR	Williston Res	Finlay Rch	Omineca River	Opportunistic	4
2016	LKTR	Fraser Lk	Fraser Lake	Fraser Lake	In-Kind FLNRO	32
2016	BLTR	Williston Res	Parsnip Rch	Parsnip Rch	Parsnip Derby	1
2016	BLTR	Williston Res	Parsnip Rch	Parsnip Rch	Targeted	12
2016	BLTR	Williston Res	Finlay Rch	Ingenika River	In-Kind FLNRO	10
2016	BLTR	Williston Res	Finlay Rch	Davis River	In-Kind FLNRO	14
2016	BLTR	Williston Res	Finlay Rch	Swannell River	Opportunistic	7
2016	BLTR	Williston Res	Finlay Rch	Chowika Creek	Opportunistic	5
2016	BLTR	Williston Res	Finlay Rch	Osilinka River	Opportunistic	3
2016	LKWH	Williston Res	Parsnip Rch	Parsnip Rch	Targeted	47
2016	LKWH	Dinosaur Res	Dinosaur Res	Johnson Creek	In-Kind OTHER	2
2016	LKWH	Fraser Lk	Fraser Lake	Fraser Lake	In-Kind FLNRO	20
2016	KOKA	Williston Res	Finlay Rch	Osilinka River	Opportunistic	13
2016	KOKA	Thutade Lk	Thutade Lake	Thutade Lake	Targeted	12
2016	MNWH	Williston Res	Parsnip Rch	Parsnip Rch	Targeted	9
2016	MNWH	Dinosaur Res	Dinosaur Res	Johnson Creek	In-Kind OTHER	3
2016	MNWH	Fraser Lk	Fraser Lake	Fraser Lake	In-Kind FLNRO	8
2016	MNWH	Thutade Lk	Thutade Lake	Thutade Lake	Targeted	2
2016	RNBW	Williston Res	Parsnip Rch	Parsnip Rch	Parsnip Derby	1
2016	RNBW	Williston Res	Parsnip Rch	Parsnip Rch	Targeted	8
2016	RNBW	Williston Res	Peace Rch	Table Creek	In-Kind OTHER	1
2016	RNBW	Dinosaur Res	Dinosaur Res	Johnson Creek	In-Kind OTHER	6
2016	RNBW	Thutade Lk	Thutade Lake	Thutade Lake	Targeted	7
2016	BURB	Williston Res	Parsnip Rch	Parsnip Rch	Targeted	1
2016	BURB	Fraser Lk	Fraser Lake	Fraser Lake	In-Kind FLNRO	4
2016	LNSC	Dinosaur Res	Dinosaur Res	Johnson Creek	In-Kind OTHER	9
2016	PMCH	Dinosaur Res	Dinosaur Res	Johnson Creek	In-Kind OTHER	20

Year	Program	N
2016	In-Kind FLNRO	88
2016	In-Kind OTHER	41
2016	Opportunistic	32
2016	Parsnip Derby	50
2016	Targeted	117

Table 2-2. Sample sizes for mercury (Hg), stable isotopes analysis (SIA), metals, and age by species, waterbody, reach, and area for measured (top) and archived (bottom) samples for 2016.

Year	Species	Waterbody	Reach	Area	Archived	Hg	SIA	Metals	Age
2016	LKTR	Williston Res	Parsnip Rch	Parsnip Rch	No	42	36	0	28
2016	LKTR	Williston Res	Finlay Rch	Omineca River	No	4	0	0	0
2016	LKTR	Fraser Lk	Fraser Lake	Fraser Lake	No	32	21	0	32
2016	BLTR	Williston Res	Parsnip Rch	Parsnip Rch	No	13	5	0	1
2016	BLTR	Williston Res	Finlay Rch	Ingenika River	No	10	6	0	9
2016	BLTR	Williston Res	Finlay Rch	Davis River	No	14	11	0	12
2016	BLTR	Williston Res	Finlay Rch	Swannell River	No	7	7	0	0
2016	BLTR	Williston Res	Finlay Rch	Chowika Creek	No	5	5	0	0
2016	BLTR	Williston Res	Finlay Rch	Osilinka River	No	3	3	0	0
2016	LKWH	Williston Res	Parsnip Rch	Parsnip Rch	No	24	24	0	0
2016	LKWH	Dinosaur Res	Dinosaur Res	Johnson Creek	No	2	2	0	0
2016	LKWH	Fraser Lk	Fraser Lake	Fraser Lake	No	20	20	0	0
2016	KOKA	Williston Res	Finlay Rch	Osilinka River	No	13	5	0	0
2016	KOKA	Thutade Lk	Thutade Lake	Thutade Lake	No	12	12	0	0
2016	MNWH	Williston Res	Parsnip Rch	Parsnip Rch	No	9	9	0	0
2016	MNWH	Dinosaur Res	Dinosaur Res	Johnson Creek	No	3	3	0	0
2016	MNWH	Fraser Lk	Fraser Lake	Fraser Lake	No	8	8	0	0
2016	MNWH	Thutade Lk	Thutade Lake	Thutade Lake	No	2	1	0	0
2016	RNBW	Williston Res	Parsnip Rch	Parsnip Rch	No	9	9	0	0
2016	RNBW	Williston Res	Peace Rch	Table Creek	No	1	1	0	0
2016	RNBW	Dinosaur Res	Dinosaur Res	Johnson Creek	No	6	6	0	0
2016	RNBW	Thutade Lk	Thutade Lake	Thutade Lake	No	7	3	0	0
2016	BURB	Williston Res	Parsnip Rch	Parsnip Rch	No	1	1	0	0
2016	BURB	Fraser Lk	Fraser Lake	Fraser Lake	No	4	4	0	0
2016	LNSC	Dinosaur Res	Dinosaur Res	Johnson Creek	No	9	8	0	0

Year	Species	Waterbody	Reach	Area	Archived	Hg/SIA/Metals	Age
2016	LKTR	Williston Res	Parsnip Rch	Parsnip Rch	Yes	25	11
2016	LKWH	Williston Res	Parsnip Rch	Parsnip Rch	Yes	23	0
2016	PMCH	Dinosaur Res	Dinosaur Res	Johnson Creek	Yes	20	0

Figure 2-1. Parsnip Reach and its main tributaries.

Version Date: 28 March 2017

Legend

- FN Communities
- BC Towns
- 1:250K Water
- Watershed Boundary

0 10 20 30 km

Data Sources

NRC - DEM, topo layers
GeoBC - Place names
Azimuth - station locations

Projection: UTM 10 NAD83

Williston-Dinosaur Watershed Fish Mercury Investigation

AZIMUTH

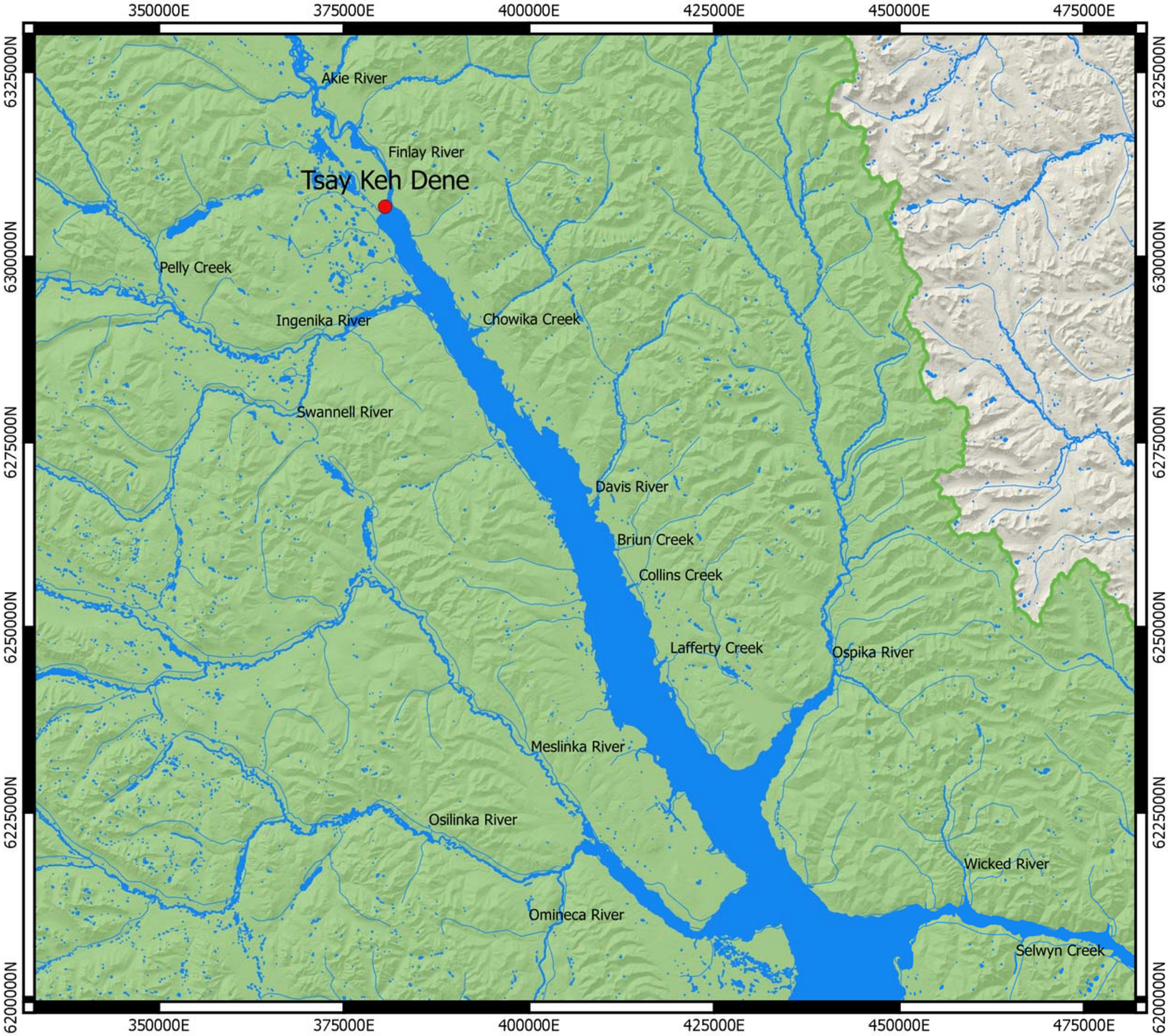


Figure 2-2. Finlay Reach and its main tributaries.

Version Date: 30 March 2017

Legend

FN Communities

Reservoir Sampling

Reference Lakes 2017

1:250K Water

Watershed Boundary

0 10 20 30 km

Data Sources

NRC - DEM, topo layers
GeoBC - Place names
Azimuth - station locations

Projection: UTM 10 NAD83

Williston-Dinosaur Watershed Fish Mercury Investigation

AZIMUTH

3. PRELIMINARY FISH MERCURY ANALYSIS

3.1. Preliminary Analysis Approach

As described in **Section 2.1**, the 2016 program represents the first year of a multi-year endeavor to characterize fish mercury concentrations within the Williston - Dinosaur Watershed. This is a large, complex watershed and monitoring efforts are focused on obtaining data within the reservoir on a per-reach basis (i.e., separate data for Parsnip Reach, Finlay Reach, Peace Reach, and Dinosaur Reservoir), as well as significant tributary streams. The focus of the 2016 program was on the Parsnip Reach, with opportunistic sampling efforts conducted on Finlay Reach. At this stage, the intent was to assess existing data to develop a preliminary understanding of fish mercury concentrations in the watershed (e.g., by comparing results within Williston [between/among reaches] and between Williston and reference lakes). A secondary objective was to identify data gaps for future work to be carried out in 2017 and 2018.

This 2016 report is strictly a 'Data Report.' While efforts were made in this report to summarize the existing data (tables) and visualize trends (plots), we will not attempt to fully explore the dynamics of mercury in the reservoirs. Finally, this report does not assess implications of the current results with respect to potential risks to ecological receptors or to human health. That will only be conducted once all data have been collected and we have a full understanding of mercury dynamics within Williston Reservoir Watershed. As noted above, we did not put 'red lines' or depict mercury guideline concentrations on to figures because this is not an actual representation of any level of health risk.

3.1.1. *Quality Assurance/Quality Control (QA/QC)*

Field QA/QC

The fish sampling SOP (**Appendix A**) was developed to ensure that data quality objectives were met throughout the study. Randy Baker, a senior mercury scientist from Azimuth was involved throughout the program and provided guidance and oversight of all scientific collection programs. EDI was responsible for direct supervision of field staff during the strategic study of Parsnip Reach under the direction of Tim Antill, a senior ecologist. Proper field protocols were followed at all times, with fish tissue sample being processed using 'clean' techniques such as frequent change of gloves, keeping the work space clean and ensuring no cross-contamination of tissue. New biopsy tools were used for each live fish that was biopsied. Tissue samples were placed into unique vials or bags marked with indelible ink. Tissues were then placed on ice and frozen at the end of the day. Tissues were kept frozen until they were sent to Azimuth for logging and processing where they were maintained in a single location until shipping to the laboratory for analysis.

In most field programs, a subset (typically on the order of 10%) of field duplicate samples are collected and submitted 'blind' to the laboratory for analysis. This would be a second piece of muscle tissue for mercury analysis from a sacrificed fish to measure precision by the laboratory. Because many small volume 'biopsy' or fillet samples were collected, there was insufficient tissue mass to split the samples, so this was not done in 2016. However, we have targeted this as a quality assurance data gap that will be filled during future sampling events.

Laboratory QA/QC

In addition to analysis of blind field samples, the laboratory also randomly choses a subset of tissues, where sufficient mass exists, to conduct a 'laboratory duplicate' analysis. This is a 'self-test' of laboratory precision and this is typically done on each 'run' of samples. In addition, the lab also tests Certified Reference Material (CRM) during each run. CRM consists of tissue with a known concentration of mercury. These are inserted into the batch for analysis to determine how close the lab result is to the CRM concentration. The acceptable limits for field and laboratory duplicates and CRM is +/- 30% either side of the 'true' value. Values that lie outside of these values are flagged.

Results of field and laboratory duplicates were assessed using the relative percent difference (RPD) between measurements. The equation used to calculate a RPD is:

$$RPD = \frac{(A-B)}{[(A+B)/2]} \times 100$$

where: A = analytical result; B = duplicate result. Note that a duplicate can be a laboratory duplicate or a field duplicate and this is specified with the data.

The laboratory data quality objectives (DQOs) for this project was analytical precision of 30% RPD concentrations that were 10x in excess of the laboratory detection limit (DL). Note that RPD values may be either positive or negative, and ideally should provide a mix of the two, clustered around zero. Consistently positive or negative values may indicate a bias. Large variations in RPD values can be seen when the concentrations of analytes are very low and near the DL.

Otolith samples were analyzed for age by North South Consultants, Winnipeg. All personnel involved in the sample processing and analyses had appropriate training. Quality control and quality assurance was conducted by an alternate (different from the original) ageing technician on 10% of randomly selected structures. All readings were conducted as "blind" (independent from each other). Results of these QA measures are reported in the results section.

Data Analysis QA/QC

As per the SOP (**Appendix A**), reliable sample tracking, logging, and data recording were documented to establish continuity between the sample collected and the results reported. Raw fish data were entered into excel and are available upon request; the entire database will be published after the next two years of data.

The initial stages of the data analysis work flow involved ensuring that there were no obvious outliers (e.g., transcriptional errors) in the data set. The initial step for all analyses was to simply plot the data. Any data not conforming to the general pattern observed in the plot were double checked for verification.

Rather than excluding outliers (i.e., for verified data) at this stage, any suspect data were flagged and clearly identified in subsequent steps (e.g., the outlier sample in a length-weight plot would be highlighted in the length-mercury plot). This approach provides flexibility for future detailed statistical analyses to be completed.

3.1.2. Feeding Relationships and Fish Mercury Concentrations

Fish acquire mercury almost exclusively via diet over the course of their life (Hall et al. 1997). Thus, dietary items and food web structure has a strong influence on how much mercury is accumulated and stored within the muscle tissue of fish over time. The amount of mercury accumulated depends on fish species, fish size, age and of course, dietary preference – which is driven by where a fish eats, what a fish eats and how much. Small, young fish that consume plankton or insects will have less mercury than large, old, predatory species at the top of the food chain (**Section 1.4**). One way of determining the food web relationship and 'trophic position' of an organism is to measure the ratios of stable carbon and nitrogen isotopes ($\delta^{15}N$ and $\delta^{13}C$ respectively) in its muscle tissue (i.e., stable isotopes analysis; SIA). Nitrogen isotopes ($\delta^{15}N$) have been used as a means of determining the trophic position (i.e., where it sits within the food chain) of consumers in aquatic systems (e.g., Vander Zanden and Rasmussen 2001, Herwig et al. 2004). Increasing stable nitrogen content in fish tissue indicates an increasing position in the food chain. For example, the nitrogen 'signature' in a mature lake trout that consume other fish will be higher than a rainbow trout or whitefish that feed on plankton, which are at a lower trophic level.

Carbon isotopes ($\delta^{13}C$) trace the flow of 'energy' (and therefore, mercury) through food webs and can help distinguish whether fish feed on or near the bottom (e.g., benthic food chains), in the water column (i.e., pelagic food chains) and dietary preferences (e.g., plants, invertebrates, fish) of different species (e.g., Hecky and Hesslein 1995, Herwig et al. 2004). Together, the concentrations of stable nitrogen ($\delta^{15}N$) and carbon ($\delta^{13}C$) isotopes and their ratio relative to each other allow us to understand trophic structure, based on dietary preferences. This information sheds valuable light on observed patterns in contaminant concentrations, such as mercury, through the food web (Cabana and Rasmussen 1994, Cabana et al. 1994, Kidd et al. 1999). This is particularly important in Williston Reservoir because of changes in fish community structure in this system since reservoir creation. Stable isotope results will help us shed light on why mercury concentrations may be higher or lower in different parts of the reservoir and its tributary streams within species, or between the reservoir and other lakes.

The SIA results presented herein are based on raw $\delta^{15}N$ and $\delta^{13}C$ results only; corrections for baseline $\delta^{15}N$ (used to adjust for differences in base $\delta^{15}N$ values among watersheds [Vander Zanden and Rasmussen 2001]) and lipid-related bias to $\delta^{13}C$ (typically only done in high-lipid samples [Post et al. 2007], such as eggs) were not conducted. That is, we did not sample SIA in benthic invertebrates and zooplankton, which provide the 'foundation' of SIA signatures in different lakes. Thus, SIA results are used here to provide more general insights into feeding relationships among the species to put mercury results into context. The focus to date has been 'fish only' for both these tools. Expanding both SIA and mercury analysis further down each food chain (i.e., to include more elements of the ecosystem) would help to better understand the key drivers behind the observed fish mercury concentrations, but would require considerably more resources to implement. This has not been conducted to date, as our resource allocation strategy has been to first characterize fish mercury concentrations in Williston Reservoir and select reference areas.

Further use of SIA and mercury analysis has always been an integral part of our "tool box" (presented as an option in our original proposal) and will be recommended for implementation later in the program if the information is deemed critical to decision making.

3.1.3. Assessment of Key Species

As stated above, the intent of this preliminary analysis is to develop an initial, broad-brush understanding of fish mercury concentrations in key species – bull trout, lake trout, lake whitefish and kokanee, in the Williston – Dinosaur Watershed and to identify key data gaps to guide the study forward. The species-specific analysis centers on characterizing the length[1]-mercury relationship within each species to determine if we can distinguish geographic differences, such as between different reaches within the reservoir, or between Williston and reference lakes. The ideal characterization for each species is based on a data set that spans the range of size classes present (e.g., between <200 mm and 400 mm+ for whitefish), with 5 – 7 samples gathered within each 50-mm length increment (n=30). Inferences regarding spatial differences in the length-mercury relationship require separate data for each area. Key steps involved in this preliminary analysis for each species were as follows:

- *Catch Data and Meristics* – Data sets were limited to recently collected samples only (2016 for most species; 2015 and/or 2014 were added for some). Catch data tables (i.e., number of fish per age class), length frequency plots, age frequency plots and summary statistics (sample size, range and mean) of key meristic (i.e., length, weight, condition, age) data were prepared to compare results among areas of interest. Length-weight and age-length relationships (where available) were plotted to visualize the underlying biological relationships and to identify potential outliers. Emphasis was placed on identifying key gaps (e.g., missing or under-represented size classes) in the data sets.
- *Mercury-related Relationships* – Scatterplots depicting the relationship between length and mercury concentration (mg/kg or parts per million [ppm] wet weight) were used to visualize patterns both within-Williston (e.g., within or among reaches) and between Williston Reservoir and the two reference lakes, Fraser Lake and Thutade Lake. Similar to the meristic plots, outliers were identified and flagged, but retained for now. While no formal statistical modelling has yet been used to test for spatial differences, obvious patterns were noted. Stable isotope results ($\delta^{15}N$-mercury and length-$\delta^{15}N$ relationships) were used to help provide some ecological context for interpreting patterns in fish mercury concentrations.
- *Data Gaps* – key gaps were summarized to aid in planning upcoming (i.e., 2017 or 2018) sampling programs.

