Williston-Dinosaur Watershed Fish Mercury Investigation

2017 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 program priorities in this region. Guided by a Strategic Planning Group (SPG), including First Nations, academia, BC Hydro and the FWCP-Peace Board, a Peace Basin Plan and six Action Plans were finalized in 2014. Objective 3a of the Reservoirs 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 2016, the Azimuth Consulting Group (Azimuth) team (including EDI Environmental Dynamics [EDI], Chu Cho Environmental [CCE] and Hagen and Associates) was awarded a multi-year contract to collect fish mercury data from the Parsnip, Peace, Finlay reaches of Williston and Dinosaur reservoirs and reference lakes (i.e., the Williston-Dinosaur Watershed Fish Mercury Study). Results of this investigation will assess provide an updated fish mercury database for the Williston-Dinosaur watershed and understanding of how results compare with nearby reference lakes. The long-term goal is to 'update' the existing fish consumption advisory, in partnership with provincial health agencies.

The scope of work for the Willison-Dinosaur Watershed Fish Mercury Study covers five key tasks. This report summarizes our findings from 2017, the second of our three-year study. Progress made to date on each task is summarized below, followed by an overview of key findings to date.

Task 1 – *Data Collection*. Over the past two years, this study has generated 551 fish mercury samples, of which 160 were collected in 2017. Samples were gathered from dedicated sampling efforts, from strategic size-based sampling in the Williston or Dinosaur reservoirs and in reference lakes, opportunistic partnering with other groups working on the reservoirs (e.g., Ministry of Forest, Lands, Natural Resources and Rural Development [FLNRORD]'s bull trout redd counts surveys and CCE's *ad hoc* fishing in Finlay Reach) to grassroots community involvement through fishing derbies and other activities. Azimuth has coordinated the entire process (i.e., from sample acquisition through analysis) across these efforts to produce high quality data suitable for supporting the objectives of the study.

Task 2 – *First Nations Involvement and Training*. In 2016, individuals from six communities were trained to collect, handle and store fish tissues for scientific analysis, as well as gather 'creel' survey data. The objective of this was to establish 'community champions' within each of the eight First Nations communities with whom we are working over this three-year contract. In 2016 this informal approach provided us with creel survey information from two communities (Saulteau and Tsay Keh), but no fish samples. In 2017 a more concerted effort was made to fund 'champions' in the communities of Saulteau, McLeod Lake, Tsay Keh Dene and Kwadacha; this effort resulted in additional creel survey information and 42 fish samples from across the communities. In 2018 we will engage with Prophet River, Doig River, West Moberly and Nak'azdli Whuten. As part of our engagement strategies we also made formal presentations to chief and council, elders and/or held public meetings in McLeod Lake, Kwadacha, Tsay Keh Dene and Saulteau First Nations to provide an overview of the program, present results of the 2016 studies, answer questions and provide information about mercury in fish.

Task 3 – *Strategic Sampling*. The 2016 program was comprised of three main programs: Parsnip Reach (EDI Environmental [EDI], CCE and Northern Spruce), Fraser Lake (FLNRORD) and Thutade Lake (CCE and J. Hagen). Three additional strategic sampling efforts were conducted in 2017. In June, a strategic program was undertaken in Thutade Lake to augment data from this reference waterbody, capturing 69 fish consisting of bull trout (13), mountain whitefish (21), kokanee (9), and rainbow trout (16). In August, a strategic program was conducted on Peace Reach by EDI, CCE, Northern Spruce, and Azimuth; that effort resulted in tissue samples from 108 fish including lake trout (27), bull trout (16), lake whitefish (28), rainbow trout (19), longnose sucker (10), and burbot (5). Data from a second reference lake was not acquired in 2017 because FLNRORD resources were re-directed to fighting forest fires.

Task 4 – *Partnership Fish Collection*. Key partnerships were established in 2016 with FLNRORD (see Tasks 1 and 3), CCE (see Task 1), Duz Cho Fishing Derby, and Carleton University (Dinosaur Reservoir). In 2017, the continued partnership with CCE resulted in the collection of additional bull trout (26) and kokanee (15) samples from Finlay Reach tributaries. EDI and Northern Spruce also participated for a second year in the Duz Cho Fishing Derby on Williston Reservoir out of Mackenzie and for a first time at the Father's Day Fishing Derby (36 fish) out of Hudson's Hope.

Task 5 – *Liaison with Health Authorities*. Azimuth strengthened its working relationship with the First Nations Health Authority and Northern Health. In January 2018 we met with both agencies in Prince George to present on importance of country foods, overview of mercury in the environment, concerns expressed by First Nations communities, a summary of results to date and an overview of fish consumption advisory strategies in place in other provinces. As a group, we committed to developing a framework and conceptual approach to review and revise the fish consumption advisory on the Williston Reservoir watershed, including Dinosaur Reservoir. In the bigger picture, this could form a framework to provide clear guidance for consumption of fish more broadly, across the FWCP-Peace Region.

Summary of 2017 Results – This is the second of our three-year study to characterize fish total mercury concentrations from across the Williston – Dinosaur watershed, relative to nearby reference area lakes. As in 2016, this primarily a 'data report' where basic data presented in a series of summary tables and graphs, depicting relationships between mercury concentration (mg/kg or parts per million, wet weight) and fish size (length) and age (y). Data from 2016 were combined with 2017 in updated tables and figures. As in 2016, we also gathered and interpreted information on the relationship between tissue mercury concentrations and stable carbon (C) and nitrogen (N) isotopes. This provides information on individual position on the food web and nature of diet. Basic interpretation is provided regarding the potential for within-watershed variability in fish mercury concentrations across key species and for differences between the Williston-Dinosaur watershed and the reference lakes. A more complete and detailed statistical analysis of all data collected 2016 – 2018 will appear in our final report.

Results in 2017 generally confirmed patterns observed in 2016. Lake trout and bull trout consistently had the highest total mercury concentrations, ranging over an order of magnitude, from 0.10 mg/kg up to 1.3 mg/kg, depending on fish size. In general, lake trout had higher mercury concentrations than bull trout. Again, there was a positive correlation between increasing fish length and mercury concentration in both species, however the relationship was much more pronounced at fish length >600 mm. In both species, mercury tended to accumulate at higher concentrations in larger fish, a reflection of reduced growth as fish became increasingly older. While changes in diet may also be a factor for individual fish, there was no clear pattern in the stable isotope results that supported dietary shift as a main driver of mercury concentrations in general for either species.

Mercury concentrations for lake trout from Parsnip Reach in 2016 and Fraser Lake (reference) were fairly similar across the size range of fish examined. Additional lake trout from the Peace Reach in 2017 were mainly comprised of smaller fish (<600 mm), but sill appeared to fit the general pattern seen last year.

For bull trout, there was some indication in 2016 that mercury concentrations could differ among reaches, with the limited mercury data from Parsnip Reach appearing slightly higher than Finlay Reach for similar size fish. Like lake trout, smaller bull trout were captured in Peace Reach, but tissue mercury concentrations appeared consistent with those from Finlay Reach. While mercury in bull trout from Thutade Lake and Williston Reservoir were very similar in 2016, this was not the case in 2017. Concentrations of mercury in all bull trout measured from Thutade Lake, regardless of size, were below 0.10 mg/kg. This is a highly unusual result that would not be expected if the same population was being sampled. It is also possible there was a laboratory error; both scenarios are being investigated.

Lake whitefish and kokanee are key prey species in the pelagic (i.e., open water) food chain. Notwithstanding differences in fish size (i.e., lake whitefish from Fraser Lake were larger), mercury concentrations were nearly all below 0.20 mg/kg and similar between Fraser Lake and Parsnip Reach in 2016. The additional lake whitefish sampled from the Peace Reach in 2017 generally appeared consistent with 2016 results. In 2017 we expanded our data set for kokanee from Peace Reach (3 fish), Finlay Reach (28 fish) and Thutade Lake (19 fish), although most fish from Thutade were small (<220 mm) while most fish from Finlay Reach were larger (>220 mm). 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 from Finlay and Peace Reach had a higher range in mercury concentration (0.05 – 0.14 mg/kg) than from Thutade Lake (0.02 – 0.05 mg/kg). While some of this difference may be size-related, it is possible that Thutade kokanee have a naturally lower mercury concentration than Williston kokanee.

Small numbers of mountain whitefish, rainbow trout, Arctic grayling, longnose sucker and burbot were also captured from Peace Reach or provided to us by the communities. Mercury concentrations in these species (except burbot) were almost always <0.20 mg/kg and when present in reference lakes (Thutade and Fraser), did not differ from Williston.

Finally, we acquired a small data set for lake trout from Dinosaur Reservoir, as well as small numbers of rainbow trout, lake whitefish and a single bull trout. Abundance of fish in Dinosaur Reservoir is relatively low because of limitations in habitat. Mercury concentrations of all species in Dinosaur are lower than from Williston Reservoir for similar size fish.

In summary, notwithstanding differences in size of fish captured between Williston Reservoir and Fraser and Thutade reference lakes, the range and magnitude of mercury concentrations appeared to be similar among Williston Reservoir and reference area lakes for most species, accounting for size-related differences between areas for some species. The focus of 2018 work is on Finlay Reach, with continuing efforts to fill data gaps elsewhere. At least one more lake trout – lake whitefish and bull trout – kokanee reference lake will be sampled in 2018. All data will be subject to full statistical analysis once the 2018 data are available.

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ACKNOWLEDGEMENTS

We would like to acknowledge that this report was prepared with financial support of the Fish and Wildlife Compensation Program (FWCP) on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and public stakeholders. Chelsea Coady, FWCP – Peace Region Manager provided excellent guidance and logistical support to continue in the footsteps of Dan Bouillon, former manager. We're grateful to her for helping to guide the project.

We have many people to thank again this year, with an expanded team effort to collect fish tissues from a wide variety of locations. In particular, we'd like to especially thank our study team members who worked hard on our behalf to collect fish tissue samples from all over the Williston Reservoir watershed in 2017. These include Mike Tilson, Luke Gleeson, Kirk Miller, Stephen Friesen, David Powe and Sina Abad (Chu Cho Environmental and the Tsay Keh Dene Nation); Tim Antill, Jason Yarmish and Vicki Smith (Environmental Dynamics Inc. [EDI], Prince George); Cheryl Chingee (Northern Spruce Contracting and the McLeod Lake First Nation); and our 'Community Champions' who diligently collected tissue and/or creel survey data, Cheryl Chingee (McLeod), Katrina VanSomer (Kwadacha), Kirk Miller (Tsay Keh Dene) and Denise Coron (Saulteau) in particular, who really went above and beyond.

We appreciated Tim Antill's (EDI) efforts to attend both the Father's Day fishing derby on Dinosaur Reservoir and the annual Duz Cho Logging derby out of Mackenzie in August. Duz Cho is also thanked for allowing us to harvest tissues from most of the fish caught during the derby and to assist them in determining the winning fishers.

We would also like to acknowledge the careful analysis of small tissue sample volumes by ALS Environmental (Burnaby, BC) and SINLAB (Fredericton, NB) for stable carbon and nitrogen analysis. Fish ages were provided by North/South Consultants (Winnipeg, MB).

This report was written by Randy Baker and Gary Mann (Azimuth). Morgan Finlay (Azimuth) participated in the Peace Reach collection program and provided 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.

ACRONYMS & GLOSSARY

BLTR	Bull trout
CCE	Chu Cho Environmental
CRM	Certified Reference Material
DL	Detection limit
dw	Dry weight
DQO	Data quality objectives
EDI	Environmental Dynamics Inc.
FLNRORD	Forests, Lands, Natural Resource Operations and Rural Development
FWCP	Fish and Wildlife Compensation Program
Hg	Mercury
KOKA	Kokanee
LKTR	Lake trout
LKWH	Lake whitefish
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 were first measured in 1980 (Health and Welfare Canada 1980, as reported in Baker et al. 2002), about 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 perceived to be elevated, leading to the BC Ministry of Environment to issue a 'fish consumption advisory'. The "Mercury Warning" first appeared in BC's 1993 – 1994 Freshwater Fishing Regulations Synopsis (Ray Pillipow, FLNRORD, personal communication) and has continued through every iteration since. The advisory specifically 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*." It has been more than 25 years since this advisory was issued and data collected as part of this program is intended to inform whether it is still relevant. Note that it is the responsibility of provincial health authorities to establish consumption guidelines for fish consumption due to mercury, or other contaminants.

This is the second of our three-year study – and this report benefits from the perspective and knowledge gained from our first year of work in 2016. For completeness, however, these introductory sections also include some of the text from the 2016 report (Azimuth 2017) for the reader's perspective.

Prior to the initiation of reconnaissance-level sampling for this initiative in 2015 (see **Section 1.3**), there was little in the way of empirical data to guide the study, with widespread belief that mercury concentrations in Williston Reservoir fish were elevated because of the 'reservoir phenomenon'. This phenomenon is quite well known and has been thoroughly studied (see **Section 1.4** for an overview), especially in large reservoirs constructed in Quebec (Schetagne et al. 2003) and Manitoba (Bodaly et al. 2004, 2007). These and other studies have demonstrated that mercury concentrations in fish (and all other biota they feed on) increase shortly after reservoir creation and peak at a much higher concentration than baseline, perhaps 8 – 12 years later. Then, concentrations decline, as the 'raw materials' needed for the mercury methylation process run out, with fish mercury concentrations returning to a new baseline about 25 – 35 years after the reservoir was formed. Given that Williston Reservoir was formed nearly 50 years ago, a return to a new baseline should have occurred, according to the scientific literature on this topic, notwithstanding on-going physical (e.g., draw down) and ecological changes within the reservoir, which can affect food web relationships and mercury concentrations in fish.

As we noted in our reconnaissance report (Azimuth 2015), prior to the start of this investigation, there were only two fish mercury studies on the reservoir over the last 15 years. The first was a comprehensive study of mercury in environmental media (i.e., water, sediment, invertebrates and fish) in 2000/2001 in Finlay Reach (Baker et al. 2002). The second study, commissioned by the West Moberly First Nations, was conducted in 2012 on the Crooked River, a tributary of the Parsnip River, during a fish camp event (ERM 2015). The Crooked River data were considered within our Azimuth (2017) report and are not further addressed here.

We were also tasked with gathering fish mercury data from Dinosaur Reservoir, immediately downstream of WAC Bennett Dam. Dinosaur Reservoir was impounded by the Peace Canyon Dam in 1979 and is quite small (20.5 km long), confined, 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). Productivity is quite low, being driven almost exclusively by inputs of cold, nutrient poor water 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 (*Oncorhynchus nerka*), and lake whitefish (*C. clupeaformis*) (Diversified Environmental and Mainstream Aquatics 2011). Also note that Azimuth (2011) collected fish from Dinosaur as part of the Site C investigation on mercury.

Large, ongoing ecological changes have occurred within Williston Reservoir over the last five decades since its formation (e.g., Stockner et al. 2005, Langston 2012) and are still occurring. Species composition and food web structure can have large influence on the pattern and magnitude of mercury accumulation by aquatic biota, including fish. The main change in Williston has been a major shift in fish species, with an increased abundance of lake trout (*S. namaycush*) and landlocked kokanee (*O. nerka*), perhaps at the expense of lake whitefish and Arctic grayling (*Thymallus arcticus*) – mostly driven by habitat changes and stocking efforts (e.g., kokanee; Langston 2012). Bull trout populations remain strong within the major tributaries, although how their abundance has changed over time within the reservoir proper is hard to know. As the fish community and population structure continues to evolve in Williston Reservoir, changes to these fundamental ecological and feeding relationships will continue to influence how mercury moves through the food web. Thus, conditions within the reservoir are not static and will continue to change over time until the fish community 'stabilizes' at some point – pointing to the need to continue ecological investigations in the reservoir, to keep information up-to-date.

An example of this is the 'evolution' of kokanee within the reservoir and their non-uniform distribution. For example, Langston (2012) observed that of the more than 1 million kokanee spawners estimated in the reservoir few were observed in Peace and Parsnip reaches (<10%) with most in Finlay Reach and Omineca Arm (~90%). 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.

As we noted in the 2016 report, updated information on fish mercury concentrations is only one piece of the puzzle. To accurately determine 'exposure' to mercury by wildlife and by humans requires a good understanding of fish consumption habits. This includes community-specific information on the preferred or most frequently consumed fish species, preferred fish sizes, where the fish was caught, how often fish are eaten (meals per week or month, including store-bought fish such as tuna or salmon), seasonal patterns (most consumed in summer? Or at fish camps?), and meal serving size. Information like this is gathered by conducting a 'creel survey', where individuals are queried about their general fish consumption habits. Gathering this information was paired with our community sampling efforts in 2017.

Note that when we refer to 'mercury' in fish this refers to total mercury (or Hg) of which methylmercury (CH_3Hg) typically comprises at least 90% of this total (Bloom 1992). We conservatively assume that all of the mercury measured by the laboratory is in the methylmercury form.

1.2. Objectives

The Fish and Wildlife Compensation Program (FWCP) – Peace Region carried out a strategic planning process in 2012-13 which included First Nations, academia, agencies, BC Hydro staff, and members of the FWCP-Peace Board. This process resulted in the creation of a Peace 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, through a competitive bid process, the FWCP-Peace selected Azimuth and team to undertake a three-year (2016 – 2018) directed project to collect fish mercury information from the three major reaches of Williston Reservoir (Parsnip, Peace, Finlay), Dinosaur Reservoir and reference lakes.

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 2017 (**Section 2**)
- An assessment of the results to date (**Section 3**) highlighting potential spatial patterns within the Williston-Dinosaur system (i.e., among reaches and Dinosaur Reservoir) and with reference areas; and
- Implications for follow-up studies in 2018 (**Section 4**).

Ultimately, this information will be used to improve our understanding regarding mercury concentrations in fish and help inform decision making regarding human health advisories related to mercury. A key outcome anticipated from this study will be to provide provincial health agencies such as the First Nations Health Authority and Northern Health with sufficient information to support management decisions and communicate / advise the public on fish consumption throughout Williston watershed as it relates to mercury in fish.

In this report, we do not assess implications of the current results with respect to potential risks to ecological receptors or to human health from mercury exposure. This task is not within our mandate. Such an assessment can only be conducted within a risk assessment framework, once all data have been collected and there is more completed understanding of dietary exposure among different First Nations communities 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.

1.3. Overview of Previous Related Work

Early in 2014, the FWCP Peace Region Board determined that they wished to address the long-standing mercury advisory for the Williston Reservoir watershed. Azimuth was commissioned 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 build the fish mercury database for Williston Reservoir watershed and ultimately provide this information to those agencies responsible for advising the public on safe consumption of fish in the province. 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 the Ministry of Forests, Lands, Natural Resource Operations and Rural Development's (FLNRORD) 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 (*O. 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 total mercury results (mg/kg ww or parts per million wet weight) 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 there may be 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 concentrations 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.