[1] Weight and age are also generally correlated with mercury concentrations. However, both variables typically have higher variability, making them less useful when testing for differences in the mercury relationship between areas.

3.2. Data Quality Results

As per the SOP and communication between Azimuth and our study team members, data quality was assured through good communication, reliable sample tracking, logging and data recording. These were documented to establish continuity between the sample collected and the results reported. In addition to the detailed SOP, the primary QA method in the field involved the completion of data sheets, which served as a check that all required information was being collected. Length and weight data collected in the field were entered electronically, double checked and plotted against each other. The initial stages of the data analysis work flow involved ensuring that there were no obvious outliers (e.g., transcriptional errors) in the data set. The initial step for all analyses was to simply plot the data. Any data not conforming to the general pattern observed in the plot were double checked for verification. Three outliers were identified in the lake whitefish data set, where either weight was correct and length was too low, or length was correct and weight was too low (due to a reading error in the field). Without knowing the correct answer and rather than exclude outliers at this stage, suspect data points were flagged and clearly identified in subsequent steps (e.g., the outlier sample in a length-weight plot are highlighted in the length-mercury plot). This approach provides flexibility for future detailed statistical analyses to be completed.

The laboratory reported quality control data were examined for each of the six sets of data submitted to ALS for moisture and mercury analysis from Parsnip Reach (strategic survey fish and derby captured fish), Finlay Reach, Dinosaur Reservoir, Thutade Lake and Fraser Lake. RPD values were calculated for all field duplicate moisture and mercury analyses as well as laboratory duplicates. Acceptability of laboratory RPD values are +/- 30, the same for field duplicates or CRM tissue. Following is a summary of results.

- Parsnip strategic survey fish – The RPD value of laboratory duplicates was <4 in all 4 samples and 89 – 96% recovery of CRM.
- Parsnip derby fish – The RPD value of laboratory duplicates was <3 in two samples but was 27 in one sample which is still below the acceptable limit of 30. Recovery of CRM samples was 89 – 99%.
- Finlay Reach – All tissues collected were biopsies so there are no field replicate samples. RPD values of CRM tissues ranged from 91 – 110%, well within acceptable limits.
- Dinosaur Reservoir – A single duplicate sample had an RPD of 12; RPD values of CRM ranged from 89 – 97%.
- Thutade Lake –No field duplicates were collected or analyzed. RPD values of 4 CRM samples ranged from 80 – 96%.
- Fraser Lake – RPD values were <2 for 3 of 4 field duplicate samples with one sample at 7. RPD values of 8 CRM samples ranged from 89 – 96%

In summary, DQOs for analysis of mercury and moisture for this project were met.

Regarding analyses of stable carbon and nitrogen isotopes (SI) by SINLAB, no deviations from laboratory DQOs were reported. Some minor discrepancies arose due to labeling errors in the field. Of the 288 fish

> **Key Aquatic Food Chains**
>
> **PELAGIC**
>
> ORIGINATING IN THE WATER COLUMN. PRIMARY PRODUCTION CONDUCTED BY PHYTOPLANKTON (SMALL PLANTS IN THE WATER). ZOOPLANKTON FEED ON PHYTOPLANKTON AND ON EACH OTHER. FISH FEED ON ZOOPLANKTON AND EACH OTHER.
>
> **BENTHIC**
>
> ORIGINATING ON THE LAKE BOTTOM. MAIN ENERGY SOURCES COME FROM DECOMPOSITION (BACTERIA BREAKING DOWN ORGANIC MATTER), SCAVENGING AND PRIMARY PRODUCTION (CONDUCTED BY ALGAE LIVING ON THE SEDIMENT). BENTHIC INVERTEBRATES FEED ON DECAYING ORGANIC MATTER, BACTERIA, ALGAE, AND ON EACH OTHER. BOTTOM-FEEDING FISH EAT INVERTEBRATES, ALGAE, DECAYING ORGANIC MATTER, AND EACH OTHER. HATCHING INSECTS, WHICH SPEND MOST PART OF THEIR LIFE CYCLE IN THE SEDIMENTS, ARE ALSO PREYED ON BY SURFACE-FEEDING FISH.

tissues submitted for analysis of stable carbon and nitrogen isotopes, two samples were not analysed by the lab because the lab judged the tissue integrity of the biopsy sample as poor. One sample was listed as a mountain whitefish on the chain-of-custody (COC) form, but was labeled as a lake whitefish on the container. Four samples were listed on the COC but were not received by the lab. It is likely that it was determined that to provide sufficient tissue for mercury analysis, the SI tissue was combined for Hg analysis, but empty vials were inadvertently sent.

With respect to fish aging, four lake trout and three bull trout otoliths were randomly chosen and re-aged. Of the seven, two had the same result, three were within 1 year, one was within 2 years and one was within 3 years of the original count. All differences of one year or more were for fish >10 years of age. According to North/South Consultants, fish are reliably aged +/- 1 year when <10 years of age and +/- 2 – 3 years when >10 years of age. Most ageing structures were rated as of 'Fair' quality – where most structures are relatively easy to read, but in older fish, there are some easy and moderately difficult interpretations. Given the large age of bull trout and lake trout, the DQOs for this aspect were met.

Overall, the DQOs for this project were met. We will continue to work with our study team partners to ensure that the collection, logging, transcription and storage of samples maintain a high standard.

3.3. Results for Feeding Relationships and Mercury Concentrations

As discussed in **Section 1.4**, tissue mercury concentrations are generally higher in large carnivorous fish feeding at the top of the food chain, such as lake trout and bull trout, relative to fish feeding at lower trophic levels, such as whitefish and rainbow trout. SIA was used to help understand feeding (trophic) relationships among key fish species. SIA results for fish caught in 2015 or 2016 are shown by species and waterbody in **Figure 3-1**. As discussed in **Section 3.1.2**, higher $\delta^{15}N$ values indicate a higher trophic position and the $\delta^{13}C$ values help to distinguish the origin of the energy flow path or the essential nature of where nutrients are gathered by individual fish within the environment (e.g., pelagic, benthic or terrestrial). There are three apparent groupings of species across the three waterbodies:

- *Top Predators* – Lake trout, bull trout and burbot are situated in the upper middle of the plot, as expected given their life history and dietary preference. Their $\delta^{15}N$ values range from approximately 12 to 14 and are clearly higher than the other species. Their $\delta^{13}C$ values range from -33 to -28, suggesting a reliance on both the pelagic-driven (more negative value) and benthic-driven (less negative value) food chains.

- *Pelagic Pathway Feeders* – Kokanee and lake whitefish typically feed on pelagic or water column zooplankton. As such both species are situated in the middle left zone of the plot in close proximity. The lower $\delta^{15}N$ and $\delta^{13}C$ values suggest that they are feeding more directly on the pelagic phytoplankton-to-zooplankton-to-fish pathway. Interestingly, mountain whitefish, which are normally more associated with the benthic pathway feeders, appear to be associated with the pelagic pathway in Williston; this may be an actual feeding shift, possible species misidentification (i.e., lake whitefish vs mountain whitefish) or hybridization.
- *Benthic Pathway Feeders* – Mountain whitefish and rainbow trout are situated in the lower right of the plot. Notwithstanding the results for Williston Reservoir, mountain whitefish are typically bottom feeders, which is consistent with the Fraser Lake and Thutade Lake results. Rainbow trout feed on a range of prey, including hatching insect larvae, which spend most of their life residing in the sediment and invertebrates with terrestrial origins (e.g., flies, spiders).

The SIA results provide a generalized conceptual understanding of "who is eating who" among the fish species. Based on the results described above, we would anticipate (see **Section 3.1.2** for general discussion) that the top predators have the highest mercury concentrations within their respective waterbodies.

Results of recent (2014 to 2016) fish mercury sampling programs are shown in **Figure 3-2**. Note that there is a wide range in mercury concentrations within each species. This is a reflection of the wide variation in body size (length, weight) and age, with small, young fish having lower concentrations and large, old fish having higher concentrations. As expected, lake trout, bull trout and burbot (limited data) consistently have the highest mercury concentrations among the species sampled. Lake whitefish, strongly identify within the pelagic food web in both Williston Reservoir and Thutade Lake (**Figure 3-1**), which explains the great similarity in mercury concentrations for this species among waterbodies. Similarly, mountain whitefish and rainbow trout – which also had similar isotopic ratios as described above, also have a similar range and magnitude in mercury concentration. Notwithstanding some differences in fish size captured between Williston Reservoir and Fraser and Thutade reference lakes, the range and magnitude of mercury concentrations was fairly similar among Williston Reservoir and reference area lakes for most species.

Interestingly, the largest apparent differences in mercury concentrations between fish caught in Williston Reservoir and the two reference lakes (Fraser and Thutade lakes) occurred for kokanee and mountain whitefish. This suggests that mercury concentrations in organisms at the base of both the pelagic and benthic food chains may be higher in Williston Reservoir than in the two reference lakes. While these differences are less pronounced or apparently absent in the top predators, caution must be used in interpreting mercury results without considering the size of the fish caught. Consequently, results of individual species are presented in the next section.

3.4. Results for Key Fish Species

3.4.1. Lake Trout

Catch Results and Meristics *(***Figure 3-3*** and* ***Figure 3-4****)*

The 2016 program focused on Williston's Parsnip Reach and Fraser Lake (reference area); a few additional fish were collected from Finlay Reach. Most of the Parsnip Reach lake trout samples came from the Duz Cho fishing derby, resulting in good numbers, but with a high bias towards larger size fish (>700 mm) and relatively few less than this size. Lake trout catch results by size class for 2016 are show below:

Year	Type	Waterbody	Reach	N	100-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900	901-1000
2016	Reference	Fraser Lk	Fraser Lake	32	0	0	6	5	8	10	3	0	0
2016	Williston	Williston Res	Parsnip Rch	42	0	0	2	2	1	3	16	15	3
2016	Williston	Williston Res	Finlay Rch	4	0	0	0	0	0	1	3	0	0

The length-frequency plot clearly shows the lack of smaller lake trout and preponderance of large lake trout collected from Parsnip Reach, relative to a more complete and even size distribution from Fraser Lake. While all 32 of the Fraser Lake fish were aged, only 28 of the 48 fish from Williston were aged. This is partly due to circumstance (e.g., non-lethal sampling in Finlay Reach) or to limited resources. Because so many large fish were captured in the Derby, only some above 700 mm were analysed for mercury (the remainder were archived). Regardless, given the narrow size range for lake trout in Parsnip Reach, the 28 age samples provided a good characterization of the 700 to 900 mm size classes and are not a limitation.

The age range of fish from Parsnip and Fraser lakes was similar, with a maximum age of 32 and 28 years, respectively (**Figure 3-3**). Despite the relatively greater abundance of larger size fish captured from Parsnip Reach, the age range of these fish (12 -22 years) was similar to the range of large fish from Fraser Lake. This may suggest that growth rates of lake trout in Parsnip Reach are higher than that from Fraser Lake, achieving a greater size at a similar age than Fraser Lake fish.

The length-weight relationship for lake trout was strong and without outliers; data from Williston and Fraser Lake appeared to show a consistent trend (despite disparate size classes sampled from each), suggesting that while growth rates may differ, the general patterns of the growth are similar. While the age (and size) data were somewhat limited, those data available suggest faster growth rates in lake trout from Parsnip Reach relative to Fraser Lake. The latter is important as faster growth has been shown to result in lower mercury concentrations. This is a phenomenon known as 'growth dilution'. Young fish and fish with faster growth rates are more efficient at converting food into biomass and will have a proportionally lower rate of accumulation of mercury than old, slow growing fish that eat, but don't gain mass. Rapid growth causes a 'dilution' of mercury in body tissues (Simoneau et al. 2005). Similarly, fish with low condition factor (i.e., lower body mass to length) will also have a higher rate of mercury accumulation and is related to reverse growth dilution (e.g., Cizdziel et al. 2002).

Mercury-Related Relationships *(***Figure 3-4****)*

The length-mercury relationship plot shows similar mercury concentrations between Williston Reservoir and the Fraser Lake reference area, with a wide range in overlap. Among larger fish, the length-mercury results suggest that Williston lake trout may even have lower mercury concentrations than similar sized fish from Fraser Lake. Additional sampling of small-size lake trout from Parsnip Reach would help to better characterize the length-mercury relationship and support a more definitive conclusion. There is an unusually wide variation in mercury concentrations within relatively narrow size ranges (i.e., of 50 to 100 mm intervals), where mercury concentrations range from <0.3 mg/kg to >1.2 mg/kg of fish between 700 and 800 mm. This may be due to different dietary histories driven by differences in feeding locations (e.g., within reservoir vs within tributary) by individual fish. There is clearly a wide range in tissue concentrations – especially for Williston Reservoir lake trout; whereas the variation in mercury concentrations among trout from Fraser Lake is lower.

The $\delta^{15}N$-mercury and length-$\delta^{15}N$ relationships show that despite the bias towards larger fish from Parsnip Reach, $\delta^{15}N$ values were slightly higher in lake trout from Fraser Lake. As described in **Section 3.1.2**, the higher $\delta^{15}N$ values may indicate a slightly higher trophic position for Fraser Lake lake trout relative to Williston Reservoir lake trout. This may reflect a slightly longer or complex food chain in Fraser Lake than in Williston. The more 'steps' there are in the food chain, the more opportunity for bioaccumulation of mercury over time. This seems plausible given the nearly identical $\delta^{15}N$ values of both lake whitefish and mountain whitefish in Williston Reservoir and Fraser Lake (**Figure 3-1**). It may also explain the mercury results described above.

Data Gaps

- We are lacking smaller size classes in Parsnip Reach; need 5+ fish in each of the 301-400, 401-500 and 601-700 mm size classes. Mercury and SIA in all fish; age on subset of fish from across all sampled size classes.
- Only 4 fish caught in Finlay Reach in 2016; need all size classes (5+ fish in each) in Finlay Reach.
- The 2017/18 investigations will focus on the Peace Reach and Dinosaur Reservoir.

3.4.2. Bull Trout

Catch Results and Meristics (Figure 3-5 and Figure 3-6)

The 2016 target program focused on Williston's Parsnip Reach and Thutade lake (reference area). For Williston Reservoir, additional fish were caught in Finlay Reach through both opportunistic (CCE in 2016) and in-kind FLNRO (2015 and 2016) efforts. Additional fish were also caught in Parsnip Reach in 2015 through in-kind efforts by FLNRO. Unfortunately, fishing on Thutade Lake was stopped in 2016 due to boat engine problems before any bull trout had been caught. However, we were able to obtain some recent (2014 and 2015) bull trout data collected from Thutade Lake during baseline studies for the Kemess Underground Project (Hatfield and Bustard 2017). Attichika Creek and South Pass Creek are tributary streams of Thutade Lake (**Figure 3**). Bull trout catch results by size class for all three years are shown below:

Year	Type	Waterbody	Reach	N	100-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900	901-1000
2014	Reference	Thutade Lk	Attichika Creek	11	0	0	0	0	0	5	5	1	0
2015	Reference	Thutade Lk	Attichika Creek	11	0	0	0	0	1	2	6	2	0
2015	Reference	Thutade Lk	South Pass	5	0	0	0	0	0	2	3	0	0
2015	Williston	Williston Res	Parsnip Rch	6	0	0	1	1	0	1	3	0	0
2015	Williston	Williston Res	Finlay Rch	20	0	0	0	4	3	3	10	0	0
2016	Williston	Williston Res	Parsnip Rch	13	0	0	3	5	1	3	1	0	0
2016	Williston	Williston Res	Finlay Rch	39	0	0	1	6	9	6	13	4	0

All but one of the Parsnip Reach bull trout samples came from the targeted fishing program, with a single bull trout acquired during the Duz Cho derby. While a wide range of sizes were obtained in that effort, samples numbers were low overall (19 across both 2015 and 2016) and remain a data gap to be filled. However, it may be that bull trout are not common within the reservoir, preferring to reside near stream mouths or well into the tributary streams themselves, such as Parsnip River. According to EDI, habitat within the reservoir in the southern area of Parsnip Reach was not ideal for bull trout, so sampling effort was directed more northwards (**Appendix B**).

The Finlay Reach data set is comprised of 59 fish, gathered from within tributary streams or their mouths including Chowika (5), Osilinka (3), Swannell (7), Davis (24) and Ingenika (20) rivers (**Figure 2-2**). Their combined distribution covers most size classes adequately, except the 301 mm – 400 mm size class. The Thutade Lake data set was more limited, with only one fish smaller than 600 mm. The length frequency plot clearly shows the more complete size range of bull trout collected from Parsnip and Finlay reaches relative to the larger fish caught in Thutade Lake.

The length-weight relationship for bull trout was strong and without major outliers; data from Williston and Thutade Lake appeared to show a consistent trend, despite disparate size classes sampled from each, suggesting similar growth patterns. There was a large disparity in age for fish of similar sizes; for example, length of six-year old fish ranged from 450 mm – 650 mm and seven-year olds from 475 mm to almost 900 mm. It is partly for this reason that age is a less accurate / reliable indicator of mercury concentrations in fish.

Given the emphasis on non-lethal sampling for bull trout in Williston Reservoir, age structures (otoliths) were only collected from incidental mortalities during the targeted program on Parsnip Reach in 2016. Notwithstanding, age structures were also collected as part of the in-kind FLNRO programs in 2015 and 2016, resulting in a total of 52 age samples from the 78 fish with mercury results in Williston Reservoir. The 2015 Thutade Lake bull trout were collected using lethal sampling and included aging for nearly all fish.

Mercury-Related Relationships *(**Figure 3-6**, **Figure 3-7** and **Figure 3-8**)*

The length-mercury relationships for bull trout from Parsnip Reach (19), Finlay Reach (59) and Thutade Lake (27) are quite variable both within and between waterbodies, with a wide spread in mercury concentration within fairly narrow size intervals. In Williston (Finlay and Parsnip), the length-mercury relationship appears flat below about 600 mm, before increasing above 600 mm. At lower sizes, this pattern is likely due to a combination of rapid growth (which results in diluted mercury concentrations in muscle tissue) and lower trophic status (which results in the ingestion of prey items with lower mercury concentrations) in smaller bull trout. The increases in tissue mercury concentration seen later in life are accentuated due to lower growth rates at older ages and higher trophic status.

Within the Parsnip and Finlay reaches of Williston Reservoir, the available data are too variable to determine whether there are within-reservoir differences in mercury concentrations for bull trout (**Figure 3-7**) [Note that information presented in **Figures 3-7** and **3-8** for bull trout will also be presented for lake trout and other species in subsequent reports]. At smaller sizes, it appears that Parsnip Reach fish may have slightly higher mercury concentrations, but there is overlap at larger sizes. However, data for Parsnip Reach are too limited at this stage to warrant further formal exploration of such differences. The rapid transition from low mercury concentration (<0.30 mg/kg) at less than 600 mm to concentrations reaching 1.0 mg/kg as early as a 700-mm fish suggests that a switch in diet from low to high mercury prey (e.g., invertebrates or small fish to larger fish) occurs around this size. Greater understanding of life history features of bull trout (e.g., the relative proportion of time spent feeding within tributary streams, within the reservoir and what prey is targeted) would help shed light on this phenomenon.

Out of interest, we compared 2015/2016 results for Parsnip Reach with the 2012 Crooked River (ERM 2015) data set (**Figure 3-6**; lower right plot). While mercury concentrations appear similar for smaller (<450 mm) and larger (>600 mm) bull trout between both data sets, medium-sized (450 mm to 600 mm) fish from Crooked River have higher mercury concentrations than similar size fish captured from Parsnip Reach (see map in **Appendix B** for sampling locations). At this stage, these should be considered 'preliminary' and more formal statistical testing will be conducted once data gaps have been filled. We also lack stable isotope information for Crooked River fish. Should there be an opportunity to collect more fish from here, SI data may also be informative and help to interpret these data.