These data were used to provide context for 2016 work and have been incorporated into the database for the Williston-Dinosaur Watershed Fish Mercury Investigation.

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 also the main form of mercury that is found in fish, usually comprising at least 90% of the total concentration (Bloom 1992). Thus, when we talk about 'mercury' in fish, we are really talking about 'methylmercury'. 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 sequestered into biological tissues and the amount that is acquired can be greater than the amount that is depurated, depending on how much fish is consumed and how frequently. This process is known as bioaccumulation. Furthermore, the concentration of methylmercury in animal tissue increases with progressively higher steps up the food web. This process is known as biomagnification. Bioaccumulation and biomagnification of methylmercury occurs in both terrestrial and aquatic ecosystems but is much more prevalent in aquatic systems 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, northern pikeminnow, walleye and northern pike typically have higher mercury concentrations than omnivorous species including whitefish, rainbow trout, suckers 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, present as a gas in the air, is captured from the atmosphere during normal respiration by plants, where it becomes incorporated into leaves and needles. Over decades or centuries as this material falls to the ground and accumulates to form terrestrial soil, atmospheric mercury also accumulates here, where it is sequestered within the soil. When terrestrial soils are flooded this organic soil is rapidly decomposed by bacteria. As part of this bacterial decomposition process, some specific groups of bacteria transform or "methylate" some of the inorganic mercury in the soil into the organic or methylmercury form. Now that methylmercury has been created and incorporated into the base of the food web, it is available to be accumulated and magnified at each increasing step up the food web, reaching 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 to pre-flooded data. 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. Like other contaminants in the environment, it is *dose* that drives risks. 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. Thus, the dose is very specific to an individual and will vary according to the frequency and amount of fish species consumed and specific to gender, age and body weight. Thus, there are no red lines that appear on graphs in this report that might suggest either safe or unsafe concentrations.

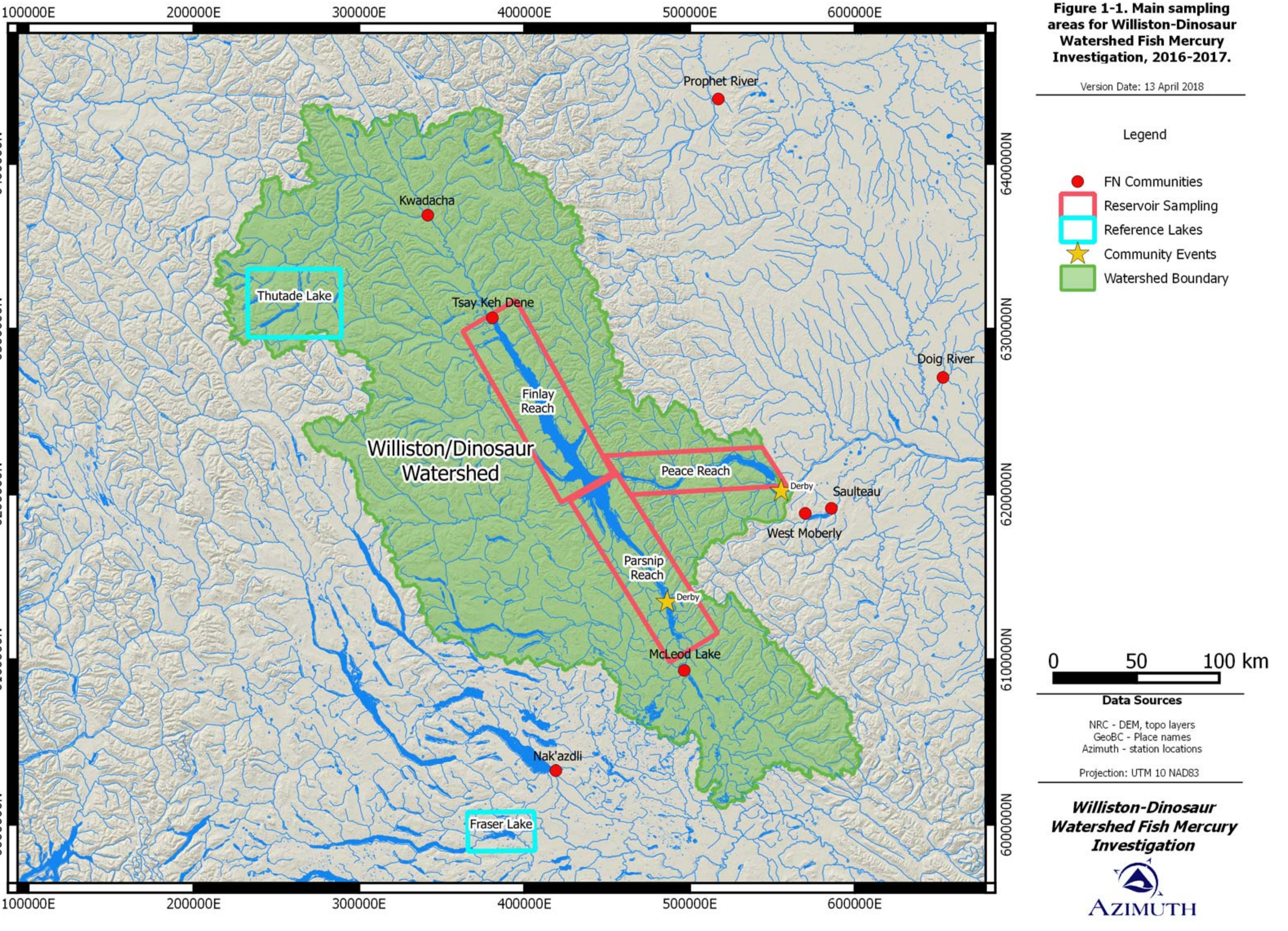


Figure 1-1. Main sampling areas for Williston-Dinosaur Watershed Fish Mercury Investigation, 2016-2017.

Version Date: 13 April 2018

2. SCOPE OF WORK DOCUMENTATION

The original, three-year scope of work contained several specific actions that were grouped into five main tasks including: 1) Study planning and data collection; 2) First Nations involvement and training; 3) Scientific study implementation; 4) Partnership fish collection programs; and 5) Health Authorities liaison. We have simplified this to present this information according to three main topics. The first, Section 2.1 combines all scientific and first nations collected data efforts (i.e., Tasks, 1, 3 and 4); Section 2.2 describes First Nations involvement and training (i.e., Task 2); and Section 2.3 describes our communications to date with provincial Health Authorities (i.e., Task 5). Following is a breakdown of the types of information that are included in each of these sections.

Section 2.1 Overview of Tissue Sampling Program – In 2016, the primary focus was on Parsnip Reach, although we also gathered tissue samples elsewhere, across the watershed including in two reference lakes, Fraser and Thutade. In 2017, the focus was on the Peace Reach and in Dinosaur Reservoir, as well as from our reference lake (Thutade). Due to the 2017 forest fires, FLNRORD was unable to augment our reference area fish dataset. This has been postponed until 2018. Subtasks in 2017 included:

- Sample target bull trout (*S. confluentus*), lake trout (*S. namaycush*), lake whitefish (*C. clupeaformis*] and kokanee (*O. nerka*) from Peace Reach.
- Targeted and strategic sampling of Thutade Lake, the bull trout – kokanee reference lake, to complete our sampling of this waterbody, building on data from 2016.
- Derby sampling at two fishing derbies; the Father's Day fishing derby on Dinosaur Reservoir out of Hudson Hope and the Duz Cho Logging fishing derby on Parsnip Reach out of Mackenzie.
- Opportunistic sampling by First Nations. In 2017 we engaged with individuals from Saulteau, McLeod Lake, Kwadacha and Tsay Keh Dene. This was part of our 'community champion' initiative that was implemented in 2016. These were dedicated individuals who provided the study with fish tissue samples from a variety of locations around the reservoir watershed, as well as creel survey information.

As noted above, we had hoped that FLNRORD would be able to collect lake trout and lake whitefish from a second reference lake. However, due to fires and re-allocation of resources by the province, this was postponed until 2018.

Section 2.2 First Nations Involvement and Training – In 2017 we were able to expand our training and engagement initiatives from 2016. Specific tasks will be described in more detail below, but included participation by Cheryl Chingee (Northern Spruce, McLeod Lake) in the Duz Cho fishing derby and participation on the Peace Reach strategic sampling program.

In-person visits were made to several communities during 2017 including McLeod Lake, Saulteau, Kwadacha and Tsay Keh Dene. The purpose of these visits was to engage with community council member and elders as well as with the general public during different meetings and community hall events. During these meetings, an overview of the FWCP program was made, a general presentation on mercury in the environment was given and results of the 2016 program were communicated. This also provided council and community members an opportunity to ask questions and gain information.

In addition, as part of the community visits we were able to provide in-person training to each of the champions and provide guidance on the collection of tissues, recording of data and storage and shipping details in addition to providing assistance with conducting interviews to gather creel survey information.

Section 2.3 Liaison with Health Authorities – In 2017 / 2018 Azimuth held two meetings with representatives from Northern Health and the First Nations Health Authority in Prince George. The purpose of these meetings was to update representatives from each agency with an overview of the program and results to date. We were also able to discuss preliminary findings from the creel survey information. Ultimately, the information gathered from this study will be used by the health authorities to re-visit and revise the current fish consumption advisory for bull trout and lake trout within the Williston Reservoir watershed. Further details are provided below.