While there is a substantial amount of overlap between the two waterbodies, mercury concentrations in larger bull trout (>600 mm) appear to be slightly higher in Williston Reservoir than in Thutade Lake (**Figure 3-8**). Thutade Lake is a headwater stream situated at a higher elevation than Williston Reservoir and therefore may be cooler, more nutrient poor and may have a simpler food web. Obtaining a more complete characterization of the length-mercury relationship for Thutade Lake bull trout should help to verify these initial observations. In both waterbodies, the range in mercury concentration within 50 mm size increments was surprisingly large. For example, for 650 – 700 mm fish, mercury ranged from 0.12 mg/kg to 1.0 mg/kg, an order of magnitude difference. Between 750 mm and 800 mm, the range was from 0.2 mg/kg to almost 1 mg/kg, a 5x difference. This great variability in growth and dietary preference (and therefore mercury exposure) of individuals may be related to geography and differences in life history strategy of bull trout (e.g., degree of mobility vs fidelity to discrete areas). Variability in size-specific mercury concentrations due to varied life history patterns within the watershed and different dietary preferences will make statistical comparisons to distinguish possible differences in mercury concentrations between geographic areas, or over time, more challenging.

The $\delta^{15}N$-mercury and length-$\delta^{15}N$ relationships were limited to Williston Reservoir as stable isotope data were not collected for Thutade Lake bull trout (in the 2014 or 2015 data sets). While the plots show increasing trends for both relationships (i.e., increased mercury concentration within increasing trophic position), variability is fairly high – reflecting the variability that is seen in size-mercury relationships. For example, for fish with $\delta^{15}N$ values between 12.0 and 12.3, mercury concentrations span the entire range of mercury concentrations measured in the Williston data set. These results suggest that while trophic status is somewhat important in determining tissue mercury concentrations in bull trout, other factors (e.g., prey item mercury concentrations, geography, life history) that vary within the reservoir (and ultimately across aquatic ecosystems) may also play important roles.

Data Gaps

- Low samples numbers were obtained in 2016 from Parsnip Reach across most size classes; need to obtain more samples from all size classes.
- Reasonable sample numbers for Finlay Reach, with the exception of the 301 to 400 mm size class.
- Relying on 2014/2015 data for Thutade Lake (mercury and age only); would be nice to get complete characterization and SIA data, but would settle for characterization of smaller BLTR size classes to augment the 2014/2015 data.

3.4.3. Lake Whitefish

Catch Results and Meristics (Figure 3-9)

The 2016 program focused on targeted studies carried out in Williston's Parsnip Reach (EDI) and in Fraser Lake (FLNRO). Lake whitefish catch results by size class for 2016 are shown below:

The length-weight relationship for lake whitefish was strong. Three potential outliers (all from Parsnip Reach) were identified; these fish were flagged for further assessment (as discussed in **Section 3.1.3**). Apart from the outliers, length-weight trends appeared consistent across the three locations sampled.

Year	Type	Waterbody	Reach	N	100-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550
2016	Reference	Fraser Lk	Fraser Lake	20	0	0	2	9	2	6	1	0	0
2016	Williston	Williston Res	Parsnip Rch	24	0	1	2	19	1	1	0	0	0
2016	Williston	Dinosaur Res	Dinosaur Res	2	0	0	0	0	0	1	1	0	0

All of the Parsnip Reach lake whitefish samples came from the targeted fishing program. While 24 fish were caught in Parsnip Reach, most were from between 251 mm and 300 mm. Only two fish were larger than 300 mm. While we expected to catch larger whitefish, it may be that larger sizes no longer exist within the reservoir. In the 2001 investigation of Finlay Reach by Baker et al. (2002) they observed that the size range of whitefish captured in 1980 (360 mm – 520 mm), 1988 (180 mm – 345 mm) and 2001 (148 mm – 301 mm) has steadily diminished. This is likely due to ecological changes that have occurred within the reservoir, but may have now stabilized, given the relative lack of whitefish captured greater than 300 mm. This may limit comparisons of lake whitefish between Williston Reservoir and elsewhere.

No lake whitefish were caught in the opportunistic Finlay Reach sampling, although two were caught from efforts on Dinosaur Reservoir. Thus, there are gaps in the size classes sampled for both Parsnip and Finlay reaches – although as indicated above, this may not be reconcilable. The Fraser Lake data set includes a wider characterization of lake whitefish size classes, ranging from 232 mm to 412 mm, which is much more typical of lake whitefish populations. While not ideal, lake whitefish often have a weak to non-existent length-mercury relationship, so the lack of good representation of all size classes may not be that important.

No age structures were sampled for any of the lake whitefish.

***Mercury-Related Relationships** (Figure 3-10)*

Length-mercury relationship were weak for both Parsnip Reach and Fraser Lake; Dinosaur Reservoir only had two samples. There did not appear to be any relationship between increasing fish-size and mercury concentration as was clear for bull trout and lake trout. This is partly due to the relatively narrow size range that whitefish were captured over, and the 2 – 3 x range in fish mercury concentration that existed within discrete (i.e., within 50 mm) size categories. Fish mercury concentrations ranged from 0.05 mg/kg to 0.28 mg/kg in Parsnip Reach and over a similar range (0.05 – 0.33 mg/kg) in Fraser Lake, also fish were larger in Fraser Lake than Parsnip Reach.

Additional fish from smaller and larger (if they exist) size classes for Parsnip Reach would help determine the strength of the length-mercury relationship for Parsnip and whether differences between the two locations exist. Although statistical comparisions have been made yet, there do not appear to be size-mercury relationships for either group – despite the inherently large differences in size-distributions.

The $\delta^{15}N$-mercury and length-$\delta^{15}N$ relationships show that despite the limited size range of fish from Parsnip Reach, $\delta^{15}N$ values were similar between Williston Reservoir and Fraser Lake. The better-characterized Fraser Lake data set showed little evidence of a relationship between length and $\delta^{15}N$ values or between $\delta^{15}N$ values and mercury concentrations. These data suggest that trophic position of lake whitefish is essentially similar over the size range and age of fish in both lakes. Improved characterization of mercury and $\delta^{15}N$ values across sizes classes for the Parsnip Reach data set is needed to better understand mercury concentrations in lake whitefish from that location. However, as indicated earlier, this may not be possible given the apparent scarcity (or absence) of lake whitefish greater than 350 mm in length.

Data Gaps

- Parsnip Reach – Need broader size range and better representation within size classes.
- Finlay Reach – Need all size classes except 251 mm to 300 mm size class.
- An alternate strategy would be to rely on mercury data for the 251 mm to 300 mm size class only to assess spatial differences in mercury concentrations. While this might lose some information, the lack of a size-mercury relationship, possible absence of large fish and the benefits of shifting sampling and analysis resources to other species (e.g., lake trout or bull trout) would likely outweigh the drawbacks.

3.4.4. Kokanee

Catch Results and Meristics (Figure 3-11)

The 2016 program focused on Williston's Parsnip Reach and Thutade Lake (reference area). No kokanee were caught in the targeted Parsnip Reach program, suggesting that they are either absent, difficult to capture or only seasonally available. Only 12 additional fish were caught opportunistically by CCE on Finlay Reach. Kokanee catch results by size class for 2016 are shown below:

Year	Type	Waterbody	Reach	N	100-150	151-200	201-250	251-300	301-350	351-400	401-450	451-500	501-550
2016	Reference	Thutade Lk	Thutade Lake	12	0	0	12	0	0	0	0	0	0
2016	Williston	Williston Res	Finlay Rch	13	0	2	10	1	0	0	0	0	0

A narrow size range of kokanee was caught in both Williston Reservoir and Thutade Lake, which is expected given that this landlocked salmon species seldom exceeds 250 mm in length and attains a maximum age of only 3 or 4 years. Again, while not ideal, kokanee have a weak to non-existent length-mercury relationship, so the lack of good representation of all size classes may not be that important to get a reasonable characterization of mercury concentrations. Furthermore, the concentration of mercury is always low for this species, seldom exceeding 0.10 mg/kg.

Mercury-Related Relationships (Figure 3-12)

Length-mercury relationships were not evident for kokanee from the Finlay Reach or from Thutade Lake, in line with expectations for this species.

Neither $\delta^{15}N$-mercury nor length-$\delta^{15}N$ relationships were evident for Thutade Lake kokanee. Too few Finlay Reach kokanee had stable isotope measurements to make conclusive statements.

Data Gaps

- No kokanee caught in Parsnip Reach in 2016. Need full range of sizes or consider changing strategy. Given the absence of large fish and lack of size-mercury relationship, switching strategies to focus on a discrete size interval (201 mm – 250 mm) as the most efficient use of time and resources.
- Limited size classes caught in Finlay Reach (10 of 13 fish from the 201 mm to 250 mm size class). Need to fill other size classes or change strategy (see below).
- May need to implement kokanee-specific program reservoir-wide to target fish when they return to spawning streams.

3.4.5. Other Species

Catch Results and Meristics (Figure 3-13 and Figure 3-14)

This section focuses on non-target species caught incidentally during the 2016 program and submitted for mercury analysis: mountain whitefish, rainbow trout, burbot, and longnose sucker. As expected given the incidental nature of these catches, sample sizes and fish sizes were low/narrow and varied across species and areas.

Although length-weight relationships are presented, no assessment of outliers has been conducted at this time. This will be done if / when further data on these species are collected during 2017 and 2018.

Mercury-Related Relationships *(***Figure 3-14** and **Figure 3-15***)*

Sample sizes were generally low, resulting in sparse data sets for all species and challenges characterizing length-mercury relationships for any species/reach combination. Mercury concentrations were also uniformly low for most species with mercury concentrations of all mountain whitefish and rainbow trout much less than 0.20 mg/kg. Of the five burbot measured (4 from Fraser Lake), all were above 0.20 mg/kg. Burbot are an ominvorous species that also target large invertebrates and fish when larger and typically have mercury concentrations that are elevated relative to whitefish, but usually less than bull or lake trout.

Similar results were observed for the $\delta^{15}N$-mercury and length-$\delta^{15}N$ relationships.

Data Gaps

- These are not target species, so no obvious gaps identified.
- Creel survey data may reveal that one or more of these species (e.g., burbot or ling) are consumed by some members of local First Nations communities. As such, greater efforts may be required to gather adequate data for these species.
- With respect to 'other' species, 2016 creel survey data suggested that northern pike (*Esox lucius*) may be commonly consumed from Moberly Lake; this is an example of where creel survey data may prompt sampling of 'non-target species' under specific circumstances.

Figure 3-1. Stable isotope results (mean ±SD for δ15N and δ13C values) by fish species and waterbody for Williston Reservoir (2015-2016), Fraser Lake (2016) and Thutade Lake (2014-2016).

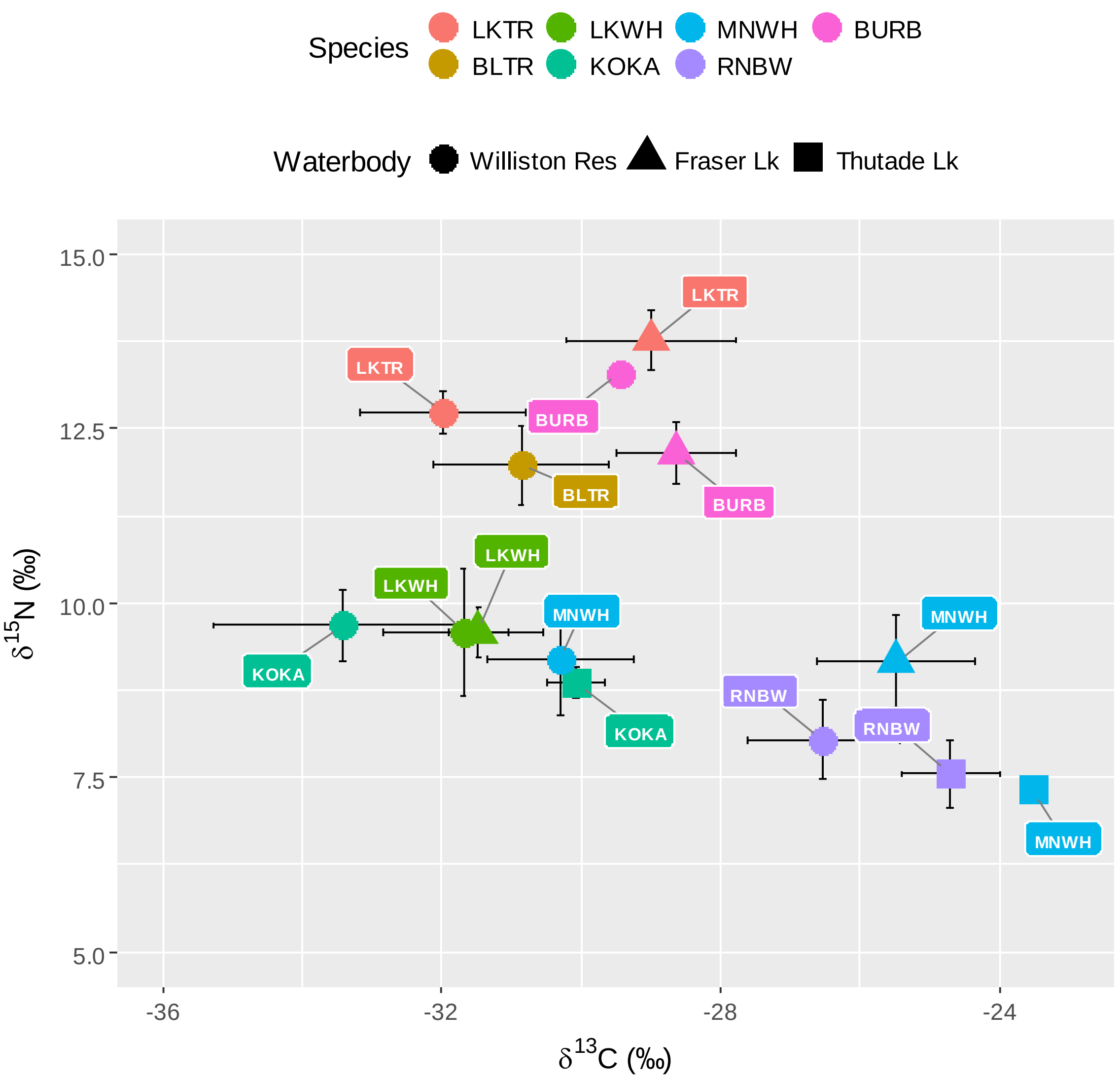


Figure 3-2. Mercury results by fish species and waterbody for Williston Reservoir (2015-2016), Fraser Lake (2016) and Thutade Lake (2014-2016).

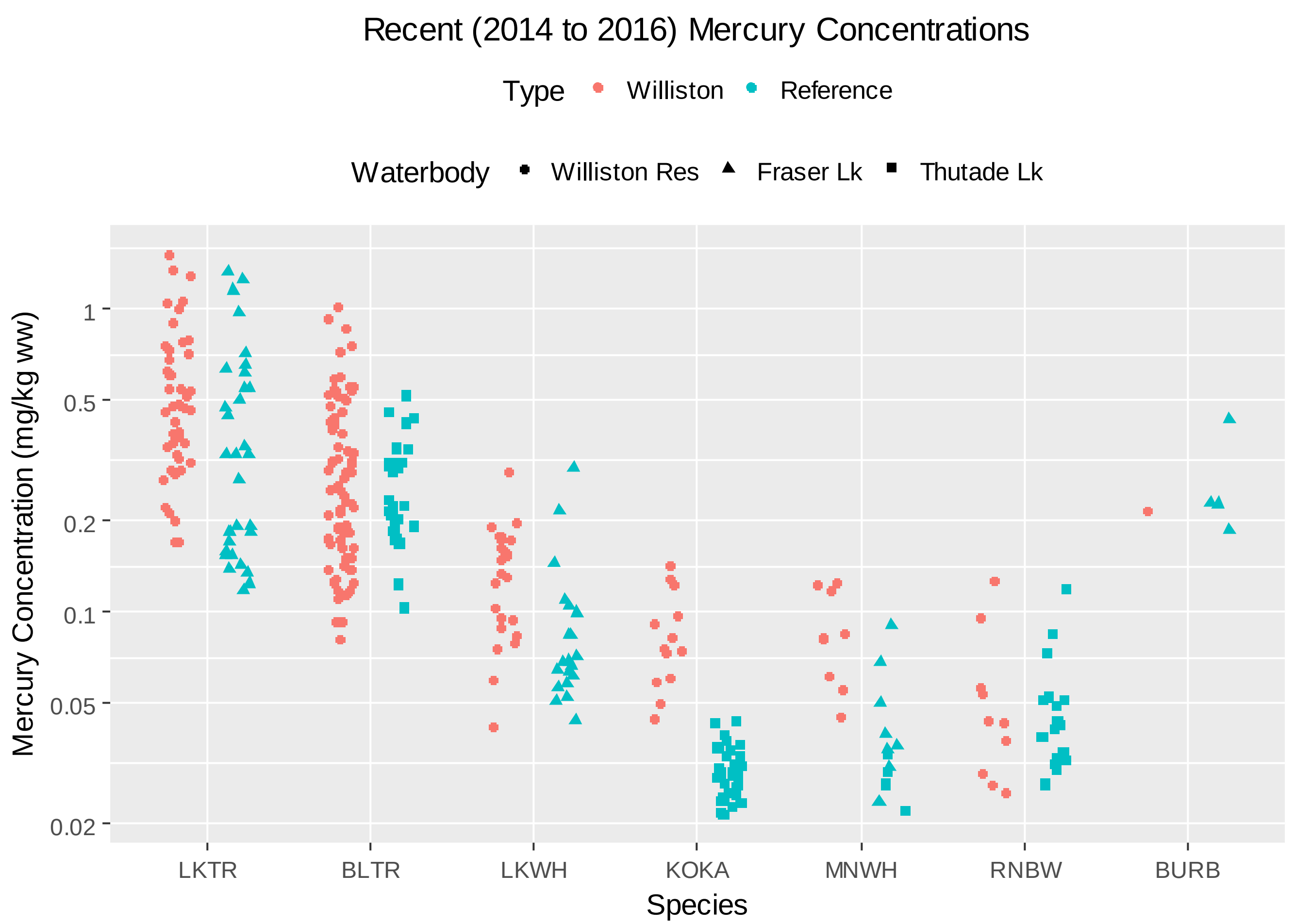
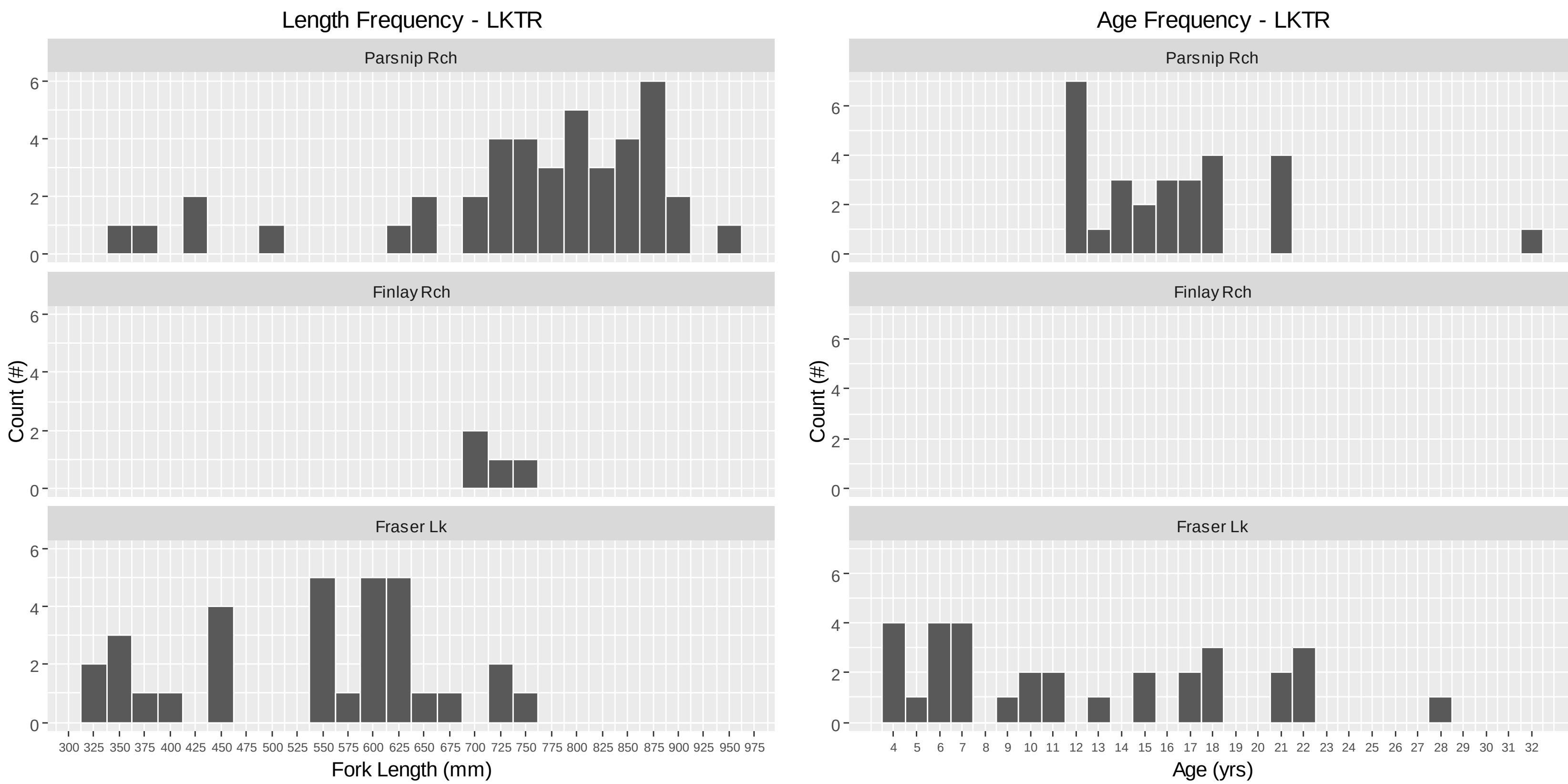
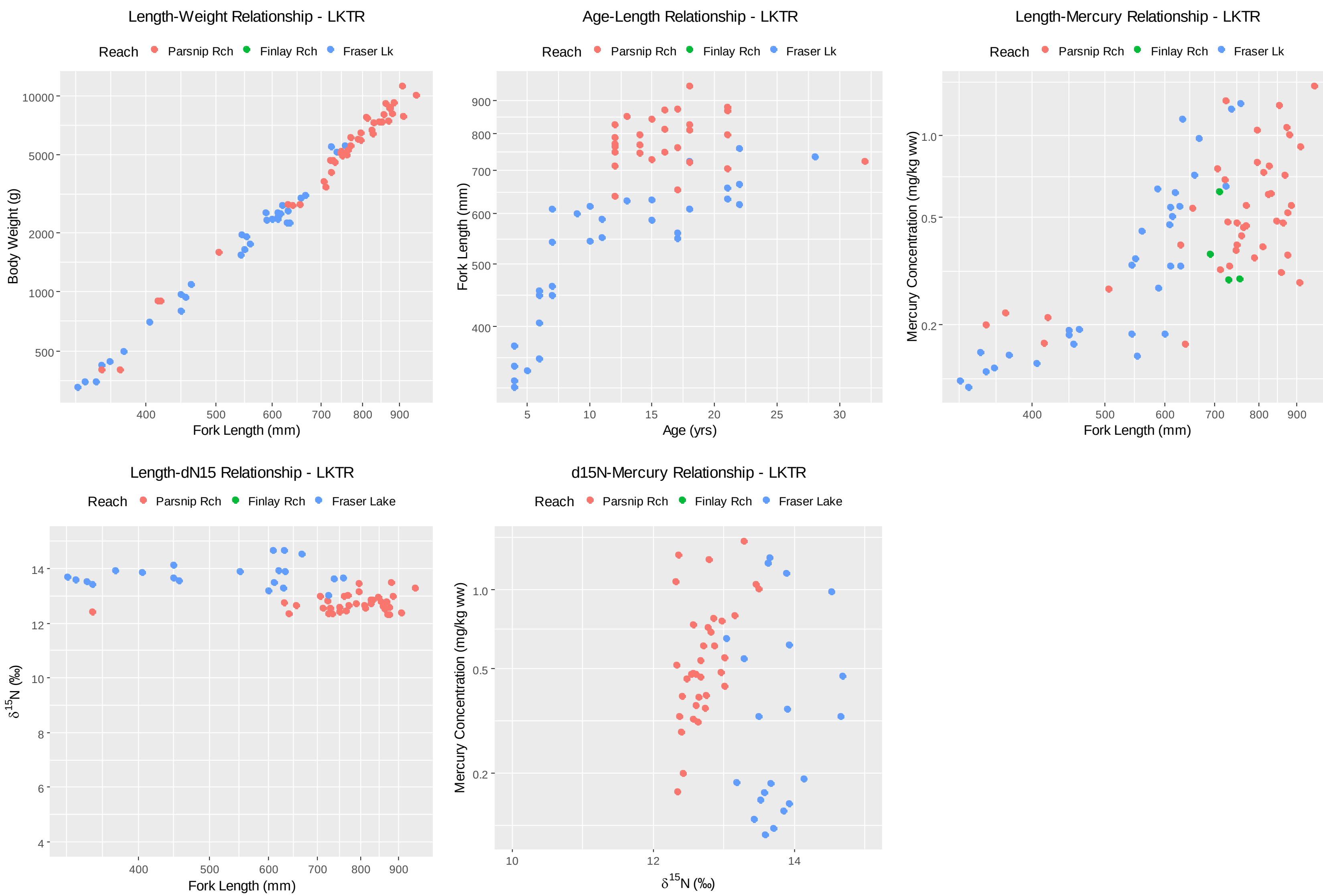


Figure 3-3. Length frequency, age frequency and meristic data summary for lake trout.



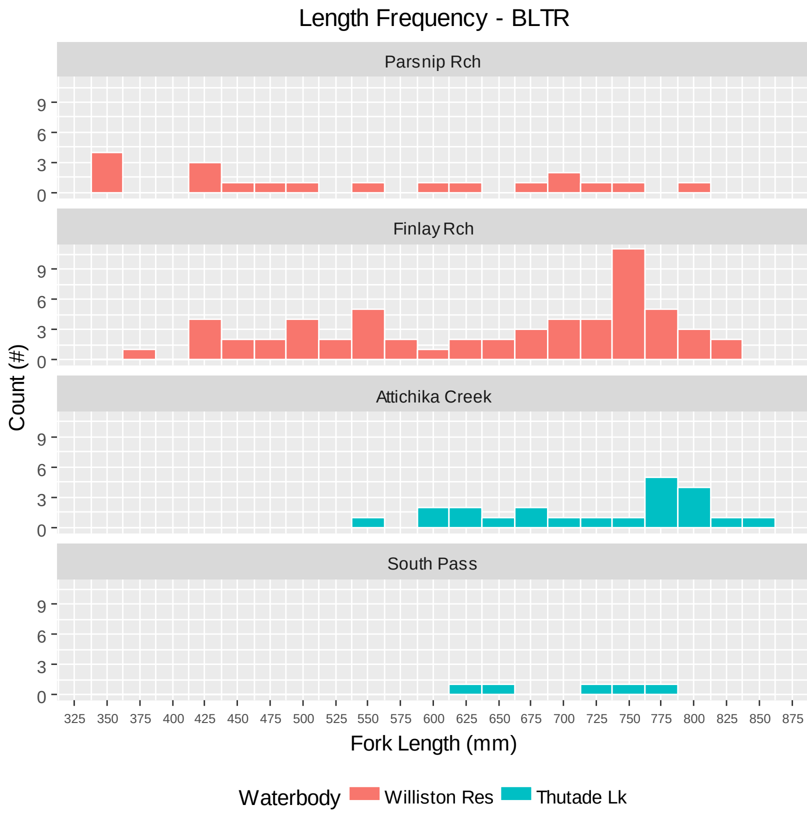
Year	Sp	Waterbody	Reach	N.FL	FL.Range	FL.Mean	N.Wt	Wt.Range	Wt.Mean	N.K	K.Range	K.Mean	N.Age	Age.Range	Age.Mean
2016	LKTR	Williston Res	Parsnip Rch	42	347-949	751	42	400-11249	5753	42	0.8-1.5	1.2	28	12-32	16
2016	LKTR	Williston Res	Finlay Rch	4	690-755	721	0	NA	NA	0	NA	NA	0	NA	NA
2016	LKTR	Fraser Lk	Fraser Lake	32	321-757	540	32	325-5600	2031	32	0.88-1.45	1.07	32	4-28	12

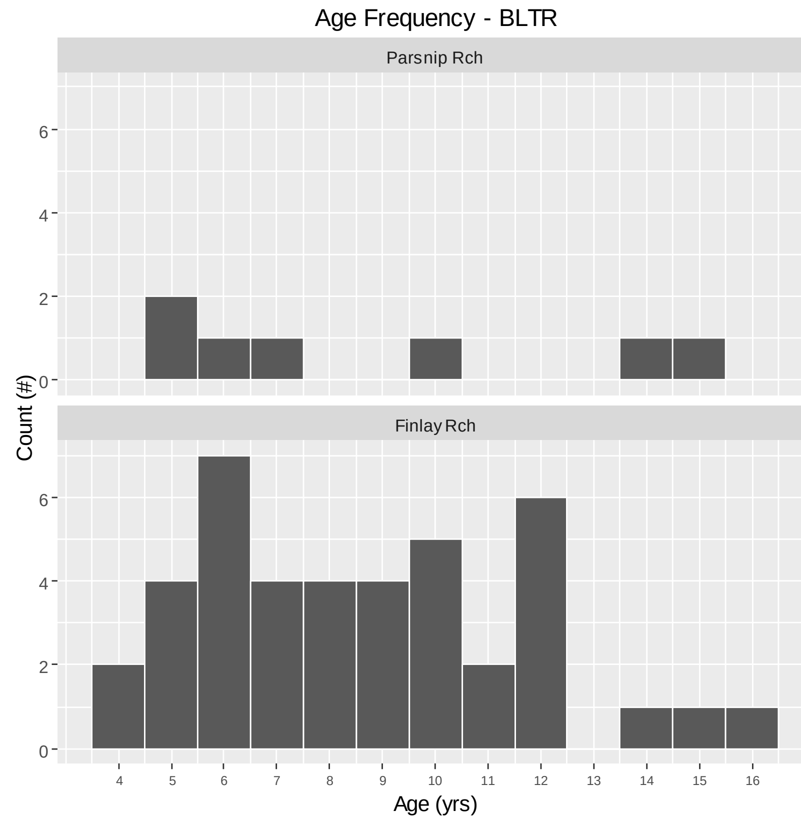
Figure 3-4. Key mercury-related relationships for lake trout (LKTR).



Note: No weight, age or $\delta^{15}N$ measurements are available for the fish from Finlay Reach.

Figure 3-5. Length frequency, age frequency and meristic data summary for bull trout (BLTR).





Year	Sp	Waterbody	Reach	N.FL	FL.Range	FL.Mean	N.Wt	Wt.Range	Wt.Mean	N.K	K.Range	K.Mean	N.Age	Age.Range	Age.Mean
2016	BLTR	Williston Res	Parsnip Rch	13	349-750	504	13	389.9-4853	1690	13	0.62-1.21	1.03	1	5-5	5
2016	BLTR	Williston Res	Finlay Rch	39	384-835	638	19	900-4850	2918	19	0.72-1.67	1.26	21	4-16	9
2015	BLTR	Williston Res	Parsnip Rch	6	340-790	611	3	300-4460	2270	3	0.57-0.9	0.74	6	5-15	10
2015	BLTR	Williston Res	Finlay Rch	20	440-785	649	10	1050-4350	1968	10	0.8-1.23	1.01	19	4-14	8
2015	BLTR	Thutade Lk	Attichika Creek	11	540-850	746	11	1400-5650	4191	11	0.89-1.08	0.98	11	5-11	9
2015	BLTR	Thutade Lk	South Pass	5	625-775	704	5	2250-4700	3550	5	0.92-1.07	0.99	5	7-13	10
2014	BLTR	Thutade Lk	Attichika Creek	11	605-830	706	11	1850-5400	3300	11	0.76-1.07	0.90	10	7-13	9

Figure 3-6. Key mercury-related relationships for bull trout (BLTR).

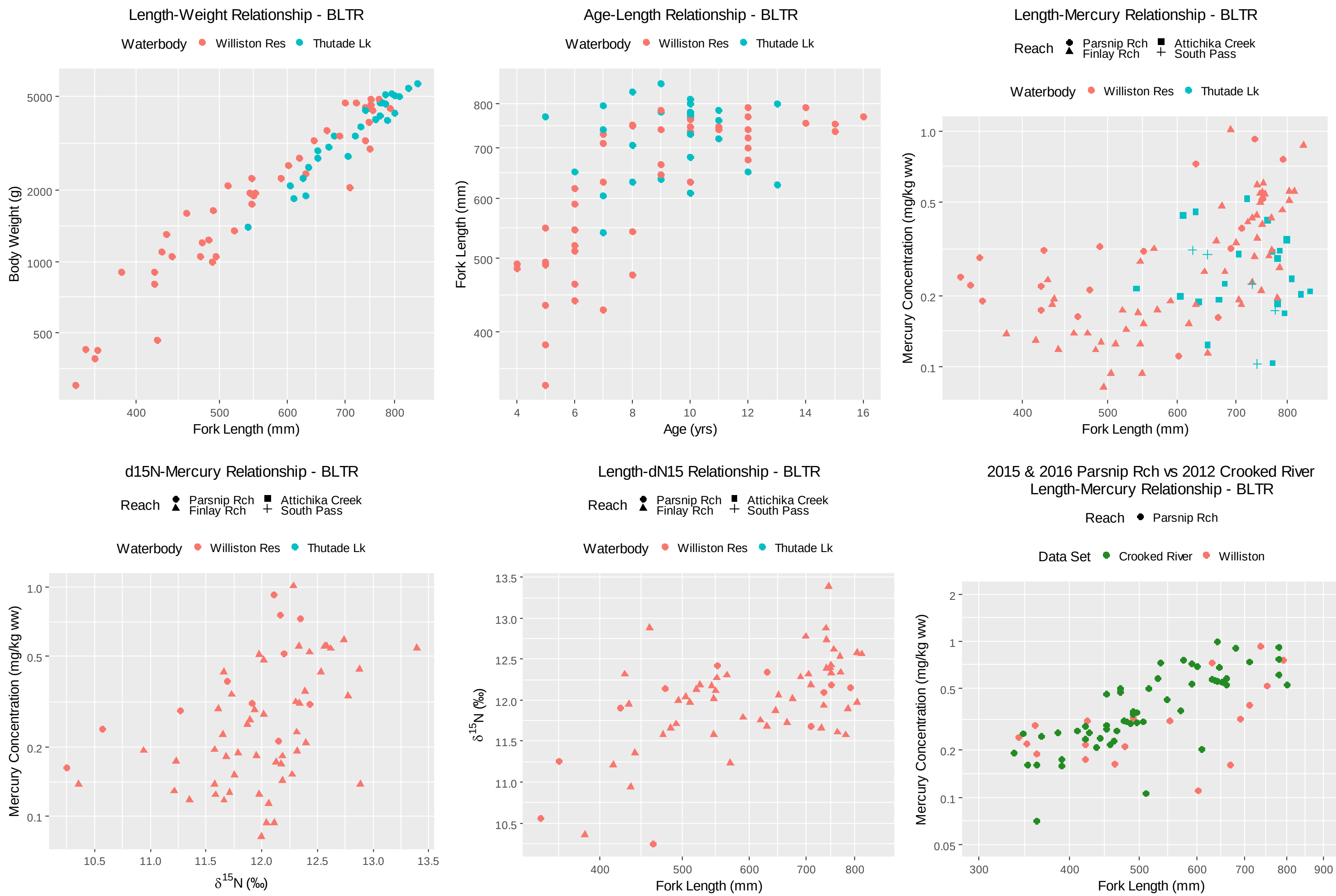


Figure 3-7. Comparison of length-mercury results (2015 and 2016) for Parsnip and Finlay Reach bull trout (bottom left: length-mercury scatter plot; top left: length density plot; top right: legend; bottom right: mercury density plot), Williston Reservoir.

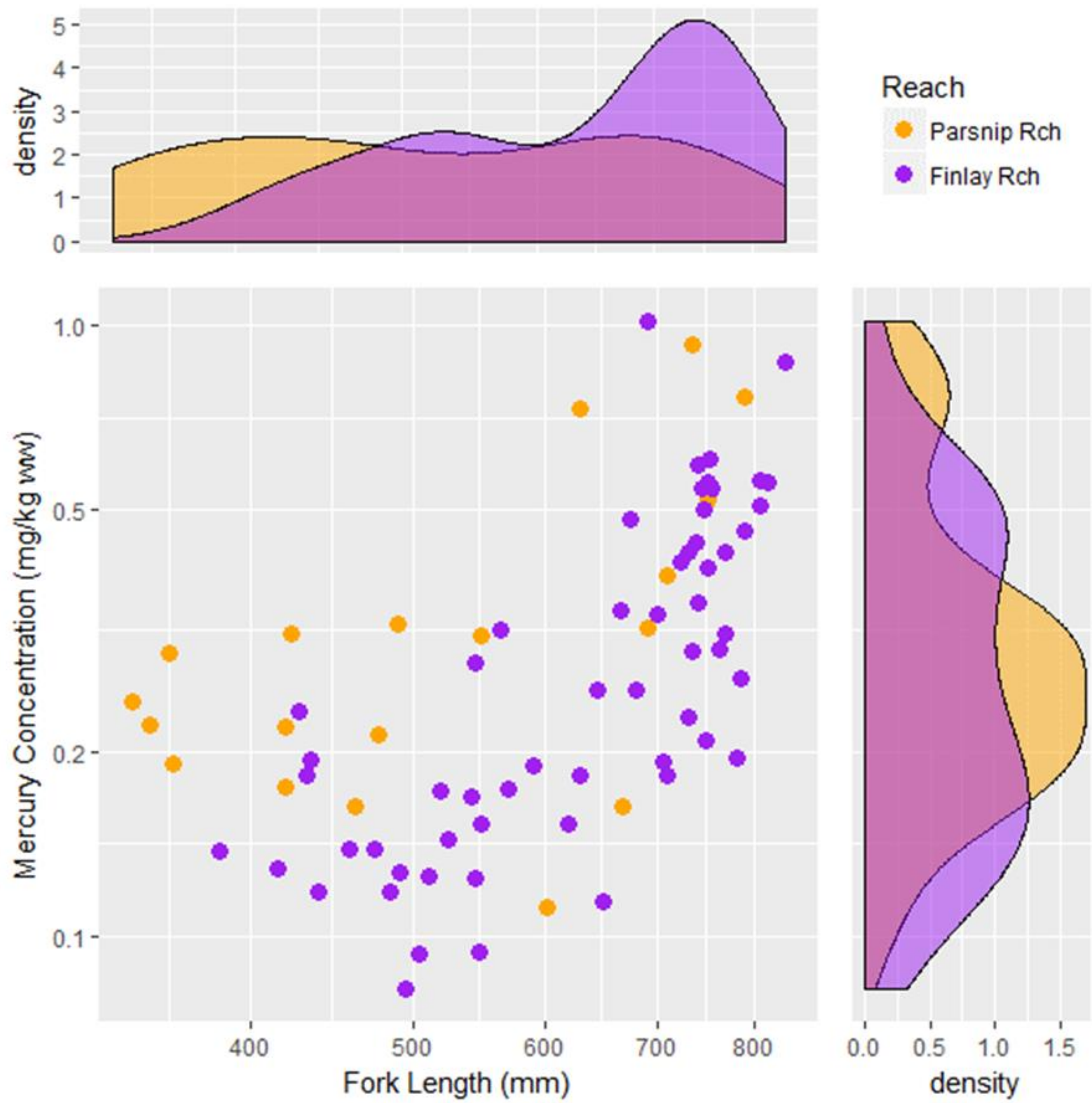


Figure 3-8. Comparison of length-mercury results (bottom left: length-mercury scatter plot; top left: length density plot; top right: legend; bottom right: mercury density plot) for large bull trout (>600 mm) between Williston Reservoir and Thutade Lake.