2.1. Overview of Tissue Sampling Program

The objective of the study is to document mercury concentrations in muscle tissues of key fish species from the three major reaches of Williston Reservoir (Parsnip, Finlay, Peace and their main tributaries), Dinosaur Reservoir and reference lakes. This effort is spread over three-years, with one of each of the major reaches targeted in 2016, 2017 and 2018. Given the limited data on fish mercury concentrations in the Williston-Dinosaur Watershed (Azimuth 2015, 2016) and the on-going changes in reservoir ecology and fish population structure (e.g., large increase in kokanee abundance) we added duplicate tissue samples (in most cases) for carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotopes (SIA). Use of stable isotopes helps us understand the detailed nature of the food web among fish species and the dietary relationships and preferences of individual fish. As well, we are able to highlight whether geographic differences in mercury concentration of prey species may exist. This has a strong determining influence on exposure to and bioaccumulation of methylmercury via dietary sources (Hall et al. 1997). Thus, an understanding of ecology (life history, diet and trophic relationships) is vital to this study. While general results are explored in this report, a more detailed and comprehensive analysis will be contained in our final report in 2019, once all of the data have been collected.

The sampling program has been centered around four sampling strategies, as follows:

1. *Core Reservoir Sampling* – Parsnip Reach was targeted in 2016, as well as opportunistic sampling of Finlay Reach. In 2017 we focused on the Peace Reach, while continuing gathering data from Finlay Reach and from Dinosaur and Parsnip reaches via fishing derbies.
2. *Reference Area Sampling* – Two reference areas were targeted in 2016 – a lake trout / lake whitefish system at Fraser Lake sampled by FLNRORD (**Figure 1-1**) and a bull trout – kokanee complex at Thutade Lake in the upper Finlay River, above an impassable fall (i.e., no connectivity for fish from the reservoir), sampled by Chu Cho Environmental (CCE). Thutade Lake was sampled again in 2017 by CCE. While FLNRORD had planned to sample fish from Cunningham Lake in 2017, the program was not implemented as resources were diverted to fighting forest fires.
3. *Partnership Program Sampling* – Opportunistic sampling by Ian Spendlow (FLNRORD), John Hagen (Hagen and Associates) and CCE targeted bull trout in tributaries to Finlay Reach (FLNRORD/Hagen) and in the reservoir itself (CCE) in 2016. The Finlay Reach bull trout sampling was continued in 2017 by CCE.
4. *Community-Led Sampling* – This strategy is flexible and driven by community objectives. In 2017 we successfully engaged 'community champions' in four communities; McLeod Lake, Saulteau, Tsay Keh Dene and Kwadacha. As a result, we were able to acquire a number of tissue samples from most communities and creel survey information from all. This program will be continued in

2018 from the remaining communities (Nak'azdli, West Moberly, Doig River and Prophet River) if desired by them.

Together, these four strategies were again implemented in 2017 and will be continued in our final, 2018 sampling program.

While Azimuth had the responsibility of project and data management, field collection activities were principally 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 Northern Spruce, a First Nations owned company based in McLeod Lake and Prince George (subcontracted to EDI). The company proprietor, Cheryl Chingee, was trained in Mackenzie in 2016 to collect fish tissue samples and she participated in the 2016 strategic survey of Parsnip Reach and on the Peace Reach in 2017 with EDI.

The sections below briefly describe each of the above fish collection programs implemented in 2017.

2.1.1. Peace Reach Strategic Sampling Program

This section addresses the strategic sampling component of this study. As outlined in our 2016 report, the overall 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, rainbow trout and others). In 2016, the study targeted Parsnip Reach (**Figure 2-2**), but also included many fish from Finlay Reach (**Figure 2-2**) collected through opportunistic, partnership sampling. The basic methodology of the 2016 and 2017 study followed the protocols laid out by Azimuth (2015) that are well accepted in these kinds of field programs.

EDI, with participation by Azimuth and Cheryl Chingee were instrumental in collecting a large number of fish during the targeted Peace Reach sampling event. This was a 5-day strategic program partly based out of Hudson Hope but also from a tent camp established mid-way down the reservoir towards the junction area. The scientific collection permit for this program is provided in **Appendix A**.

It is well known that as most fish species get larger and older, their muscle tissue concentration of mercury increases. This relationship is particularly strong for piscivorous species such as lake trout, bull trout and northern pikeminnow 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, longnose sucker) that consume low mercury prey.

Therefore, in order to determine the size-mercury 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 (normally length but can use weight) or age (y) and mercury concentration (mg/kg or ppm). This study approach has been used by Azimuth in BC in a variety of other fish mercury studies in British Columbia lakes and rivers (e.g., Pinchi Lake, Stuart Lake, Tezzeron Lake, Francois Lake, Seton Lake, Bridge River, Peace River) and reservoirs (e.g., Dinosaur, Carpenter, Downton, Falls River and others). This approach has also been used to study many reservoirs in Manitoba (e.g., Bodaly et al. 2007) and Quebec (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. For example, the most commonly used standardized size for bull trout is 550 mm, 600 mm for lake trout and 350 mm for lake whitefish. The standardized sizes represent fish typically captured (and commonly consumed) from the respective populations. Of course, some people may choose to routinely eat larger or slightly smaller fish. Standardized sizes will be used next year (i.e., when statistical analyses will be conducted) to report fish mercury concentrations in an unbiased manner when comparing among species, or when assessing spatial (e.g., between/among reaches or lakes) or possibly 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 have implemented an alternate strategy – to collect about 10 fish per species from within a narrow (+/- 50 mm) interval around the 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 2017 study design approach for the strategic survey during August 20 – 25, 2017 of Peace Reach (**Figure 2-3**) is as follows:

- The study team systematically sampled fish from Peace Reach in late August using short-set gill nets and angling. Gill netting used methods similar to those employed by the 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.
- The study 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.
- All fish were identified to species, measured for fork length (mm) and weighed (g).
- Where mortalities occurred, we also harvested ageing structures – otoliths for all species except suckers where a pectoral fin ray was collected. We also examined these fish for gender and state of maturity, calculated the Fulton's condition factor (based on the length – weight ratio) and examined fish for parasites, stomach contents or other parameters of interest.
- In addition to mercury, as in 2016, Azimuth et al. continued to collect 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.
- A subset of samples was analysed for 'total metals' including mercury in order to determine species-specific concentrations of other metals, but in particular selenium. Selenium is known to be an 'antagonist' to mercury in health studies (e.g., Ralston et al. 2008, Berry and Ralston 2009.), so understanding the mercury – selenium relationship puts this into perspective.
- As above, ageing structures (otoliths) were acquired from a subset of fish – from lethally sampled fish from the Mackenzie fishing derby, the Dinosaur Derby and the Peace Program where non-

destructive techniques were not used. All collected structures were aged by North/South Consultants, Winnipeg, as in 2016.

Gill nets were initially set for 4-6 hours; 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. Nets were set at 28 locations throughout the Peace Reach as described in the methods employed by EDI/Azimuth during the strategic gillnetting effort (**Appendix B**). The majority of sampling took place within large inlets associated with past river channels. These areas offered protection from weather conditions mid-reach, while allowing for a range of habitats for targeted sets, including near river mouths. The crew (J. Yarmish, D. Powe, C. Chingee, M. Finlay) spent three days camped in the Carbon Creek area in an attempt to maximize fishing effort by limiting travel time to and from the study area.

Fish handling and tissue sampling methods followed those identified in the Azimuth *Fish Tissue Collection & Recording Procedures* (2016) document. Non-destructive biopsy sampling (Baker et al. 2004) 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*).

One hundred and fifteen (115) fish were captured consisting of 10 species including lake whitefish (30), mountain whitefish (8), bull trout (16), lake trout (29), kokanee (3), longnose sucker (10), rainbow trout (7), largescale sucker (*C. macrocheilius*, 3), pikeminnow (4) and burbot (5). Most fish were captured using gill nets while angling only yielded 8 fish, mostly rainbow trout.

Tissues were stored on ice and frozen as soon as practical. Frozen samples were then 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. Age structures were shipped to North/South Consultants, Winnipeg, Manitoba.

2.1.2. Finlay Reach Opportunistic Sampling

As in 2016, CCE was solely responsible for all sampling on Finlay Reach in 2017. This involved opportunistic fishing for bull trout and other species (e.g., kokanee) at a variety of tributary stream locations within Finlay Reach, augmenting 2016 data and filling data gaps. Finlay Reach sampling was coordinated by Mike Tilson, with participation by Kirk Miller, Stephen Friesen and Jimmy Ware, all of Tsay Keh Dene.

Fishing activities were carried out between September 12 and 26, 2017 and mostly involved angling for bull trout on a few key tributary streams. A total of 26 bull trout were captured and non-lethally sampled for mercury and stable isotopes, including 14 from Chowika Creek, 11 from Pesika Creek and 1 from Ruby Creek (**Figure 2-2**). In addition, on September 13 a total of 15 kokanee were sampled from Aley and Stephenson creeks.