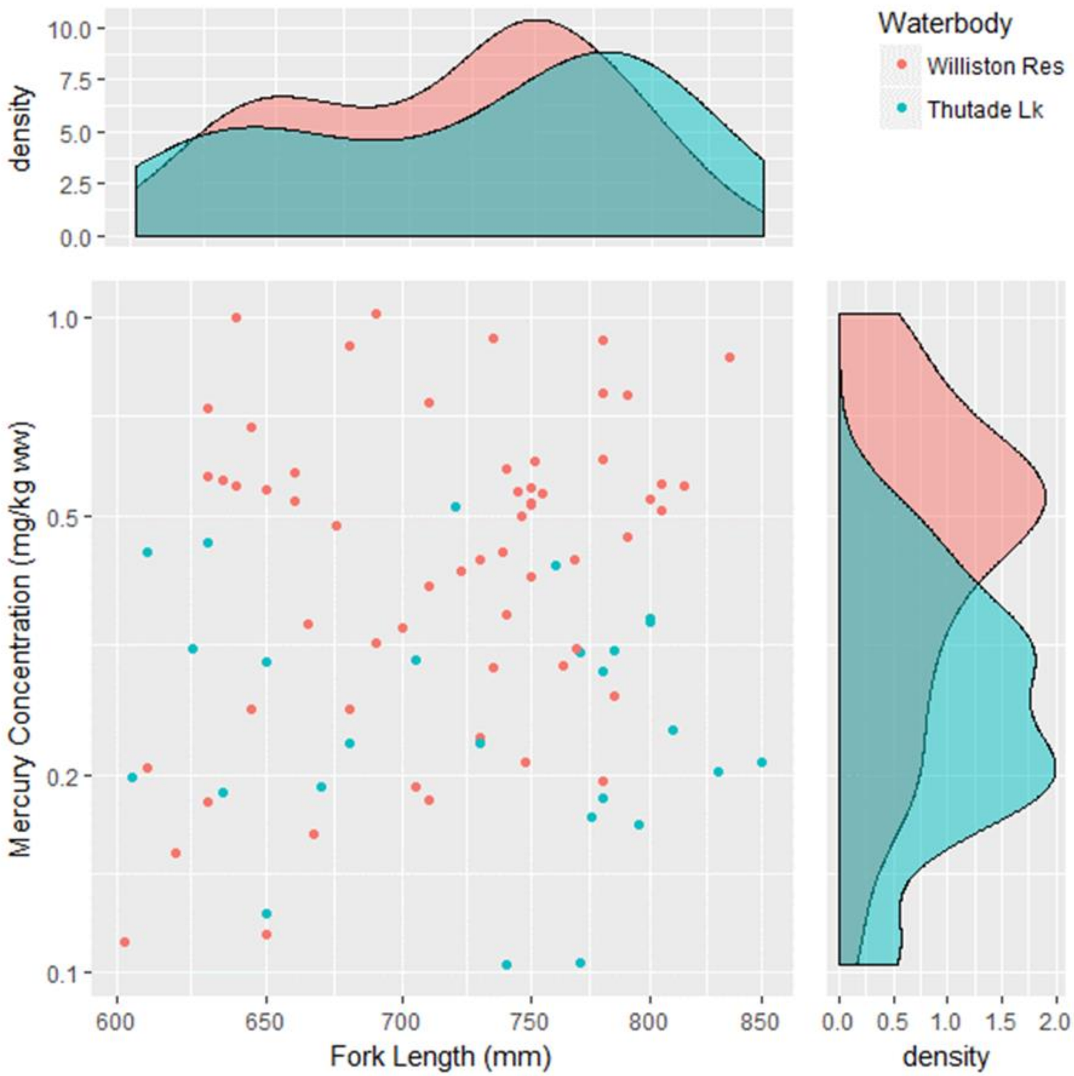
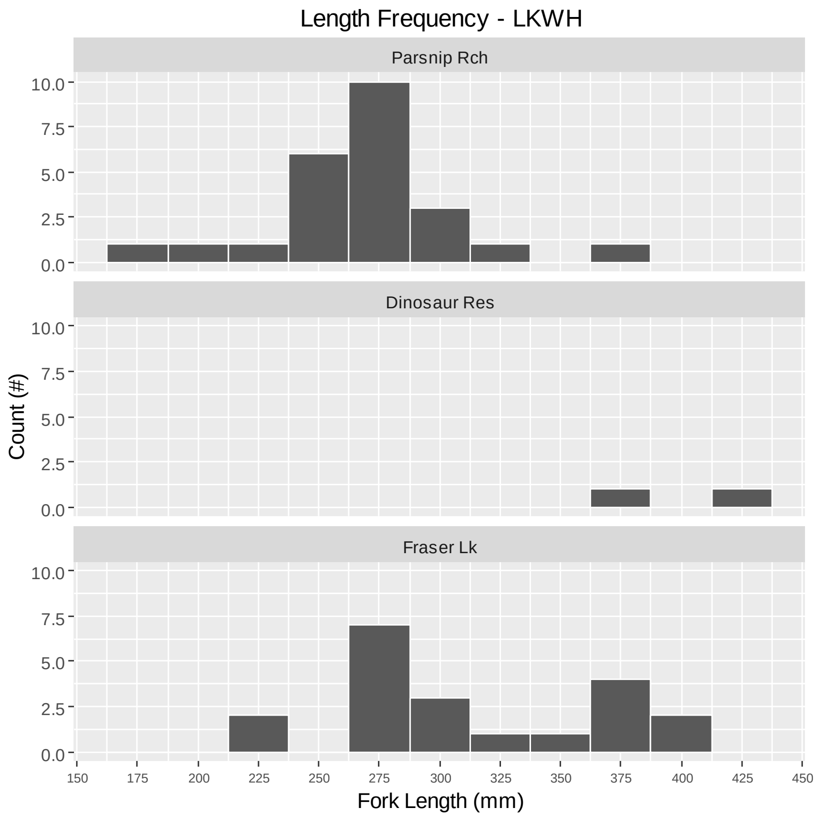


Figure 3-9. Length frequency and meristic data summary for lake whitefish (LKWH).



Year	Sp	Waterbody	Reach	N.FL	FL.Range	FL.Mean	N.Wt	Wt.Range	Wt.Mean	N.K	K.Range	K.Mean	N.Age	Age.Range	Age.Mean
2016	LKWH	Williston Res	Parsnip Rch	24	164-374	270	24	49.4-525.1	214	24	0.41-1.61	1.04	0	NA	NA
2016	LKWH	Dinosaur Res	Dinosaur Res	2	385-415	400	2	480-560	520	2	0.78-0.84	0.81	0	NA	NA
2016	LKWH	Fraser Lk	Fraser Lake	20	232-412	313	20	124-840	364	20	0.83-1.3	1.10	0	NA	NA

Figure 3-10. Key mercury-related relationships for lake whitefish (LKWH). Potential outliers circled by type: red (L-Wt) or green (L-Hg).

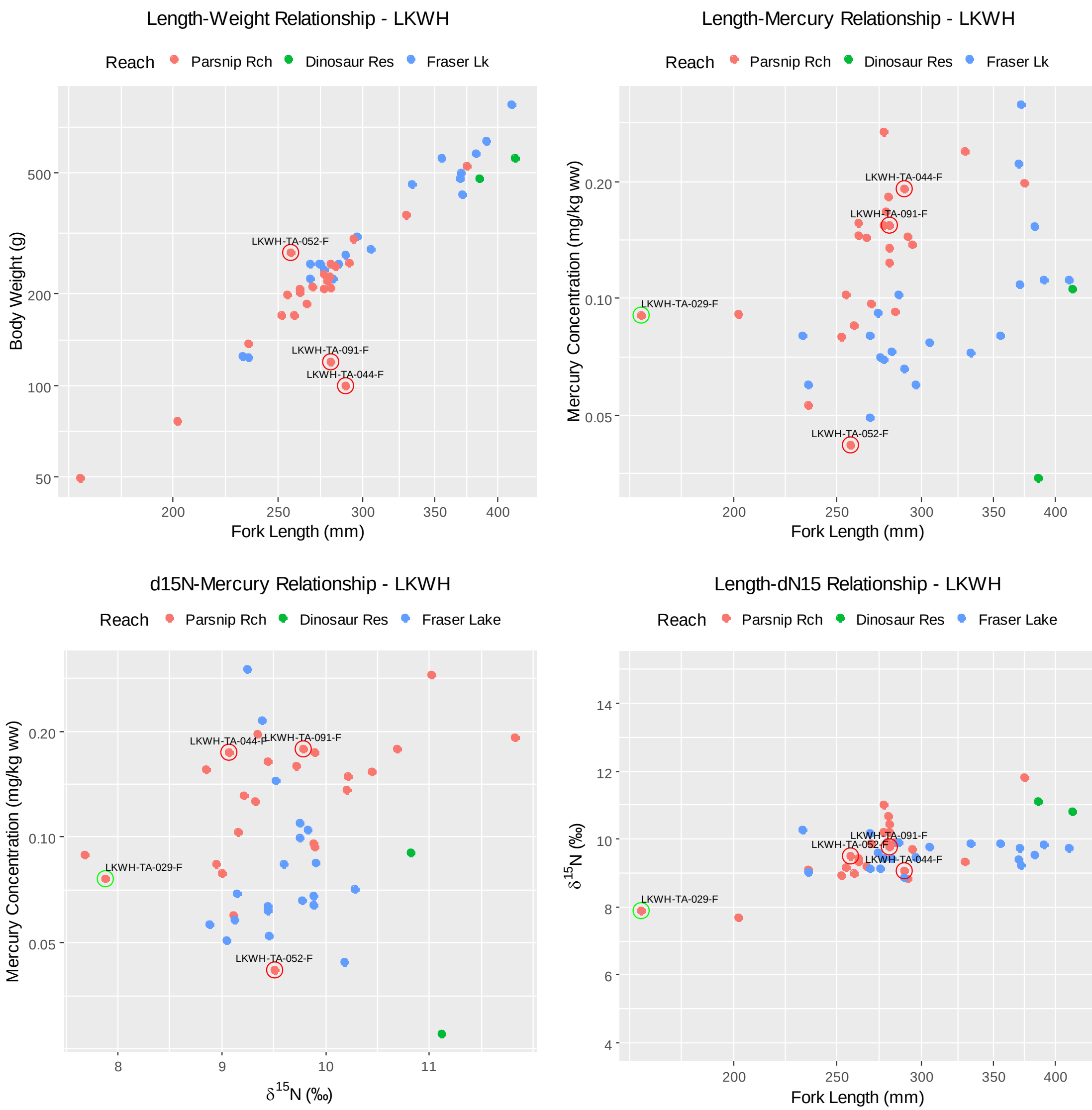
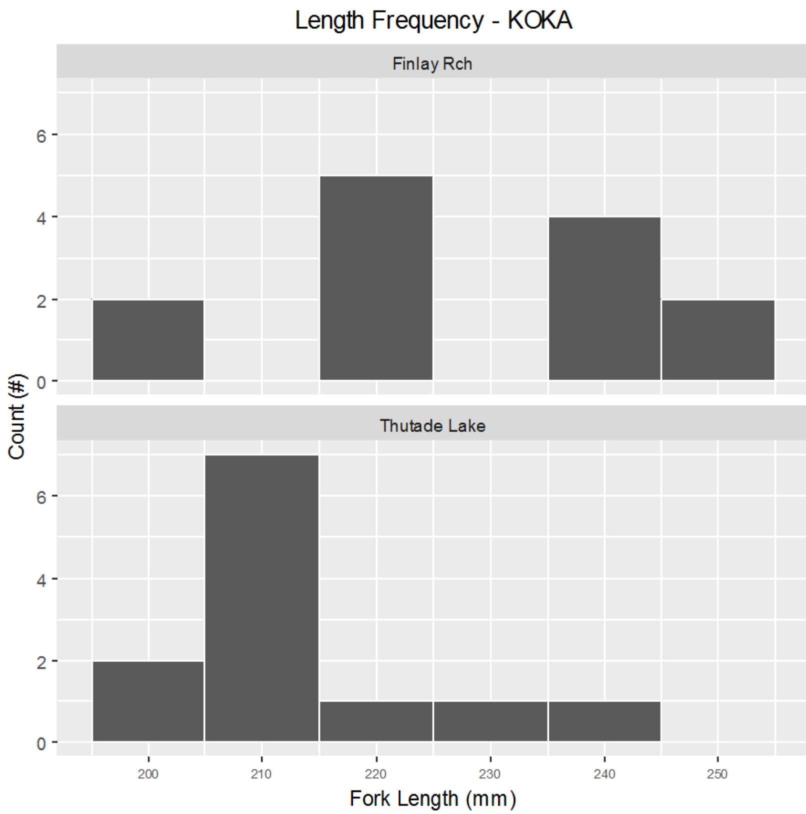


Figure 3-11. Length frequency and meristic data summary for kokanee (KOKA).



Year	Sp	Waterbody	Reach	N.FL	FL.Range	FL.Mean	N.Wt	Wt.Range	Wt.Mean	N.K	K.Range	K.Mean	N.Age	Age.Range	Age.Mean
2016	KOKA	Williston Res	Finlay Rch	13	195-255	229	0	NA	NA	0	NA	NA	0	NA	NA
2016	KOKA	Thutade Lk	Thutade Lake	12	205-240	216	0	NA	NA	12	0-0	0	0	NA	NA

Figure 3-12. Key mercury-related relationships for kokanee (KOKA).

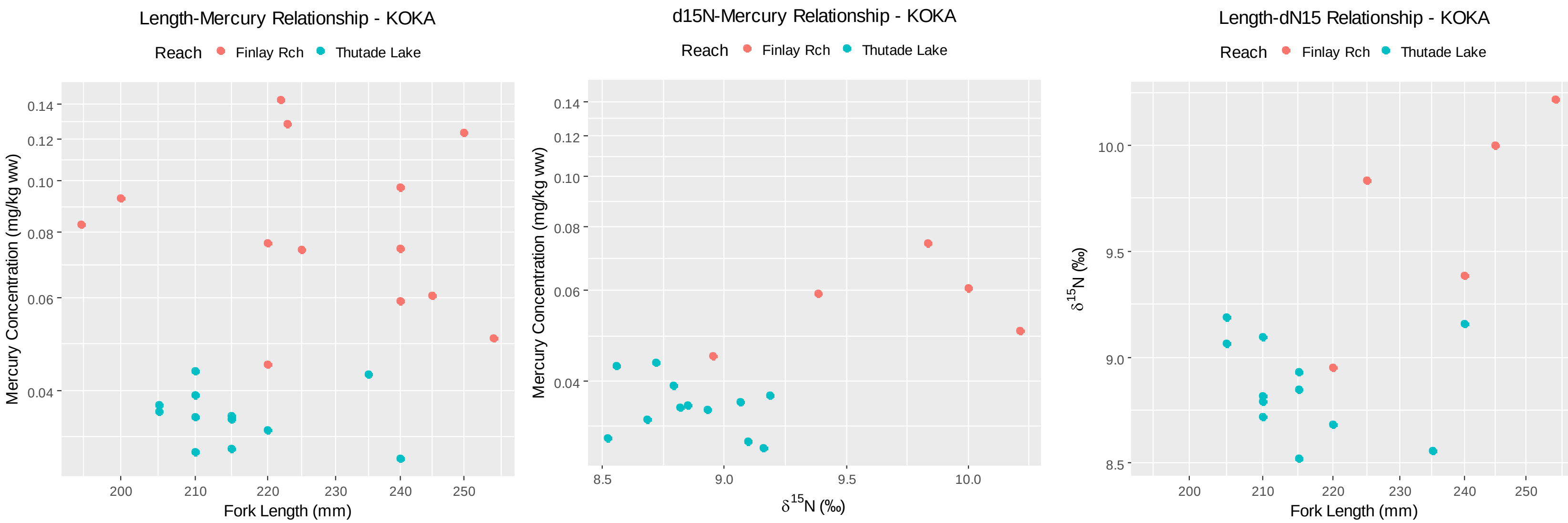
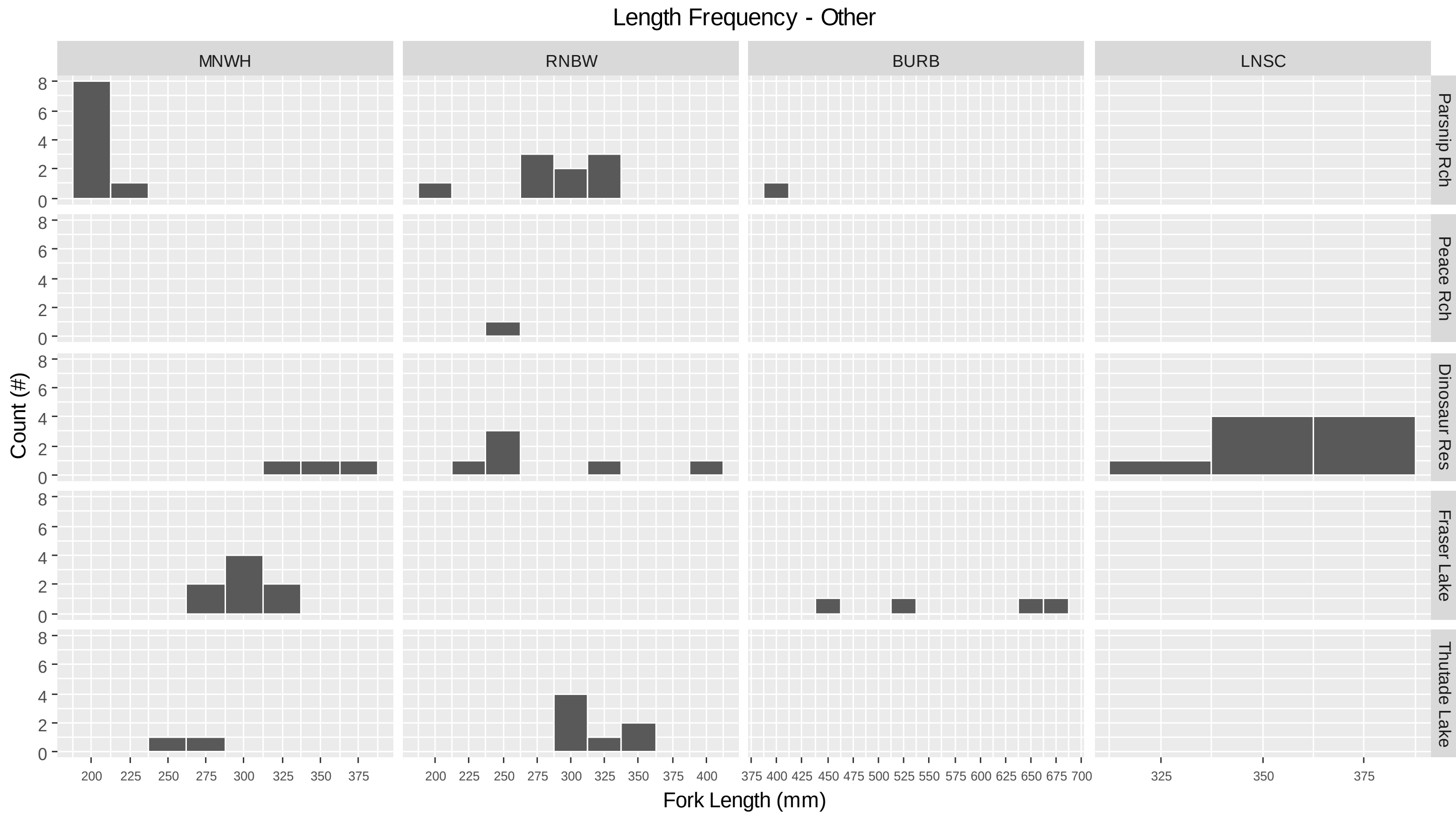


Figure 3-13. Length frequency and meristic data summary for mountain whitefish (MNWH), rainbow trout (RNBW), burbot (BURB), and longnose sucker (LNSC).



See meristic data results on next page.

Year	Sp	Waterbody	Reach	Area	N.FL	FL.Range	FL.Mean	N.Wt	Wt.Range	Wt.Mean	N.K	K.Range	K.Mean	N.Age	Age.Range	Age.Mean
2016	MNWH	Williston Res	Parsnip Rch	Parsnip Rch	9	189-225	204	9	47.5-87.8	73	9	0.42-1	0.89	0	NA	NA
2016	MNWH	Dinosaur Res	Dinosaur Res	Johnson Creek	3	325-365	346	3	330-380	357	3	0.68-1.05	0.88	0	NA	NA
2016	MNWH	Fraser Lk	Fraser Lake	Fraser Lake	8	282-329	304	8	260-460	363	8	1.08-1.63	1.28	0	NA	NA
2016	MNWH	Thutade Lk	Thutade Lake	Thutade Lake	2	250-265	258	0	NA	NA	2	0-0	0.00	0	NA	NA
2016	RNBW	Williston Res	Parsnip Rch	Parsnip Rch	9	202-324	286	9	88.2-724	278	9	0.61-2.13	1.08	0	NA	NA
2016	RNBW	Williston Res	Peace Rch	Table Creek	1	250-250	250	1	130-130	130	1	0.83-0.83	0.83	0	NA	NA
2016	RNBW	Dinosaur Res	Dinosaur Res	Johnson Creek	6	234-411	288	6	50-600	198	6	0.39-0.86	0.66	0	NA	NA
2016	RNBW	Thutade Lk	Thutade Lake	Thutade Lake	7	300-350	319	0	NA	NA	7	0-0	0.00	0	NA	NA
2016	BURB	Williston Res	Parsnip Rch	Parsnip Rch	1	400.2-400.2	400	1	384.3-384.3	384	1	0.6-0.6	0.60	0	NA	NA
2016	BURB	Fraser Lk	Fraser Lake	Fraser Lake	4	450-679	576	4	500-2050	1250	4	0.55-0.65	0.59	0	NA	NA
2016	LNSC	Dinosaur Res	Dinosaur Res	Johnson Creek	9	330-377	358	9	350-500	430	9	0.79-1.01	0.94	0	NA	NA

Figure 3-14. Length-weight and length-mercury relationships for mountain whitefish (MNWH), rainbow trout (RNBW), burbot (BURB), and longnose sucker (LNSC).

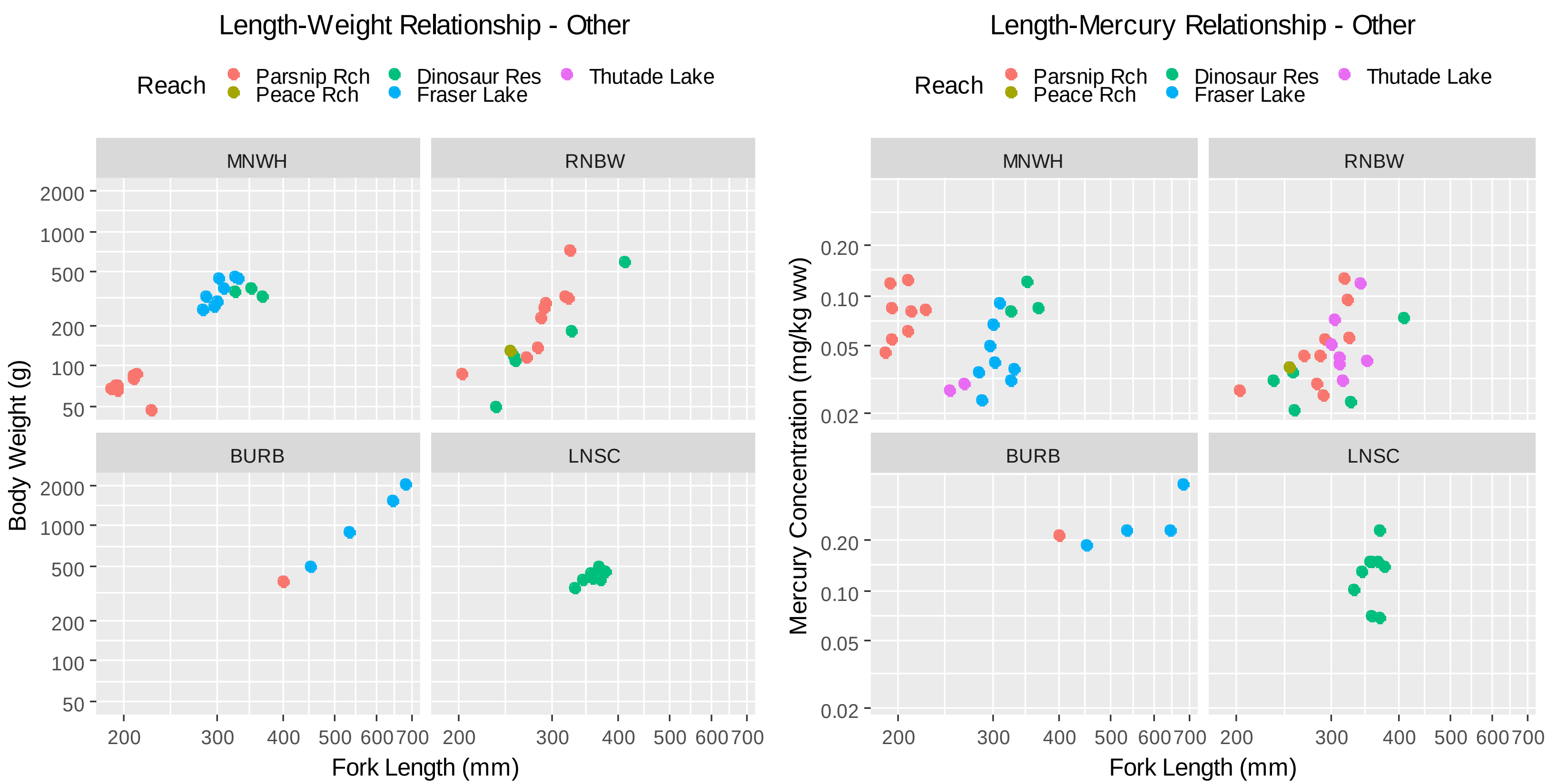
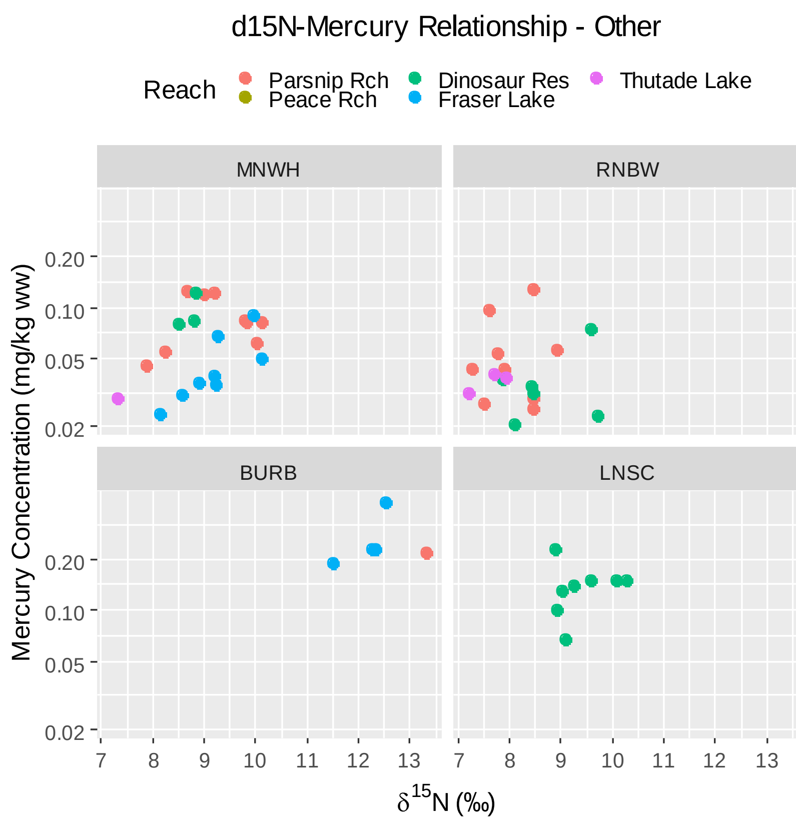
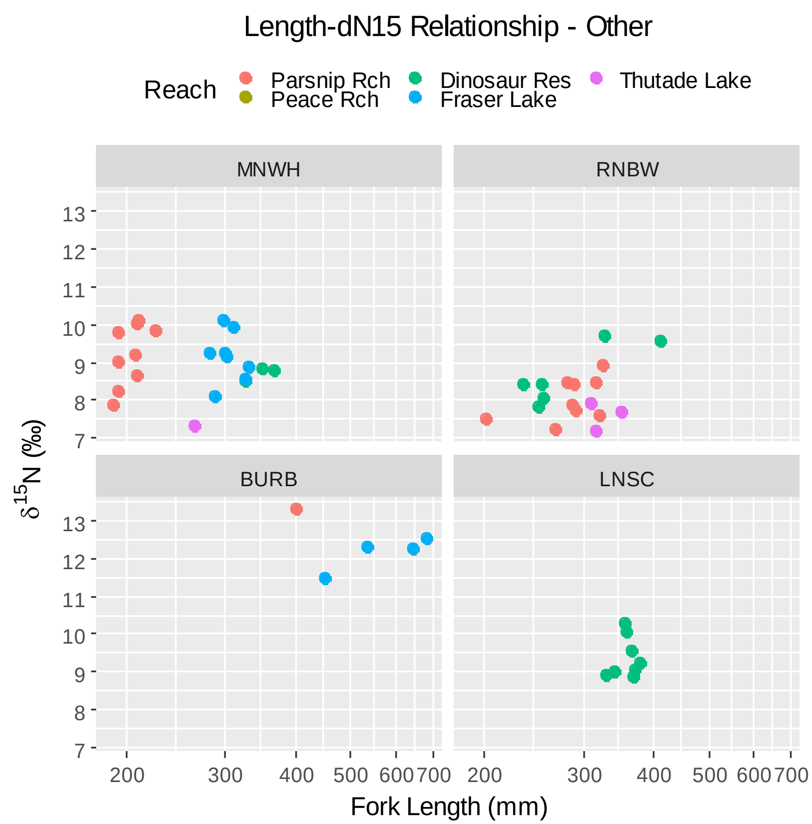


Figure 3-15. Nitrogen ($\delta^{15}N$)-mercury and length-nitrogen ($\delta^{15}N$) relationships for mountain whitefish (MNWH), rainbow trout (RNBW), burbot (BURB), and longnose sucker (LNSC).





4. IMPLICATIONS FOR FOLLOW-UP STUDIES

This program was originally envisioned to be implemented over three years, with 2016 being the first. Results of preliminary analyses are presented in **Section 3**. **Section 4** compiles key data gaps and recommendations to inform the next phases of this investigation. As noted earlier, study resources were directed towards getting more fish mercury samples rather than conducting more detailed analyses of the data.

The status of sample collection by species is shown in **Table 4-1**. An overview of results and discussion for key species is as follows:

- *Lake Trout* – We are on track with this species. The existing data show a strong length-mercury relationship, especially for larger size fish. This warrants continuation of the size-class-based strategy that has been implemented. While smaller fish are needed in Parsnip Reach, these size classes can likely be obtained efficiently at the Duz Cho Logging fishing derby in 2017. Strategic sampling of the Peach Reach is the main focus of 2017 sampling, while opportunistic sampling within Finlay Reach will continue to be carried out by CCE. The program on Fraser Lake successfully acquired fish from across the size spectrum. In general, mercury concentrations of Williston Reservoir lake trout appear similar to concentrations in Fraser Lake. These results are not unexpected given the age of the reservoir. To put Williston Reservoir watershed in better regional context, we are adding additional reference lakes to the program where possible.
- *Bull Trout* – We are on track with this species. The current data indicate a weak relationship between increasing length and mercury for fish that are smaller than about 600 mm. Beyond this size, tissue mercury concentrations rise sharply for larger fish, suggesting a switch in diet by larger fish and/or lowered growth rates. The overall mercury-size relationship is life history, movement and migration pattern and variable diet that will make 'general' conclusions difficult. Nevertheless, our preliminary analysis highlighted some potential differences within the reservoir (i.e., Parsnip Reach higher than Finlay Reach) and between Williston Reservoir and Thutade Lake (i.e., large bull trout from Thutade Lake appear to have lower mercury concentrations than similar sized fish from Williston). Given the clear differences in mercury concentrations between smaller and larger bull trout, we recommend continuation of the size-class-based strategy we have implemented. Additional sampling should be conducted in Thutade Lake in 2017. Strong consideration should be given to adding at least one more reference lake for bull trout to better characterize regional conditions. Additional samples are also needed in each of the Williston reaches and in Dinosaur Reservoir. The main foci for 2017 will be Finlay Reach and Peace Reach.
- *Lake Whitefish* – Sampling to date of lake whitefish in Parsnip Reach resulted in catching a fairly narrow size range (19 of 24 fish were in 250 to 300 mm size class), which is consistent with historic data from Finlay Reach; the size range from Fraser Lake was a bit broader, but most fish were within two size classes. Regardless of this difference, mercury concentrations were relatively low in both systems, with no apparent size-mercury relationship for Williston Reservoir fish. While the length-mercury relationship was inconsistent between the two areas, the 251 to 300 mm size class is well-represented in both Parsnip Reach and Fraser Lake. Thus, the strategy for lake whitefish could be modified to focus on that size class (i.e., size-class based approach)

for assessing spatial trends (while opportunistically sampling mercury in other size classes). While this approach might lose some information, the benefits of shifting sampling and analysis resources to other species (e.g., lake trout or bull trout) would likely outweigh the drawbacks.

- *Kokanee* – Similar to lake whitefish, kokanee catches in both Thutade Lake and Finlay Reach were also limited to small fish within a narrow size range (i.e., 201 – 250 mm); no kokanee were caught in the targeted program in Parsnip Reach in 2016. As expected, there was no relationship between fish length and mercury concentration. Consequently, a change in strategy to size-class based approach (i.e., based on single size class only) is needed to characterize mercury concentrations in kokanee in the reservoir. Based on our understanding of kokanee populations in the reservoir, it may be prudent to adopt a reservoir-wide strategy and have a dedicated effort to sample prior to spawning. We recommend targeting the 201 to 250 mm size class only.
- *Other Species* – Creel survey results indicated that several other species may commonly be consumed, such as ling (burbot), rainbow trout and northern pike from lakes directly connected to the reservoir (e.g., McLeod Lake) or downstream on the Peace River (e.g., Moberly Lake). Fish tissue samples will be collected from these species and archived / analysed to fully characterize mercury concentrations in commonly consumed species within this watershed.
- *General* – The use of stable isotope analysis and mercury analyses to date has been limited to fish. While these complementary tools provide insights into the role of feeding relationships in driving fish mercury concentrations, their application to 'fish only' results limit our ability to further elucidate some of the potential underlying reasons for observed patterns in fish mercury concentrations. Applying SIA to lower levels of the food chain (e.g., zooplankton and benthic invertebrates) may help to resolve this. While not integrated into our 2017 program, consideration should be given to implementing this study element in the future if there is a greater appetite to understand the "why" behind observed differences in this investigation.

Table 4-1. Sampling status by species for the Williston-Dinosaur Watershed Fish Mercury Investigation after the 2016 program.

Waterbody (Reach)	Lake Trout	Bull Trout	Lake Whitefish	Kokanee	General
Williston-Dinosaur					
Williston (Parsnip)	Good numbers for big size classes. Need to fill smaller size classes.	Need more samples from all size classes.	Have lots of 251-300 mm size class; sufficient fish for a size-class based approach.	No samples yet; pursue size-class based approach.	Consider measuring SIA and Hg in zooplankton and benthic invertebrates.
Williston (Finlay)	Limited fish to date; need full range.	Need more samples from 301 to 400 mm size class.	No samples yet; need full range.	Have lots of 201-250 mm size class; sufficient fish for a size-class based approach.	Consider measuring SIA and Hg in zooplankton and benthic invertebrates.
Williston (Peace)	No samples yet; need full range.	No samples yet; need full range.	No samples yet; need full range.	No samples yet; pursue size-class based approach.	Consider measuring SIA and Hg in zooplankton and benthic invertebrates.
Dinosaur	No samples yet; need full range.	No samples yet; need full range.	No samples yet; need full range.	No samples yet; pursue size-class based approach.	Consider measuring SIA and Hg in zooplankton and benthic invertebrates.
Reference Lakes					
Thutade Lake	NA	Relying on 2014/15 data now (no SIA). Either need full range of new data or augment older data with smaller size classes.	NA	Have lots of 201-250 mm size class; sufficient fish for size-class based approach.	Consider measuring SIA and Hg in zooplankton and benthic invertebrates.
Fraser Lake	Good size range and sample numbers in each.	NA	Adequate numbers only in 251-300 mm and 351-400 mm size classes sufficient fish for a size-class based approach targeting 251-300 mm.	NA	Consider measuring SIA and Hg in zooplankton and benthic invertebrates.
New	Recommend adding new reference areas for regional context.	Recommend adding new reference areas for regional context.	Recommend adding new reference areas for regional context.	Recommend adding new reference areas for regional context.	Consider measuring SIA and Hg in zooplankton and benthic invertebrates.

Colour Legend: **Sufficient Data** | **Need More Data** | **Limited or no data yet**

NA: Not applicable as lake does not contain that target species.

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APPENDIX A

Standard Operating Procedures and Training Session Summary Documents

Williston Reservoir Watershed Fish Mercury Study – Training Session

The objective of this training session is to inform people about the Williston Reservoir watershed fish mercury study, provide background information on the issue of mercury in fish and to train people how to process fish to take a tissue sample for mercury analysis. As representatives for your communities, we are training you to be able to collect and store tissue samples over the course of the summer and fall, from fishing derbies, dedicated fishing trips or camps, or opportunistically from community members.

When – To be held on July 6 from 10:00 to approximately 2:30 PM in Mackenzie BC.

Where – At Morfee Lake, near the picnic area located just 2 km east of Mackenzie and is accessed from Centennial Drive by a gravel road – see the attached map. Morfee Lake is divided into two sections by a large sandbar, we will be at *First Beach*, along the Morfee Lake road.

What to bring – Bring a notebook and pen or pencil to make notes. We are hoping there is no rain of course, but dress appropriately for the weather. We'll be working outside at the picnic area, so bring a hat for sun protection. Also, given that attendance is uncertain, please bring a lunch; however, we will also provide drinks and some snacks.

Who is involved – The lead consultant for this work is Azimuth Consulting in Vancouver. Other people attending are Tim Antill representing EDI Environmental in Prince George, Mike Tilson from Chu Cho Environmental in Tsay Key Dene, Cheryl Chingee from Northern Spruce in McLeod Lake and Darrell Garbitt from 4Evergreen in Saulteau.

Agenda

10:00 - 10:30 AM **Introduction to the 2016 – 2018 Williston Reservoir Mercury project** – There will be an opening welcome/prayer, an introduction to the project and study team, an overview of why the study is being done and the ultimate the goals of the project.

10:30 – 11:00 **Background information on mercury in the environment** – To put this issue into perspective, all participants, including our study partners will receive training on the science of mercury in the environment, including in air, water, land and animals, with an emphasis on fish. A summary of this information will also be handed out and/or emailed.

11:00 – 12:00 **Fish tissue extraction techniques** – For the next hour or so, a demonstration of each step in the technical procedure to record the appropriate information (species, length, weight) on a data recording sheet, steps to remove, package and label a tissue sample, handling, storage and shipping will be discussed. Two techniques will be presented – collecting tissue from a dead fish or from a live fish using non-destructive, biopsy techniques. This is a technique developed by Azimuth that has been widely used in Canada to take tissue samples from fish in science programs without causing long-term harm.

12:00 – 12:45 Lunch

12:45 – 1:45 **On-hands experience** – All participants will be able to work with fish supplied by Azimuth and EDI to practice using a biopsy tool to collect a tissue sample from a fish for mercury analysis. This will include all steps in the collection, handing, labeling, and storage of tissue.

1:45 – 2:30 **Questions and Answers** – Participants will have an opportunity to ask questions, conduct further practice and speak with the team and each other as to how we can achieve the project goals!

Directions to find Morfee Lake, First Beach picnic area – see the red square, lower right. Take Morfee Lake Road from Centennial Drive, just south of town.