2.1.3. Thutade Lake Reference Sampling

A second and more comprehensive sampling program than the 2016 program was carried out at Thutade Lake on May 28 – 30, 2017. The objective of this program was to augment the small 2016 catch to acquire more bull trout, kokanee, rainbow trout (*S. mykiss*) and mountain whitefish (*Prosopium williamsoni*) tissue samples for mercury and stable isotope analysis. The program was organized by CCE and carried out by staff from Tsay Keh Dene and CCE. This program was successful in acquiring 13 bull trout (over a wide size range; diet consisted of fish, principally whitefish and kokanee); 16 rainbow trout (mostly similar size; diet of insects, snails, 2 small fish) from Attichika River, a tributary to Thutade; 16 kokanee (again, mostly similar size; all stomachs were empty) and 21 mountain whitefish (insects in the stomachs when present). Mountain whitefish were captured from the mouths of the Niven River, Attichika River and Northeast Bay.

2.1.4. Parsnip Reach Fishing Derby

EDI (Tim Antill) with assistance by C. Chingee conducted fish sampling during the annual August fishing derby on Parsnip Reach operated out of Mackenzie and sponsored by Duz Cho Logging. The Duz Cho derby is well-attended with big prizes. This was the second year we acted as the 'official adjudicator' of fish size to determine the winner. We had acquired a large sample size of lake trout from Parsnip Reach in 2016 from both the strategic program and derby, so we attempted other means to gather tissue samples from smaller fish. We did this by offering cash prizes for fish captured within smaller size classes (e.g., 300 – 400 mm; 401 – 500 mm), that would not normally be submitted for weighing.

Participants in the fishing derby brought 50 fish to the weigh-in station, consisting mostly of lake trout (40), northern pikeminnow (*Ptychocheilus oregonensis*; 4), peamouth chub (*Mylocheilus caurinus*; 4), and two rainbow trout (*O. mykiss*). Lake trout were captured from boats on the reservoir; however, the rainbow trout, northern pikeminnow, and peamouth chub were all caught from shore in the Cut Thumb Bay campground area. The largest fish caught at the derby was a lake trout measuring 905 mm in length and weighing 8,754 g. Of the 40 lake trout captured, 34 exceeded 700 mm in length and most were not required by the program due to their large size. Otoliths were collected from 27 individuals. Of the stomachs of 27 fish examined, 86% were empty. When present, the stomach content typically consisted of kokanee (*O. nerka*) and lake whitefish (*Coregonus clupeaformis*). A full description of the EDI field report is provided in **Appendix B**. This is the last year we will attend the derby.

2.1.5. Dinosaur Reservoir

EDI (T. Antill) also attended the June 18 Father's Day derby on Dinosaur Reservoir. In advance of the derby we circulated information to the organizers making participants aware of our program – so that fish of all sizes and species captured could be submitted for weighing and tissue sampling – again, providing cash prizes for smaller size-class fish. Participants in the derby brought 36 fish to the weigh-in station; the catch consisted of 22 lake trout (*S. namaycush*), 13 rainbow trout (*O. mykiss*) and one bull trout, an untended mortality by an angler. The largest fish caught in the derby was a lake trout measuring 610 mm in length and weighing 2,631 g.

Overall, participants were very interested in the study and willing to offer their fish for tissue sampling. Participants were encouraged to catch and bring in lake trout less than 600 mm, as well as non-lake trout target sport fish species through the use of a cash reward program. The cash reward was helpful at bringing in smaller fish, particularly for those caught by youth.

2.1.6. Fish Tissue Collection by 'Community Champions'

In 2016 we initiated the 'community champion' program for individuals who attended the fish collection and preservation training session at Morfee Lake near Mackenzie in June 2016. Each of the people who attended the training from five communities were acknowledged to be the 'champions' the project and undertake the responsibility gather fish tissue samples and creel information. Thus, our community champion was designated as the 'point-person' responsible to collect fish tissue samples on behalf of the FWCP program – gathered from community members or fish they catch themselves, or at fish camps. This person would also conduct informal interviews to gather information on fish consumption patterns among community members – a creel survey. As part of the fish tissue collection program contributors of fish would be asked a variety of questions, such as …"*what fish do you or your family prefer to eat (species and how big)? Where do you normally go to catch fish? How often do you eat fish? Is this mostly at fish camps, or do you regularly eat fish all year round? Do you eat the fish yourself or provide them to other family members or elders*" These are only a few of the questions we are trying to answer, to help us understand where people are getting their nutrients from and partly to inform whether or not mercury is a relevant health risk.

This was a voluntary task in 2016, as we did not have budget to support it. Unfortunately, it did not yield any tissue samples, although we did get some creel survey information. In 2017 we took a different approach by offering an honorarium for the role and reaching out to community leadership to either having someone appointed, or through an application process for the position through the band office. Funds for community champions were offered to Kwadacha, Tsay Keh Dene, Saulteau, West Moberly and McLeod Lake First Nations. Four of the five First Nations were able to fill the position and we were reasonably successful at gathering fish tissue samples from a variety of species and lakes from three of the communities. We also gathered creel survey information from four communities. This program will be extended in 2018 and will include Doig and Prophet River First Nations and Nak'azdli Whuten, at a minimum. A brief summary of fish tissue collections by our community champions is below.

Kwadacha – Nine fish tissue samples were collected from bull trout (4), Arctic grayling (*Thymallus arcticus*; (2) and three rainbow trout. and an anadromous spring salmon (fish were collected from several locations on the Finlay River, Bower Creek, Fox River and Sardine Lake.

Tsay Keh Dene – Eleven fish samples were collected including eight bull trout, two rainbow trout and one Arctic grayling, all from the Finlay River or tributaries to it. In addition, a single 1 anadromous spring salmon *Oncorhynchus tshawytscha* was sampled from the Sustut River, a tributary to the Skeena River that runs to the Pacific Ocean.

Saulteau – Twenty-nine fish tissue samples were collected over a wide area including the Parsnip Reach (War Lake, Carp Lake, Pack River), Peace Reach (Carbon Lake, Johnson Creek, 11-Mile Creek) and the Peace River (Boulder Lake, McLeod Lake). Most of the fish captured were rainbow trout (23), with small numbers of lake whitefish (3), longnose sucker (*Catostomus catostomus*; 1), burbot (*Lota lota*; 1) and one northern pike (*Esox lucius*).

2.2. First Nations Involvement and Training

This study was designed to include and collaborate with the eight First Nations communities, who have representation on the **FWCP Peace Region Board and First Nations Working Group**. There were three main components to First Nations participation: 1) direct involvement in all fish tissue sampling programs in targeted (e.g., Peace Reach), reference area (Thutade Lake), opportunistic fishing programs (e.g., Finlay Reach bull trout) and fishing derbies; 2) as 'community champions' tasked with collecting fish tissue samples and creel survey information and 3) as participants in round-table and community presentations held in four communities during the summer of 2017.

Direct involvement in fishing efforts by First Nations-owned companies or First Nations community members has been described above in Overview of Tissue Sampling Program **Section 2.1** and are not repeated here. The remainder of this section focuses on direct involvement in the community and on efforts by community champions to gather creel survey information and the training that was involved to support the community champions.

2.2.1. Community Presentations and Discussions

A very important part of our study is engagement with First Nations communities. This is where we had opportunities to communicate results of our studies thus far– but also to have the opportunity to listen to and learn from local residents and council members about their views and perspectives on this issue. We engaged with the communities situated nearest to the reservoir in 2017: Tsay Keh Dene, Kwadacha, McLeod Lake, West Moberly and Saulteau. All of those communities were visited, except West Moberly, although some council members from West Moberly attended the meeting in Saulteau. During these meetings, local residents had the opportunity to ask questions, seek clarification and better understand the issue of mercury in fish – generally and how it pertains to reservoirs and Williston Reservoir in particular. Below is a brief summary of the timing of presentations and participation by local community and council members. An example of a presentation given within a community is provided in **Appendix C**.

McLeod Lake – A presentation was given to the McLeod Lake elders during a meeting in Prince George on June 17. There were about 15 participants in the meeting, most of whom were McLeod Lake elders. Cheryl Chingee also attended the meeting to assist. During this time Cheryl and R. Baker had the opportunity to go over the creel survey forms and discuss how such information can be gathered, as well as discussing the protocols for fish collection and preservation.

Kwadacha – A presentation was given on July 12 in the community band office. It was attended by six residents; unfortunately, people were out on the land at the time and many were unavailable to attend. R. Baker met with Katrina VonSomer to review the creel survey forms and fish tissue information protocols.

Tsay Keh Dene – Our presentation was given on July 13 in the band office and was attended by 22 people, including some of the staff from CCE, Luke Gleeson and a number of elders. R. Baker met with K. Miller, the champion from Tsay Key Dene, again to review the information to be collected.

Saulteau and West Moberly – A meeting was held in the Saulteau Band Office on September 13 with the chief and 2 band councilors from Saulteau and 3 councilors from West Moberly. This was followed up with a public meeting in the same venue, attended by only 4 community members. R. Baker again met with the champion from Saulteau, Ms. D. Coron. She was provided with instructions on completing creel data documentation and recording, logging and preserving fish tissue samples.

BC Hydro 'Reservoir Days' Presentation – On November 16, R. Baker made a presentation in Ft. St. John during the 'BC Hydro Reservoir Days' where he was one of three speakers to a large group that focused on Treaty 8 communities and included several band members from Doig and Prophet River First Nations.

2.2.2. 2017 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 27 respondents from Tsay Keh Dene, Kwadacha, McLeod Lake and the Saulteau First Nations.