FWCP-PEACE MERCURY INVESTIGATION PROGRAM - FISH KIT

Version: 7 July 2016

Each sampling kit is contained within a Rubbermaid tote and has the following materials:

- Spring scale (some kits)
- Measuring tape
- Disposable nitrile gloves
- Anesthetic – clove oil & rubbing alcohol (with quick-reference card of mixing instructions)
- Scalpel and disposable scalpel blades
- Fillet knife
- 6 mm Biopsy punches
- Plastic cutting board and small plastic 'boats'
- Forceps
- Small vials for **biopsy samples**
- Waterproof sticky labels for small vials
- Whirl-Pak© bags for **fillet samples**
- Bottle of Vetbond liquid bandage
- Soap and scrub brush
- Clipboard with these procedures & datasheets
- Sharpie markers and pencils

Many thanks to you for participating in the training and being your community's liaison for this program! As the holder of a FISH KIT, you are the designated representative for your community responsible for the proper collection, handing, and recording of information and storage of fish tissues for this program.

As community liaison, you will work with Azimuth during the course of the summer to collect:

1. Fish tissues for the lab assessment of mercury content
    a. Fish data sheets
    b. Tissue samples will be collected, stored, and shipped using described methods
2. Information on the general fish consumption patterns within your communities
    a. Creek Survey data sheets
    b. When you collect a tissue sample from a fish, this is an opportunity to interview the fisherman about their fish consumption habits.

It is important that you communicate with Azimuth on a regular basis so that we can help you maximize the number of samples you collect during the course of the summer. The information you collect is key to this programs success. Thank you again!

Randy Baker, Project Lead
Azimuth Consulting Group Partnership

Fish Tissue Collection and Recording Procedures

1. RECORD KEEPING

If you are **sampling fish tissue**, use the datasheet labelled "**Fish Tissue Sample Records**". The datasheets are printed on waterproof paper; a pencil should be used to write on this type of paper. Fill in a separate line for every individual fish sampled. Fill in the following information:

- Record Information:
  - **Number** sample
  - **Date** the record was taken
  - **Name** of the person recording the data
- Fishing Information:
  - **Date** the fish was caught
  - **Name** of the person who caught the fish
  - Description of the approximate **location** where the fish was caught. Include which reach of Williston Reservoir if appropriate (i.e., Finlay, Parsnip, Peace)
  - IF caught on a river, indicate using a unique code for each… for example, Pack River = PackR; Manson River = MR; Nation River = NR; Crooked River = CR, Back River = BR; McLeod Lake = ML; Parsnip River = ParsnipR
- Fish Sample Information:
  - Fish **species** sampled (use 4-letter abbreviations listed on the datasheet)
  - **Fork length** of the fish in millimeters (mm) – from tip of snout to fork in middle of tail
  - **Weight** of the fish in grams (g), if possible
  - Indicate whether a **biopsy** (B) or a **fillet** (F) sample was taken
  - **Sample ID** that is written on the sample (vial or bag); assign an ID using the 4-letter fish species code, followed by the waterbody the fish was captured in, followed by a sequential number, followed by the date caught.

  For example, the sixth bull trout captured from Crooked River on July 4 would be assigned the code- **BLTR-CR-06-July 4**

Contact Randy Baker or Laura Bekar at Azimuth Consulting Group in Vancouver if you have any questions:

- Office phone: 604-730-1220
- Email: rbaker@azimuthgroup.ca or lbekar@azimuthgroup.ca

2. SAMPLE COLLECTION

Biopsy or Fillet Sample?

When sampling fish tissue, decide whether a biopsy sample or a fillet sample will be collected. If fish are being caught-and-released alive, then it is preferable to collect a biopsy sample. However only large fish can survive the wound of a biopsy sample. If fish are already dead or will be sacrificed, or the fish is small, then it is preferable to collect a fillet sample.

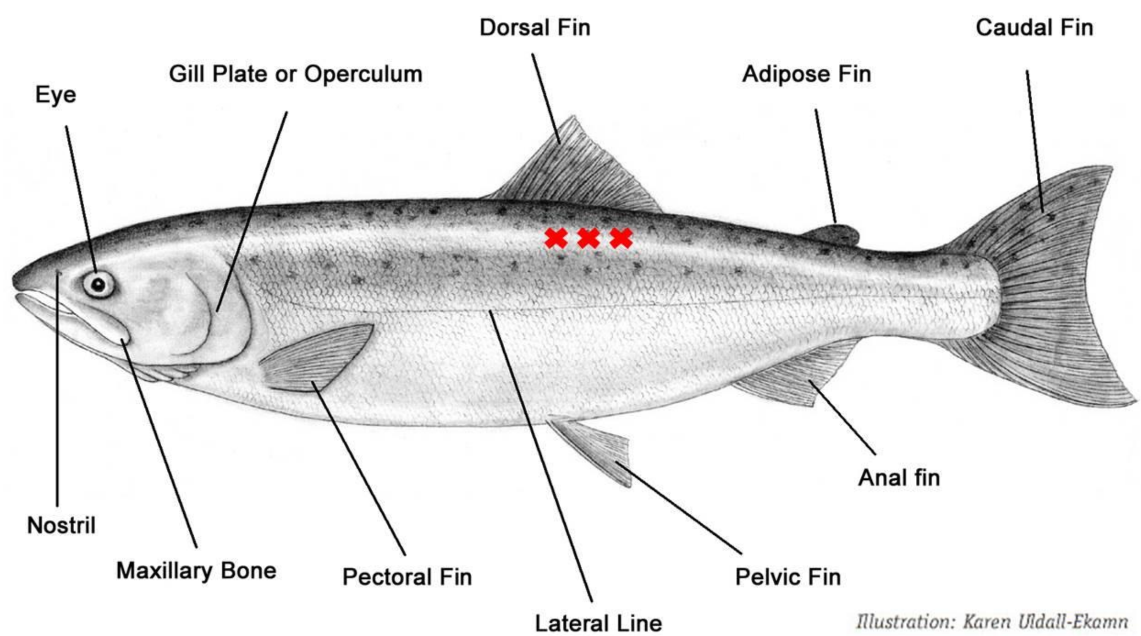
Biopsy Sample Collection

This procedure is conducted on live fish over 200 mm in length (anything smaller likely won't survive the wounds). Fish are anesthetized then released back into the water after recovery. This procedure is preferably done with two people, one person to handle the fish and one person to record the data.

1. Put on a clean pair of nitrile gloves and ensure that all equipment is clean or new.
2. Prepare the fish anesthetic bath in a large plastic tub (the tote used for the FISH KIT works well). To do this, collect about 10 liters (L) of lake water into the tub (or this is equivalent to filling the Rubbermaid tote about ¼ full). Then mix about 1 generous drop of clove oil combined with 9 drops of rubbing alcohol. Add the clove oil/rubbing alcohol mixture to the lake water. If the bath seems too shallow, double the quantity of water and anesthetic. The anesthetic bath should be replaced after 8 – 10 fish are sampled or more frequently in hot weather to rejuvenate the water.
3. Place the live fish in the anesthetic bath for 1 – 2 minutes and wait until such time as it has lost equilibrium (swimming on side). If it does not lose equilibrium during this time, add a bit more clove oil / alcohol mixture.
4. Measure and record fork length (mm; i.e., from the snout along the body to the middle of the tail notch) and total weight (g), if a scale is available.
5. Place the fish on its right side on a large flat surface. Remove the 6 mm diameter biopsy punch from the package. While holding the fish down with your left hand, use the tool in your right hand to gently scrape away several scales from the left side of the fish, just beneath the dorsal fin, as shown where **X X X** is illustrated in the fish diagram below.
6. To extract a tissue sample, twirl the biopsy tool back and forth with gentle downwards pressure to allow the tool to cut through the skin and into the dorsal muscle. Once fully inserted to the plastic handle, turn sideways so the tool is parallel with the fish and twist

again a few times to cut the tissue. Then, lift upwards, removing the tool with the tissue plug embedded in the end of the tool.

7. Using your mouth, blow the sample out of the tool onto a clean, plastic surface (cutting board or weigh boat) for processing. Examine the plug for acceptability. The tissue plug should appear to be an intact piece of muscle that filled or nearly filled the punch and should be about 1 cm long.
8. Using the same biopsy tool, repeat the procedure to extract two more tissue plugs from the same area where the scales were scraped away. Again, place this on the clean plastic surface for processing. Now seal the 3 punch holes in the fish by placing a few drops of the '3M Vetbond' liquid tissue adhesive. This is a veterinary supply material that seals the wound immediately on contact with water or blood. Once hardened in a few seconds, place the fish into a recovery tub with sufficient fresh, clean water to allow the fish to recover. If no tub, gently hold the fish in the lake/creek. Gently move the fish through the water to allow water to flow across the gills. Only release once the fish has fully recovered from the anesthetic.



9. Using the scalpel, remove the outer skin from the 3 tissue plugs, leaving only the muscle tissue. Use the tweezers to transfer **two tissue plugs into one small sampling vial for**

mercury analysis. Transfer the third tissue plug into a second vial for analysis of stable isotopes.

10. Seal the vials and label them as indicated in the record keeping section, using the waterproof sticky labels and the Sharpie marker provided. Both vials are labelled with the same ID; however, **indicate on the label which vial has one (1) plug for stable isotopes (SI) and which vial has (2) plugs for mercury (Hg).**
11. Put the tissue sample vials on ice in a cooler in the short term and transfer to a freezer as soon as possible. It is preferable to organize the vials into a single large Ziploc bag by species/date etc. to minimize the chances of vials getting lost.
12. Prior to processing the next fish, ensure that your working surface is clean. Use a drop of the provided concentrated soap and the brush to scrub clean all equipment between each fish. Use the lake water for rinsing (this soap is safe for the environment).
13. Dispose of the biopsy punch and use a new punch for each fish. Make sure that the punch samples are put on ice and frozen as soon after collection as practical.

Fillet Sample Collection

This procedure is only conducted on dead fish that are being sacrificed for consumption or science. Only a small amount of fillet is needed (size of a pack of gum) and can be collected from an area that doesn't impact the take-home fillet a fisherman desires, like near the head or tail. This procedure can be done by one person as there is no time pressure to work fast since the fish is already dead.

1. Put on a pair of nitrile gloves and ensure that all equipment is clean.
2. Measure and record the fish's fork length (mm) and total weight (g). If you have a scale handy, record the weight to the nearest gram. If you have a spring scale, place the fish in a large Ziploc bag to hang from the scale. Subtract the weight of the bag, or use the "tare" function before adding the fish.
3. Place the fish on its right side. Using the fillet knife, cut out a small section of muscle (aim for 10 – 15 grams). The area just beneath the dorsal fin (same area as shown in the above diagram for biopsy) is a good location, but any area of the fish fillet will do (near head or tail is just fine). Place fillet onto a clean plastic cutting board for processing.
4. Seal the bags and label them as indicated in the record keeping section above, using a sharpie marker (write directly on the Whirl-Pak© bag in the white section or use provided labels). Both bags are to be labelled with the same ID.

5. Put the tissue sample bags on ice in a cooler in the short term and transfer to a freezer when possible.

6. Clean all materials. To do this, use a drop of the soap (it's quite concentrated) and the brush to scrub clean. Use the lake water for rinsing (this soap is safe for the environment).

3. STORAGE AND SHIPPING

- All samples should be ***frozen as soon as possible*** after sampling
- Contact Randy Baker or Laura Bekar at Azimuth Consulting Group in Vancouver when your sampling program is finished (if short term sampling) or at the end of each month (if ongoing sampling) to coordinate a shipping plan:
    - Office phone: 604-730-1220
    - Email: rbaker@azimuthgroup.ca or lbekar@azimuthgroup.ca
- We will send you shipping instructions at that time; but you will likely be shipping samples to Azimuth's office; OR, someone from BC Hydro our one of our other partners may pick the samples up directly from you. We can help you coordinate this.
- If we do use a courier, samples need to be kept frozen while shipping – use a cooler and ice packs (lots) and select a one-day shipping service
- Please include all the data sheets, placed inside a sealed zip loc bag so they are dry and place these with the samples in the cooler
- Double check to make sure that the number of samples and information on the data sheets matches the tissue samples in the cooler you are sending, or give to us.

CREEL SURVEY INFORMATION

A creel survey is basically the name given to the gathering of information on things people might eat – in this case, fish! For this information collecting exercise we are interested in learning the ***general pattern of fish consumption of an individual or family in your community***.

- What species are consumed by individuals in your community?
- How often are each species eaten?
- How big a serving portion is normally eaten?

Questions like these help us understand the exposure people may have to the contents of fish, including nutrients and mercury.

Your creel survey may focus on what people can remember they eat, say over the last week or two, or might document special events such as a fishing expedition. Consumption might also be high in summer but low in winter. Remember to document this sort of information and if a special event, how often these happens… 1, 2 or 3x per summer? during the weekend? or during the summer? Do you fish during the winter? – or is frozen fish eaten that they caught in the summer?

Contact Randy Baker or Laura Bekar at Azimuth Consulting Group in Vancouver if you have any questions, need more creel survey sheets or when the summer is over and fishing has ceased.

    - Office phone: 604-730-1220
    - Email: rbaker@azimuthgroup.ca or lbekar@azimuthgroup.ca

1. RECORD KEEPING

If you are conducting a Creel Survey, use the datasheet labelled "**Creel Survey Records**". The creel survey datasheets are printed on waterproof paper; a pencil should be used to write on this type of paper. Fill in the following information:

- Recorder Information:
    - **Date** the record was taken
    - **Name** of the person recording the data
- Catch Information:
    - **Date** the fish was caught, if appropriate … a range can be used if a fishing trip
    - **Name** of the person who caught the fish or who is being interviewed

- Description of the **location** where the fish was caught. Include which reach of Williston Reservoir if appropriate (i.e., Finlay, Parsnip, Peace)
- If caught on a river, indicate using a ***unique*** code for each… for example, Pack River = PackR; Manson River = MR; Nation River = NR; Crooked River = CR, Back River = BR; McLeod Lake = ML; Parsnip River = ParsnipR. Make up your own code if not from one of these waterbodies.
- Fish **species** that was caught – if more than one species, list then and describe how many per species were caught for consumption
- The **number** of fish caught for each species – you can use a separate line for different fish species if lots were caught and if that is easier for you.

- Consumption Information:

This is where we need to gather information on the pattern of fish consumption by the person you are interviewing. Ask them questions about the following things:

- What fish **species** is normally eaten
- The approximate **number of meals per week** for each fish species consumed ("frequency") – be as descriptive as necessary to accurately determine how often fish is eaten.
- The **meal size** in grams or ounces if possible. A descriptor is also fine … such as a quarter pound, size the size of my palm, or the size of my hand, etc.

Be as descriptive as you need to be and write as many notes as necessary to capture as accurately as you can about the amount of different fish that people eat over time.

Fish Tissue Sample Records

	Recorder Information		Fishing Information			Fish Sample Information					
	Date Recorded	Name of Recorder	Date Caught	Name of Fisher	Location Caught	Species Code	Length (mm)	Weight (g)	Biopsy (B) or Fillet (F)	Sample ID	Comments?
Example	28-Jun-16	Laura Bekar	27-Jul-16	Randy Baker	Pack River PR	BLTR	482	none taken	F	BLTR-PR--04-July27	Eaten for dinner
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											

Notes:

Location Caught: provide an accurate a description of the location; if in Williston, include the reach (i.e., Finlay, Parsnip, Peace), or use the code below or assign a new one

Species Code: use the following abbreviations - **BLTR**=Bulltrout, **LKTR**=Lake trout, **RNBW**=Rainbow trout, **KOKA**=Kokanee, **ARGL**=Arctic grayling, **PMCH**=Peamouth chub, **LKWH**=Lake whitefish, **MNWH**=Mountain whitefish, **BURB**=Burbot, **LNSC**=Longnose sucker, **LGSC**=Largescale sucker, **WHSC**=White sucker, **RDSH**=Redside shiner.

Sample ID: assign a ***unique*** ID code to each tissue sample using the 4-letter species code, followed by the waterbody code, a unique sequential number, and the date of capture.

Waterbody Codes: Williston Reservoir Parsnip reach =WRFR; Pack River = PackR; Crooked River - CR; Manson Rver = MR; Nation River = NR; McLeod Lake = ML; Parsnip River = ParsnipR

Creel Survey Records

	Recorder Information		Fishing Information		Consumption Information				
	Date Recorded	Name of Recorder	Name of Fisher	Location of Fishing	Fish Species Consumed	Number Caught	Frequency of Meals	Meal Size (g)	Description or Comments on Fish Consuption Patterns
e.g.	27-Jul	Cheryl Chingee	John Snow	Back River, about 50 km upstream of reservoir	Bull trout, rainbow trout	3 of each	We had fish 2x/day for 3 days	About 400 g per meal	Fish were caught on a weekend fishing trip; John does this about once a month during summer. His wife and kids usually come along and eat about half of what John does. His kids are 7 and 9. Tissue samples collected from 3 fish: BLTR-BR-04, BLTR-BR-05, BLTR-BR-04
1									
2									
3									
4									
5									
6									
7									
8									

Notes:

Location Caught: Describe the location fish were caught - if in Williston, include the reach name WRParsnip; If a river, use the code Back River = BR; Crooked River = CR; Parsnip River = PR; McLeod Lake = ML; etc.

Fish Species: use the following abbreviations - **BLTR**=Bulltrout, **LKTR**=Lake trout, **RNBW**=Rainbow trout, **KOKA**=Kokanee, **ARGL**=Arctic grayling, **LKWH**=Lake whitefish, **MNWH**=Mountain whitefish, **BURB**=Burbot, **LNSC**=Longnose sucker, **LGSC**=Largescale sucker, **WHSC**=White sucker

Consumption: Describe the ***pattern*** of fish consumption which fish are eaten during a typical or specific week to incluce **Frequency of consumption** (# meals eaten per week) and **Meal Size** in grams, ounces or describe

APPENDIX B

Environmental Dynamics Inc. Catch Summary Log – Parsnip Reach

ENVIRONMENTAL DYNAMICS INC.

301 George Street
Prince George, BC V2L 1R4
P: (250) 562-5412

December 15, 2016

EDI Project No: 16P0108

Azimuth Consulting Group
218-2902 West Broadway Ave
Vancouver, BC. V6K 2G8

Attention: Randy Baker

RE: Williston Reservoir, Parsnip Reach Fish Tissue Collection - 2016

In 2016, EDI Environmental Dynamics Inc. (EDI) was responsible for collecting fish tissue within the Parsnip Reach of the Williston Reservoir for Azimuth Consulting Group (Azimuth). The fish tissue collection was associated with BC Hydro's Fish and Wildlife Compensation Program (FWCP) Peace Mercury Investigation Project. Fish tissue for mercury and stable isotope analysis was collected during two separate events, the Duz Cho Fishing Derby and a dedicated sampling program. This document is intended to provide a brief summary of methods and sampling results for fish tissue collection within the Parsnip Reach in 2016.

Duz Cho Fishing Derby

Fish tissue was acquired during a fishing derby hosted by Duz Cho Logging Ltd. (Duz Cho) on August 20 and 21, 2016. The Duz Cho Fishing Derby was located at Cut Thumb Bay situated 40 km north of Mackenzie on the east side of the Parsnip Reach. An EDI biologist assisted with the official weigh-in of derby fish. For each fish brought into the weigh station it was identified to species, given a unique alphanumeric identifying code, and fork length (mm) and total weight (g) was recorded. In most cases the fish were gutted, allowing for sexing, inspection of stomach contents, and general internal health assessment. Otoliths for ageing were also collected and placed in labeled envelopes. Wearing clean nitrile gloves and using a sterile fillet knife and cutting surface, a small (10-15 g) fillet sample was removed from the caudal peduncle of the fish. Skin was removed during the filleting process. The fillet was cut in two, with each portion being placed into a labeled Whirl-Pak sample bag; one for mercury analysis and one for stable isotope analysis. Samples were stored in a cooler with ice packs, and transferred to a freezer at the end of each day.

Participants in the fishing derby brought 50 fish to the weigh-in station; the catch consisted of 48 lake trout (*Salvelinus namaycush*), one bull trout (*Salvelinus confluentus*) and one rainbow trout (*Oncorhynchus mykiss*) (Table 1). The largest fish caught in the derby was a lake trout measuring 949 mm in length and weighing 11,249 g. Of the lake trout, 45 exceeded 700 mm in length. The one bull trout brought in was an accidental capture. The smallest fish recorded was the lone rainbow trout (fork length 286 mm). This fish was brought to the weigh-in station by an engaged participant wanting to provide a tissue sample to the program. Otoliths were collected from 39 individuals. Of the stomachs of 27 fish examined, 93% were empty. The total stomach content of all fish examined consisted of two kokanee (*Oncorhynchus nerka*) and six lake whitefish (*Coregonus clupeaformis*).

Overall, participants were very interested in the study and willing to offer their fish for tissue sampling. Most participants in the derby were aware of the consumption advisory in the reservoir. Many fishers practiced catch and release due to concerns related to mercury levels in fish tissue, however a number of individuals reported consuming fish at low to moderate levels, preferring to target smaller fish than those captured in the derby.

Table 1. Size class and species of fish captured during the Duz Cho Fishing Derby.

Length (mm)	Lake/ Mountain Whitefish	Lake Trout	Bull Trout	Kokanee	Rainbow Trout	Burbot	Northern Pikeminnow	Peamouth Chub
100-199								
200-299					1			
300-399								
400-499								
500-599								
600-699		3						
>700		45	1					
Total	**0**	**48**	**1**	**0**	**1**	**0**	**0**	**0**

Parsnip Reach Sampling Program

The goal of the Parsnip Reach Sampling Program was to acquire 24 – 36 fish, over a range of sizes for four target species; lake trout, bull trout, whitefish and kokanee (Table 2). A crew consisting of EDI and Northern Spruce Contracting Ltd (Northern Spruce) personnel conducted fish sampling on the Parsnip Reach from August 22 to 26, 2016. Sampling was done using a boat and operator from Chu Cho Industries Ltd. Fish sampling techniques included pelagic sets of 64 m monofilament gill nets made up of 8 panels of 57, 64, 70, 76, 89, 102, 114, and 127 mm mesh sizes. These nets were set at depths of 5 to 20 m. Littoral set were done using a 16 m gill net made of two 34 mm mesh panels. These nets were set near shorelines to a depth 10 m. Gill nets were initially set for 2 hour durations; however soak times were generally extended later in the program to improve catch success. Caution had to be used when setting the nets due to the abundance of sunken woody debris within the lake. The on-board depth/fish finder was used to target fish locations and depths, as well as to assess the profile of the lake bottom for trees and other woody debris. Angling/trolling was done opportunistically between sets throughout the program.

There were a total of 14 gill net locations, primarily within the vicinity of the Nation River and Cut Thumb Bay, midway up the Parsnip Reach (Attachment 1 – Sample Site Map). The area around the confluence of the Parsnip Reach was investigated on Day-1, but the general area was relatively shallow with numerous submerged stumps and not considered a great location for sampling, particularly for lake trout. Sampling near Mackenzie was considered, but test sets resulted primarily in non-target coarse fish species. The area around the Nation River and Cut Thumb Bay was targeted, based on comments from local residents at the fishing derby, early and repeated success at capturing target fish species during the program, and the perceived likelihood of capturing kokanee moving into the Nation River system to spawn.

Fish handling and tissue sampling methods followed those identified in the Azimuth *Fish Tissue Collection & Recording Procedures* (2016) document. Non-destructive biopsy sampling was used for bull trout and lake trout; while lethal sampling was used for the other target species. Fillet samples were collected from rainbow trout, lake whitefish, mountain whitefish (*Prosopium williamsoni*), and burbot (*Lota lota*). As requested by Carleton University, whole body samples were collected for northern pikeminnow (*Ptychocheilus oregonensis*) and peamouth chub (*Mylocheilus caurinus*). For live biopsy, efforts were made to minimize fish stress and harm, through the use of aerated holding and recovery tubs, anesthetic baths, Vetbond application to biopsy wounds, and limited handing times. Lethal sampling was required for fillet and whole body tissue collection. Fish were dispatched using blunt force impact to the head.

Each fish used for tissue collection was identified to species, given a unique alphanumeric identifying code, and measured to fork length (mm) and weighed (g). Samples were collected while wearing clean nitrile gloves and using a sterile biopsy tool/fillet knife and cutting surface. Whole body fish were placed in Zip Loc bags, fillets were placed into labeled Whirl-Pak sample bags, and biopsy plugs were placed into labeled vials. Samples were stored in a cooler with ice packs, and transferred to a freezer at the end of each day.

Tissue was collected from a total of 129 fish from the Parsnip Reach during the dedicated sampling program (Table 2). Of the fish captured, 128 were by gillnetting and one rainbow trout by angling. Tissue was collected from 56 whitefish, 19 lake trout, 12 bull trout, 8 rainbow trout, 1 burbot, 13 northern pikeminnow and 20 peamouth chub. Although kokanee were a target species for this study, none were encountered. The desired number of fish for each size class was not achieved during the sampling program (Table 2). Certain size classes were disproportionally captured for lake trout and whitefish. Of the lake trout 74% were >700 mm, while of the whitefish 89% were in the 200-299 mm size class. During the sampling, the shortest fish was a lake whitefish measuring 164 mm and the longest fish was a lake trout measuring 850 mm.

Table 2. Size class and species of fish captured during the Parsnip Reach sampling program.

Length (mm)	Lake/ Mountain Whitefish	Lake Trout	Bull Trout	Kokanee	Rainbow Trout	Burbot	Northern Pikeminnow	Peamouth Chub
100-199	5 (12)*			(12)*			5	11
200-299	50 (12)*			(12)*	5		2	9
300-399	1 (12)*	2 (7)*	3 (7)*		3		6	
400-499		2 (7)*	5 (7)*			1		
500-599		1 (7)*	1 (7)*					
600-699		(7)*	3 (7)*					
>700		14 (7)*	(7)*					
Total	**56 (36*)**	**19 (35*)**	**12 (35*)**	**0 (24*)**	**8**	**1**	**13**	**20**

*Desired number of individuals

For the effectiveness of the gill nets, the catch per unit effort (CPUE) was calculated by determining the number of fish captured by each metre of net for every 100 hours of soak time. The CPUE is represented in hundred hours to reduce the number of decimal places for clarity of results. The total CPUE for all fish was 0.323 fish/m-100 h (Table 3). Lake whitefish had the highest CPUE (0.119 fish/m-100 h) while burbot had the lowest (0.003 fish/m-100 h). The CPUE for opportunistic angling effort was not calculated.

Table 3. Gillnet catch per unit effort for species captured during the Parsnip Reach sampling program.

Species	Number of Individuals	Total CPUE (fish/m-100 h)
Bull trout	12	0.030
Burbot	1	0.003
Lake trout	19	0.048
Lake whitefish	47	0.119
Mountain whitefish	9	0.023
Northern pikeminnow	13	0.035
Peamouth chub	20	0.050
Rainbow trout	7	0.015
TOTAL	**128**	**0.323**

Closure

Fish tissue was collected from 179 fish in the Parsnip Reach during the Duz Cho Fishing Derby and dedicated sampling program. The 2016 program in the Parsnip Reach was successful in collecting tissue samples from a number and sizes of fish species; however the overall desired number of fish for each size class was not achieved. For future efforts, additional sampling time, additional sampling gear, and the selection of different locations/habitat may be required to capture the desired size class distribution for target species.

Please feel free to contact Tim Antill if you have any questions, or required additional detail, regarding the information provided.

Yours truly,

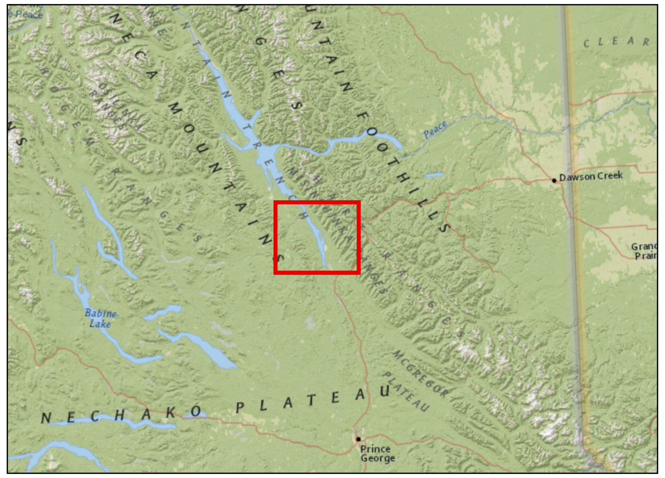
EDI Environmental Dynamics Inc.

Author:
Alissa Nyheim-Rivet
Environmental Scientist

Author/Senior Review:
Tim Antill, M.Sc., R.P.Bio., P.Ag.
Senior Biologist

Attachments:

- Appendix A – Map of Sampling Locations



Legend

Fish Sample Site

Base features from Toporama Web Mapping Service, Natural Resources Canada

BC HYDRO

LOWER WILLISTON RESERVOIR FISH SAMPLE SITES

Drawn: D. Wiens	Checked: T. Antill
Date: 12/20/2016	Data Sources: Refer to References Section
EDI Project Number: 16P0108	Map Projection: NAD 1983 UTM Zone 10N

0 2.5 5 10
Kilometers

Map Scale = 1:225,000 (printed on 11" x 17")

EDI ENVIRONMENTAL DYNAMICS INC.

Path: L:\PROJECTS\16P0108_BCH_Williston_Mercury\Mapping\16P0108_BCH_Williston_Fish_Sample_Sites.mxd

APPENDIX C

Scientific Collection Permit

Ministry of Forests, Lands and Natural Resource Operations

FISH COLLECTION PERMIT

Research

vFCBC Tracking #: 100170460
ATS Project #: 213980

Permit #: PG16-232536

Permit Holder: Leslie Chamberlist
EDI Environmental Dynamics Inc.
301 George Street
Prince George BC V2L 1R4

Authorized Persons: Tim Antill, Jason Yarmish, Vicki Smith, Mark Asquith, John Hagen, Mike Tilson, Sean Rapai, Stephen Friesen.

Pursuant to section 19 of the *Wildlife Act*, RSBC 1996, Chap. 488, and section 18 of the Angling and Scientific Regulations, BC Reg. 125/90, the above named persons are hereby authorized to collect fish for scientific purposes from non-tidal waters subject to the conditions set forth in this Permit:

Permitted Sampling Period: 6/20/2016 to 9/30/2016
Permitted Waterbodies: see Appendix C
Permitted Sampling Techniques: (subject to permit terms and conditions) AG, EF, GN, TN
Potential Species: (subject to permit terms and conditions) LW, LT, BT, KO, RB, BB, MW, GR, LSU, CSU, NSC, LKC, PCC, RSC
Permitted Lethal Sampling: (subject to permit terms and conditions) see Appendix C
Provincial Conditions: (Permit holders must be aware of all terms and conditions):
See Appendix A.
Region Specific Conditions:
See Appendix A.

Authorized by:

Susanne Williamson
Fisheries Information Specialist
A person authorized by the Regional Manager
Recreational Fisheries & Wildlife Programs, Omineca Region

Date: June 10, 2016 Permit Fee $25

Any contravention or failure to comply with the terms and conditions of this permit is an offense under the *Wildlife Act*, RSBC 1996, Chap. 488 and B.C. Reg. 125/90.

Appendix A: Fish Collection Permit Conditions

Any Variation of the following terms and conditions will require explicit authorization by the appropriate regional Fish & Wildlife Section Head.

Provincial Conditions

1. This collecting permit is not valid
   - in national parks,
   - in provincial parks unless a Park Use Permit is also obtained,
   - in tidal waters,
   - for eulachon or for salmon* other than kokanee, or
   - for collecting fish by angling unless the permit holder and crew members possess a valid angling licence.

   This collecting permit is **only** valid for species listed as threatened, endangered or extirpated under the Species at Risk Act (SARA) **in conjunction with a permit issued under Section 73 of SARA from Fisheries and Oceans Canada.**

   *Contact the Department of Fisheries and Oceans for fish collecting permits for salmon, eulachon or SARA listed species (see Appendix B).

2. The permit holder (or the project supervisor) named on the application for a scientific collection permit will carry a copy of this permit while engaged in fish collecting and produce it upon request of a conservation officer, fisheries officer or constable.

3. Any specimens surplus to scientific requirements and any species not authorized for collection in this permit shall be immediately and carefully released at the point of capture.

4. Fish collected under authority of this permit shall not be used for food or any purpose other than the objectives set out in the approved application for a scientific collection permit. The permit holder shall not sell, barter, trade, or give away, or offer to sell, barter, trade or give away fish collected under authority of this permit. Dead fish shall be disposed of in a manner that will not constitute a health hazard, nuisance or a threat to wildlife.

5. No fish collected under authority of this permit shall be
   - transported alive unless authorized by this permit, or
   - transplanted unless separately authorized by the Federal/Provincial Fish Transplant Committee.

6. The permit holder shall, within 90 days of the expiry of this permit, submit a report of fish collection activities. Interim reports may also be required and shall be submitted as required by the permit issuer. All submissions must be filed electronically to: http://www.env.gov.bc.ca/fish_data_sub/index.html

   Reporting specifications, information and templates are available from this website and outline the mandatory information requirements. Prior notification of submission or questions regarding data report standards can be made to: fishdatasub@gov.bc.ca

7. This collecting permit is subject to cancellation at any time and shall be surrendered to a conservation officer on demand or to the issuer upon written notice of its cancellation.

8. This permit is valid only for the activities approved on the application form and in accordance with any restrictions set out therein.

9. This permit is valid only for trained, qualified staff named in the Application. The permit holder will comply with all Worker's Compensation Board requirements and other regulatory requirements. Permit holders are responsible for ensuring staff members listed on the permit are properly certified for specific sampling methods or activities (e.g. electroshocking).

10. Any workers not listed on the permit must be supervised by the permit holder or one of the additional persons as named on the permit.

Appendix A: Fish Collection Permit Conditions Continued

11. All sampling equipment that has been previously used outside of B.C. must be cleaned of mud and dirt and disinfected with 100mg/L chlorine bleach before using in any water course to prevent the spread of fish pathogens (e.g. Whirling disease) and / or invasive plant species. Any washed off dirt or mud must be disposed of in a manner such that it cannot enter a watercourse untreated.

12. No electrofishing is to take place in waters below five degrees C.

13. Electrofishing may not be conducted in the vicinity of staging fish, spawning fish, redds, or around gravels which are capable of supporting eggs or developing embryos of any species of salmonid at a time of year when such eggs or embryos may be present.

14. Angling must only occur in accordance with the regulations specified in the current BC Freshwater Fishing Regulations Synopsis.

Region Specific Conditions

Omineca Region

- No electrofishing will be permitted between September 15 and June 15 in streams containing bull trout.
- Voucher specimens for all regionally significant red and blue-listed species (3 per species), with exception to SARA-listed white sturgeon (*Acipenser transmontanus*), must be submitted to the Regional Fish Information Specialist as per RISC standards.
- All sampling gear follow Association of Professional Biologist's advisory practice bulletin #5. Practice Advisory Didymo, see: https://www.professionalbiology.com/sites/default/files/pdfs/Didymo.pdf
- When lethal sampling has occurred for the purposes of environmental effects monitoring or impact assessment, the permit holder shall, within 90 days of the expiry of this permit, submit a report that summarizes all raw data related to the lethal program. This would typically include location of catch, species, fish tissue metals analysis, fish tissue moisture content, fish length and fish weight, at minimum. Interim reports may also be required and shall be submitted as required by the permit issuer. All fish tissue analysis data related to the lethal program must be submitted ALONG with the standard sampling effort data submission template to http://www.env.gov.bc.ca/fish_data_sub/index.html. Questions regarding submission requirements for lethal sampling may be directed to Susanne.Williamson@gov.bc.ca.
- Lethal fish sampling for metal analysis to environmental studies must have an approved sampling plan prior to any field work; discussion should be held with Environmental Impact Biologists.

Appendix B: Table 1 - Species at Risk

The following are species at risk that have been listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as either endangered, threatened or a species of special concern. Species also listed under the Species at Risk Act (SARA) are identified with an asterisk, and are subject to additional permitting requirements through the Federal Department of Fisheries and Oceans (DFO).

Common Name	Scientific Name
Benthic Paxton Lake Stickleback	**Gasterosteus sp.*
Benthic Vananda Creek Stickleback	**Gasterosteus sp.*
Limnetic Paxton Lake Stickleback	**Gasterosteus sp.*
Limnetic Vananda Creek Stickleback	**Gasterosteus sp.*
Nooksack Dace	**Rhinichthys sp.*
Morrison Creek Lamprey	**Lampetra richardsoni*
Vancouver Lamprey (Cowichan Lake Lamprey)	**Lampetra macrostoma*
Cultus Pygmy Sculpin	**Cottus sp.*
Shorthead Sculpin	**Cottus confusus*
Hotwater Physa	**Physella wrighti*
Limnetic Enos Lake Stickleback	*Gasterosteus sp.*
Benthic Enos Lake Stickleback	*Gasterosteus sp.*
Salish Sucker	*Catostomus sp.*
Speckled Dace	*Rhinichthys osculus*
Charlotte Unarmoured Stickleback	*Gasterosteus aculeatus*
Columbia Mottled Sculpin	*Cottus bairdi hubbsi*
Giant Stickleback	*Gasterosteus sp.*
Green Sturgeon	*Acipenser medirostris*
Umatilla Dace	*Rhinichthys umatilla*
West Slope Cutthroat Trout	**Oncorhynchus clarki lewisi*
White Sturgeon	*Acipenser transmontanus*

Applications for permits to specifically collect and retain listed species must be reviewed by the appropriate provincial expert, who will screen permits to ensure that any impacts on listed species are acceptable. For white sturgeon the contact is Steve McAdam (steve.mcadam@gov.bc.ca). For listed non-game freshwater fish the contact is Jordan Rosenfeld (jordan.rosenfeld@gov.bc.ca).

Appendix C: Sampling Locations and Lethal Sampling Program Description

Scientific Fish Collection Permit Application – Additional Information
Applicant: EDI Environmental Dynamics Inc.

2.2 Sampling Locations

Activity	Ministry of Environment Region	Waterbody	Watershed Code
Research	Omineca	Pack River	230-906800
Research	Omineca	Thutade Lake	239
Research	Omineca	Parsnip River	236
Research	Omineca	McLeod Lake	230-906800
Research	Omineca	Crooked River	230-906800-97600
Research	Omineca	Manson River	230-917600
Research	Omineca	Nation River	237
Research	Omineca	Parsnip Reach of Willison Lake	230

2.6 Lethal Sampling Program Description

Fish sampling is proposed for the Parsnip Reach of Williston Lake and major tributaries, as well as Thutade Lake as a reference lake. Target species include lake trout, bull trout, lake whitefish (and mountain whitefish) and kokanee. Tissue from additional fish species will be collected opportunistically. Bull trout, lake trout, as well as rainbow trout, Arctic Grayling and burbot if captured, will be sampled using non-destructive biopsy techniques; Other fish species (eg. kokanee and whitefish) will be lethally sampled. Table 1 provides the number of target fish species and whether lethal Sampling will be required. Fish tissue will be analyzed for Hg and stable isotopes at a minimum, with a subset for total metals (including Hg and Se).

The team will systematically sample for fish in the Parsnip Reach of Williston Lake and Thutade Lake (as reference lake) using gill netting and angling techniques. Where gill netting is used, we propose to use methods similar to those within Summer Profundal Index Netting (SPIN) programs. SPIN uses 64 m monofilament gill nets made up of 8 panels of 57, 64, 70, 76, 89, 102, 114, and 127 mm mesh sizes, set for 2 hours. Other sample methods may be used as required (i.e. hoop/trap nets, boat electrofishing).

Table 1. Anticipated quantity of fish samples desired from the Williston Reservoir Parsnip Reach for mercury analysis, by species and size range.

Area/Source	Species	Target Sample Size	Lethal Sampling
Parsnip Reach and Tribs	Bull Trout	35 from lake 50 from tributary systems	No
	Lake Trout	35 from lake 50 from tributary systems	No
	Lake Whitefish	36 from lake 50 from tributary systems	Yes
	Kokanee	24 from lake 50 from tributary systems	Yes
	Rainbow Trout	20	No
	Burbot	20	No
	Mountain whitefish	20	Yes
	Arctic Grayling	20	No for fish >180 mm Yes for fish < 180mm
	Longnose Sucker	20	Yes
	Largescale Sucker	20	Yes
	Northern Pikeminnow	20	Yes
	Lake Chub	20	Yes
	Peamouth Chub	20	Yes
	Redside Shiner	20	Yes
	Total:	***530***	
Thutade Lake	Bull trout	22	No
	Kokanee	24	Yes
	Rainbow Trout	20	No
	Total:	***66***	