Tsay Keh Dene Nation – This was the second year of creel survey information from Tsay Keh Dene. In 2016, eight people were interviewed by Kirk Miller with the most commonly consumed species reported as bull trout (all people), with two people also reported consuming rainbow trout and burbot, as well as one individual consuming anadromous steelhead and spring salmon. With the exception of salmon, all fish consumed were from the Finlay River or a tributary to the Finlay.

In 2017, only three people were interviewed – although the trends were similar results as in 2016. Bull trout and rainbow trout (1x / month) were reported as the most commonly consumed all from the Finlay River or tributaries. Respondents also reported eating kokanee (1x per year), chinook or spring salmon (*O. tshawytscha*; 2x year) and canned tuna. In general, the majority of people interviewed reported eating fish relatively infrequently. Of all people interviewed, most reported eating fish 1x per month or less frequently. In 2016, two people mentioned that their fish consumption was 'episodic' and largely limited to fishing trips, when a large amount is consumed, but not regularly. Consumption is also quite seasonal, with fish generally not reported as being consumed during winter.

Kwadacha Nation – Ten people were interviewed by Katrina VonSomer in the summer of 2017. Bull trout and rainbow trout were the most frequently consumed local fish, with approximately equal frequency; two people also reported consuming Arctic grayling. The location that people fished was quite varied and usually occurred when people were traveling and was a more opportunistic endeavor. Again, most fish were captured from the Finlay River or tributaries to the Finlay such as Bower Creek, Fox River and Amazay Lake. Two respondents also reported eating fish from outside of the region (e.g., Sardine Lake) and from the Sustut River (a tributary of the Skeena River), where a trip to capture anadromous chinook salmon was made. The frequency of fish consumption was 2 x per month by 4 people, 1 x per week by three people and 2 x per week by two people. Most people reported eating a 'piece of fish' which was interpreted as being a single fillet. People also said that sometimes they ate a whole fish or preserved portions of fish for consumption later on. If salmon were fished for they were brought back to the community and distributed.

McLeod Lake First Nation – Seven people were interviewed by Cheryl Chingee in spring 2017. The most commonly reported local fish species consumed was rainbow trout (4 people) followed by lake trout *(Salvelinus namaycush*) and bull trout (2 people) and peamouth chub (*Mylocheilus caurinus* 2 people). Fish were reported captured from a large number of locations including McLeod Lake (4 people), Williston Reservoir (2 people) and Pack River, Carp Lake, Moose Lake and Morfee Lake (one respondent). One individual also reported fishing from the Skeena River for anadromous salmon. Two respondents also reported consuming wild and canned salmon as well as canned tuna. Only one of seven respondents reported consuming fish twice per week, with one person consuming fish 1 x per week. Fins consumption was less frequent for the remaining respondents ranging from 1 x per month, 2 x per year or 3 x per year.

Meal size, when reported, was relatively small, with 5 people indicating an average meal size of 75 grams (g), less than a can of tuna (~120 g). One person consumed 300 g per fish meal, another 500 g per meal and one respondent up to 1 kg per fish meal. The preferred means of cooking fish was baking and frying, while some people also dried or smoked fish for later consumption.

Saulteau First Nations – Seven community members from Saulteau and possibly West Moberly First Nations were interviewed by Denise Coron in fall 2017. This was supplemented by creel survey information from Denise herself, who doesn't eat much fish, but instead providing all the fish she catches to many community elders within the Saulteau community. Among fish provided to elders, the most commonly captured species by far was rainbow trout (23 samples) followed by lake whitefish (3), 'trout' (which we are unsure are bull trout or lake trout, suspecting the latter) and individual burbot (*Lota lota*), northern pike (*Esox lucius*) and Dolly Varden (bull trout).

Fish were captured over a wide geographic area including the drainages of the Peace Reach (Carbon Lake, 11-Mile Creek), Parsnip Reach (War Lake, Carp Lake), Dinosaur Reservoir (Johnson Creek), and Peace River (Moberly Lake, Pine River, Boulder Lake). Given the number of fish captured over the course of the summer, and their wide distribution to people in the community, we assume that consumption frequency would be infrequent for most. Whether the fish supplied by Denise to elders and others from the community were augmented with fish from elsewhere is not known. Frequency of fish meals and meal size was not reported.

Summary – The most commonly reportedly consumed fish species is rainbow trout, followed closely by bull trout. A small number of other species were reported consumed including lake whitefish, burbot and anadromous salmon, as well as canned tuna and salmon. Few fish are collected from Williston Reservoir directly. This is because nearly all of the communities are not situated directly on the reservoir and it is much easier to capture fish from tributary streams (e.g., Finlay River) or lakes (Moberly). Also fishing on Williston Reservoir typically requires a large vessel with a jet drive and would be opportunistic at most, unless involved in a fishing derby, such as the Duz Cho derby out of Mackenzie in August.

In general, the 2017 data augment and supported what was learned in 2016. Fish consumption, where reported, most commonly averaged 1 – 2 fish meals per month. While there were a few people who reported consuming fish 2 x per week, consumption frequency was less than this for most people who consumed fish 1 – 6 x per year and was strongly seasonal, with very few fish reported consumed during winter. The exception is for a few people who fish Moberly Lake under ice in mid-winter (January, February when ice is reliably thick), targeting ling or burbot.

The issue of mercury was not raised during interviews, as we did not want to bias responses; and to our knowledge no one raised mercury as a reason why they did not fish. Most people regard fishing as a recreational activity and do not target fish as a primary protein source, with most people expressing a preference for mammals (e.g., deer, caribou, moose). That fish comprised a small portion of diet of non-coastal First Nations, including from this area, was also the finding of the First Nations Food, Nutrition and Environment Study 2008 – 2009 (FNFNES 2011). Several local communities participated in that study, including Saulteau, Tsay Keh Dene, Doig River and Prophet River First Nations. The study identified that on average, fish was consumed 9 – 11 days per year in these communities, including canned salmon.

2.3. Engagement with Health Authorities

Azimuth met with several members from Northern Health and the First Nations Health Authority in Prince George on January 9, 2018. The attendees and minutes of this meeting are provided in **Appendix D**. The meeting began with an update on the FWCP program, re-visiting the minutes from the meeting in 2017 and then a presentation by Azimuth, similar to the presentations given to First Nations communities in **Appendix C**. One of the key parts of the presentation was providing an overview of the strategies used in other provinces (Quebec, Ontario and Manitoba) to communicate health information regarding mercury in fish. In Ontario, for example, there are thousands of natural lakes where there is guidance (not an advisory *per se*) to help consumers determine how many meals per week of different species of particular size classes from individual lakes can be consumed to fall within Health Canada guidelines with respect to the 'tolerable daily intake' (TDI) of mercury. A similar approach was followed in Quebec for northern hydroelectric reservoirs, but with more lenient guidance, recognizing the cultural importance and nutritional value of fish in the diet of First Nations communities.

At the meeting, the concept of developing a working group between Azimuth and FNHA and NH (later in 2018 or 2019) and potentially other agencies or partners was discussed and agreed upon. It was determined that a collaborative working group, consisting of Azimuth and representatives from both the First Nations Health Authority and Northern Health would be the best approach to develop communications materials and a strategy for moving forward to revise the existing consumption advisory. It was further agreed that some members of the health authorities would discuss this project at their next inter-agency meeting to determine a future working group and if communications should be extended beyond the FWCP to include MOE or BC Hydro, for example. It was noted at the meeting that funding under the FWCP will end in early 2019 and that another funding vehicle to carry this work forward would need to be found. For example, developing fish consumption guidance for the Peace Region (i.e., within the Omineca Region as specified by the province) would be our first goal – but that it might necessarily require a broadening, to include other parts of the province of BC. The participants at the meeting recognized this and acknowledged that the FNHA Contaminants Program may have funds available to support a study focusing on contaminants of concern to First Nations, obviously including mercury, but perhaps other contaminants.

The outcome of the meeting and a budget item in the 2018 proposal was for Azimuth to develop a conceptual approach for a fish consumption advisory for the Peace Region. We would present examples of what has been implemented in other provinces and use those to build from within the context of BC. Determining whether particular strategies implemented in other provinces are more or less effective than others is not within our scope of work as noted above. The focus of any consumption recommendations would be based in empirical data and would begin with a positive focus on the health benefits of fish consumption. This is consistent with Health Canada guidance as well as in other provinces, especially Quebec where there are many more reservoirs with higher fish mercury concentrations and where fish is a much more staple part of the diet than in BC non-coastal First Nations communities (FNFES 2011).

Table 2-1. Detailed (top: by species, waterbody, reach, and program) and summary (bottom: by program and year) sources of fish tissue samples for 2017.

Year	Species	Waterbody	Reach	Program	N
2017	LKTR	Williston	Parsnip Rch	Parsnip Derby	10
2017	LKTR	Williston	Peace Rch	Community	3
2017	LKTR	Williston	Peace Rch	Targeted	24
2017	LKTR	Dinosaur	Dinosaur Res	Dinosaur Derby	22
2017	BLTR	Williston	Finlay Rch	Community	8
2017	BLTR	Williston	Finlay Rch	Opportunistic	26
2017	BLTR	Williston	Peace Rch	Targeted	16
2017	BLTR	Dinosaur	Dinosaur Res	Dinosaur Derby	1
2017	BLTR	Peace R	Peace DS	Community	1
2017	BLTR	Thutade Lk	Thutade Lake	Targeted	13
2017	LKWH	Williston	Peace Rch	Targeted	28
2017	LKWH	Peace R	Peace DS	Community	3
2017	KOKA	Williston	Finlay Rch	Opportunistic	15
2017	KOKA	Williston	Peace Rch	Targeted	3
2017	KOKA	Thutade Lk	Thutade Lake	Targeted	9

Program	2016	2017
Community	0	42
Dinosaur Derby	0	36
In-Kind FLNRO	88	0
In-Kind OTHER	21	0
Opportunistic	32	41
Parsnip Derby	38	12
Targeted	81	160

Table 2-2. Sample sizes for archived (none in 2017), mercury (Hg), stable isotopes analysis (SIA), metals, and age by species, waterbody and reach for 2017.

Year	Species	Waterbody	Reach	Archived	Hg	SIA	Metals	Age
2017	LKTR	Williston	Parsnip Rch	No	10	10	0	10
2017	LKTR	Williston	Peace Rch	No	27	27	10	28
2017	LKTR	Dinosaur	Dinosaur Res	No	22	22	0	18
2017	BLTR	Williston	Finlay Rch	No	34	34	10	0
2017	BLTR	Williston	Peace Rch	No	16	16	3	11
2017	BLTR	Dinosaur	Dinosaur Res	No	1	1	0	1
2017	BLTR	Peace R	Peace DS	No	1	0	0	0
2017	BLTR	Thutade Lk	Thutade Lake	No	13	13	0	0
2017	LKWH	Williston	Peace Rch	No	28	28	10	28
2017	LKWH	Peace R	Peace DS	No	3	0	0	0
2017	KOKA	Williston	Finlay Rch	No	15	15	0	0
2017	KOKA	Williston	Peace Rch	No	3	3	0	3
2017	KOKA	Thutade Lk	Thutade Lake	No	9	8	0	0
2017	ARGR	Williston	Finlay Rch	No	2	2	0	0
2017	MNWH	Williston	Peace Rch	No	8	8	0	8
2017	MNWH	Thutade Lk	Thutade Lake	No	21	21	0	0
2017	RNBW	Williston	Parsnip Rch	No	6	6	0	2
2017	RNBW	Williston	Finlay Rch	No	1	1	0	0
2017	RNBW	Williston	Peace Rch	No	19	19	5	6
2017	RNBW	Dinosaur	Dinosaur Res	No	13	13	0	12
2017	RNBW	Peace R	Peace DS	No	2	0	0	0
2017	RNBW	Thutade Lk	Thutade Lake	No	16	16	0	0
2017	RNBW	Sustut R	Sustut River	No	1	1	0	0
2017	RNBW	Sardine Lk	Sardine Lake	No	1	1	0	0
2017	BURB	Williston	Peace Rch	No	5	5	0	5
2017	BURB	Peace R	Peace DS	No	1	0	0	0
2017	LNSC	Williston	Peace Rch	No	10	10	0	9
2017	LGSC	Williston	Peace Rch	No	0	0	0	3
2017	LGSC	Peace R	Peace DS	No	1	0	0	0
2017	NRPK	Peace R	Peace DS	No	1	0	0	0
2017	NRPM	Williston	Peace Rch	No	0	0	0	3
2017	SPSL	Sustut R	Sustut River	No	1	1	0	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

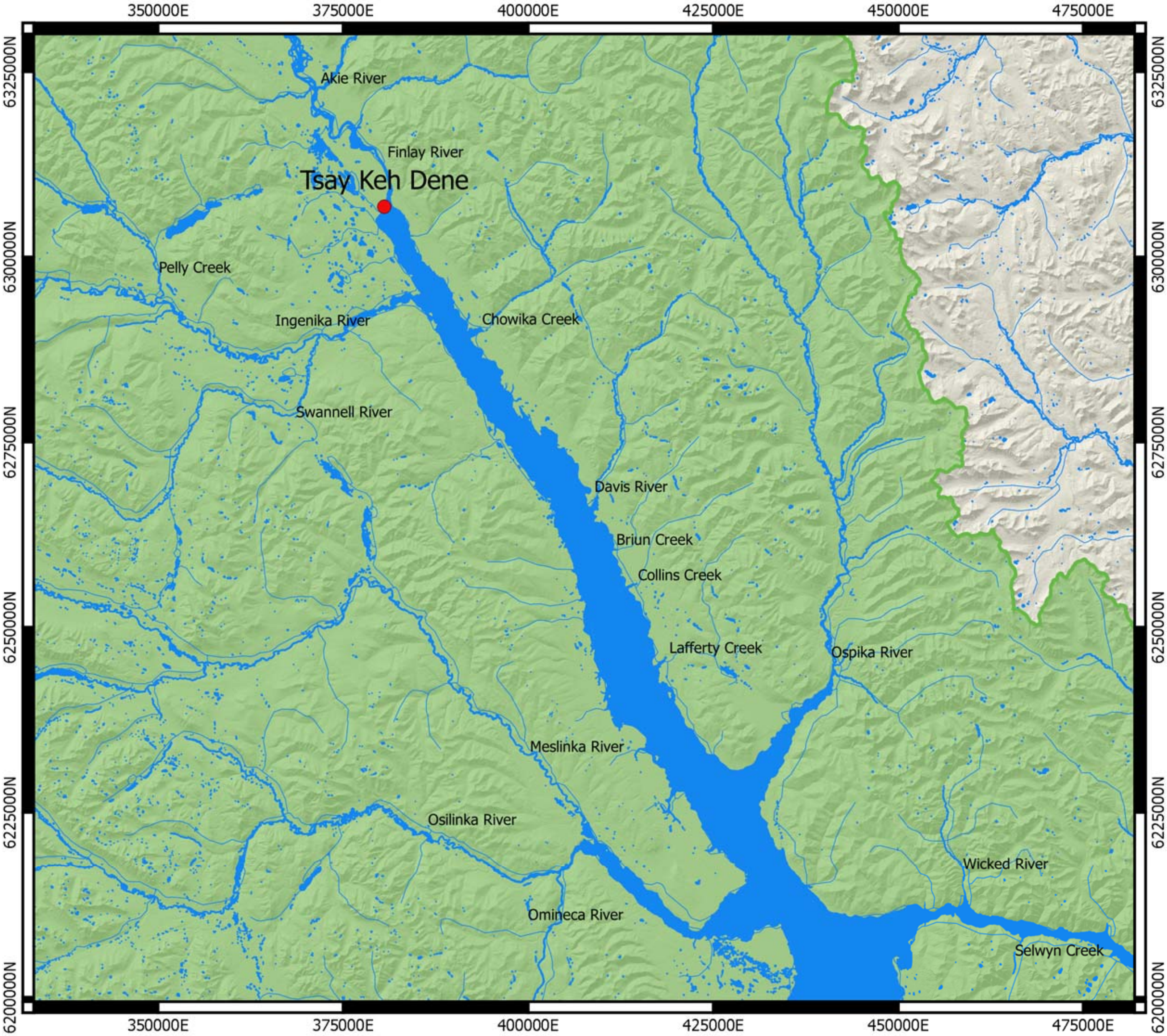


Figure 2-2. Finlay Reach and its main tributaries.

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

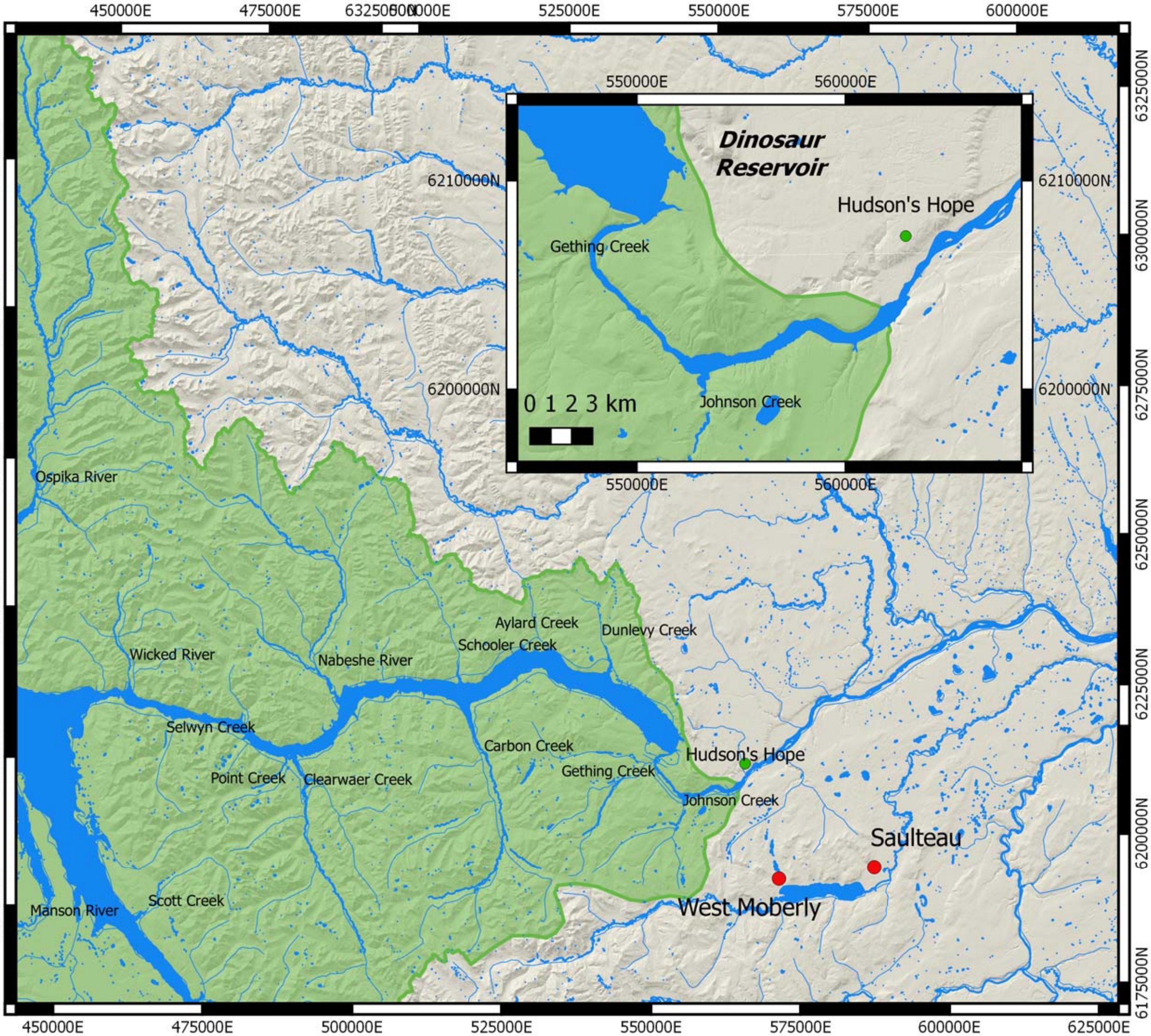


Figure 2-3. Peace Reach and Dinosaur Reservoir (inset) and their main tributaries.

Version Date: 13 April 2018

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

3. PRELIMINARY FISH MERCURY ANALYSIS

3.1. Preliminary Analysis Approach

As described in **Section 2.1**, this is the second of a three-year investigation to characterize fish mercury concentrations within the Williston - Dinosaur Watershed. Williston is a large, complex system and monitoring efforts were necessarily stratified over time, to obtain data on a reach-by-reach basis (i.e., Parsnip Reach, Finlay Reach, Peace Reach, and Dinosaur Reservoir), as well as significant tributary streams where possible.

This 2017 report builds on the 2016 report (i.e., data from both years are integrated where appropriate), providing greater and more depth insight into relationships between mercury in tissue and fish species, size-age classes and geographic extent, by comparing Peace Reach with Parsnip and Finlay Reach, as well as data from Dinosaur Reservoir. This report, like the 2016 report is not strictly a 'Data Report', as we have made efforts to summarize the existing data (tables) and visualize trends (plots) in mercury data, as well as by incorporating stable carbon and nitrogen isotope data ($\delta^{15}N$ and $\delta^{13}C$, respectively; See **Section 3.1.2**). Stable isotope information gathered from individual fish helps us understand the dietary pattern/history of a fish and how it compares to other individuals or species with respect to its trophic position – as a detritivore, planktivore, omnivore, or piscivore – because mercury in fish muscle is incrementally higher moving up the food web from a planktivore (e.g., kokanee) to a piscivore (e.g., bull trout).

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

Field QA/QC

Quality assurance (QA) methods consistent with those used in 2016 were carried forward in 2017 to ensure consistency in methodology and to ensure that data quality objectives were met throughout the study. These included:

- Experienced and qualified people led the investigation and provided senior-level oversight. EDI was responsible for direct supervision of field staff during the strategic study of Parsnip Reach under the direction of Tim Antill and Jason Yarmish, both senior ecologists.
- Sample collection followed a standard operating procedure (SOP) developed for the 2016 program (Azimuth 2017). Key elements of the SOP included, but were not limited to, the use of standardized field forms (i.e., to ensure that key meristic data was clearly linked to specific fish), processing of fish tissue samples using 'clean' techniques (e.g., frequent change of gloves, keeping the work space clean and new biopsy tools for each live fish) and careful sample handling practices (e.g., samples were placed into unique vials or bags labeled with indelible ink; samples were stored on ice until they could be frozen; frozen samples were sent to Azimuth for logging and processing where they were maintained in a single location until shipping to the laboratory for analysis).

Quality control (QC) sampling involved the collection of field duplicate samples which were submitted 'blind' to the laboratory for analysis. To limit stress on live fish, field duplicates were limited to sacrificed fish only (i.e., fillet samples only, from about 5% of samples). These samples help determine laboratory precision. Note that this was for a subset of tissues in the strategic Peace Reach sampling program, but not for the community led sample collections.

Laboratory QA/QC

This information was presented in the 2016 report and we have implemented the same approach in 2017. At the laboratory, their internal QA procedure requires they randomly choose 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 both 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 RPDs were used directly; these were typically 40% for mercury and only apply when measured concentrations 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. The rationale for the inclusion of the 10x DL rule in the DQO is that large variations in RPD values are often 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 outlined in the SOP (**Appendix E**), standard procedures were used to ensure reliable sample tracking, logging, and data recording to establish continuity between the sample collected and the results reported. Fish meristic data and sampling details recorded on the field data sheets were entered into the

Excel-based repository started in 2016. Initial stages of the data analysis involved ensuring that there were no 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. The entire database will be published at the end of the program in 2018.

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) and a very small amount directly from water. Thus, diet and food web structure have 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, what and how much a fish eats. Small, young fish that consume plankton or insects will have less mercury than large, old, predatory species at the top of the food chain. Life history of individual fish is also important – especially for large piscivorous species like bull trout that may range great distances within the reservoir and up tributary streams where they will gather nutrients (and mercury) over a wide area, integrated over time. Other factors such as growth rate, age, maturity and individual parameters (genetics, metabolism) will also influence the burden of mercury within fish populations.

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 be used to determine whether fish are feeding more from the benthic or pelagic (i.e., water column) food webs (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.

Understanding the trophic relationships among and within fish species allows us to interpret 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 may help shed light on why mercury concentrations differ geographically, or between 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. 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, which are not at our disposal.

3.1.3. Assessment of Key Species

As described in **Section 1.2**, the ultimate goal of this three-year program is to develop an understanding of fish mercury concentrations in key species – bull trout, lake trout, lake whitefish and kokanee, across a very large spatial area, covering 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 among the three major reaches within the reservoir, or between Williston Reservoir and reference lakes.

The ideal characterization for each species with a strong length-mercury relationship 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 (e.g., n~30)[2]. Using this length – mercury relationship, we can compare concentrations across space or time at a \`standardized size\`. An example of this is provided here.

LENGTH INTERVAL (MM)	LAKE WHITEFISH	LAKE TROUT	RAINBOW TROUT
100-199	7		7
200-299	7	5	7
300-399	7	5	7
400-499	7	5	7
500-599	7	5	7
600-699		5	
700-799		5	
>800		5	
Total	**35**	**35**	**35**
"Standardized Size"	**350 mm**	**550 mm**	**350 mm**

[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.

[2] These sample sizes are based on past experience. Variability in mercury concentrations within each species/area combination will dictate how small a difference in tissue mercury concentrations will be able to be detected between any two areas.

In cases where the length-mercury relationship is weak or it is logistically challenging to sample fish from across the entire size distribution, efforts can target a smaller number of fish (e.g., n~10)[2] within a specific, more narrow size class (e.g., 500 – 600 mm for bull trout). To meet the end goal of this program (see above), sufficient data are required to make inferences regarding spatial differences in mercury concentrations within species – especially using statistical procedures, such as analysis of covariance (ANCOVA). In reality, despite efforts to collect ideal data sets for all species/area combinations, it is anticipated that some gaps will remain due to the size and complexity of the Williston – Dinosaur Watershed.

As described in **Section 3.1**, this report focuses on presenting a preliminary analysis that uses summary tables and data plots to help understand the data, discern potential spatial patterns and identify key data gaps for the 2018 program. A full and formal statistical analysis of the entire three-year data set will be presented in next year's final report.

Key steps involved in this preliminary analysis for each species were as follows:

- *Catch Data and Meristics* – The 2016 and 2017 data from this study were augmented with project-related reconnaissance data from 2015 (Azimuth 2016). In addition, the Thutade Lake data set was augmented by including fish sampled in 2014 and 2015 during baseline sampling for the Kemess Underground Project (Hatfield and Bustard 2015, 2016). For the key fish species (i.e., lake trout [LKTR], lake whitefish [LKWH], bull trout [BLTR] and kokanee [KOKA]), data were summarized in tables (e.g., catch, length, weight, condition, and age by area and year) and plotted (e.g., length frequency, age frequency, length-weight, age-length where available) 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 spatial 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.

3.2. Data Quality Results

As documented in Section 3.1.1, extensive quality assurance (QA) measures were used to minimize deviations from the program's data quality objectives. This section presents the results of quality control (QC) testing conducted to verify data quality relative to the DQOs. Three types of QC testing were completed: laboratory, field and data analysis.

3.2.1. Laboratory

ALS Laboratory – Tissue Chemistry

The QC assessment completed by ALS for tissue samples submitted in 2017 are shown in **Table 3-1**. Results of the QC analysis are discussed below, along with a discussion on the implications of the assessment on the interpretation of the tissue chemistry results. Overall, these tissue chemistry data meet the data quality objectives for this baseline study.

Six laboratory reports from ALS for tissue mercury analysis were generated during the 2017 sampling program (available upon request). While total metals were also analyzed for selected fish from the Peace Reach and Finlay Reach data sets, these data are not discussed in this report and were not assessed relative to the data quality objectives. ALS reported results for four types of QC checks (**Table 3-1**):

1. *Detection Limits (DL)* – Changes to DLs may be needed when the planned DLs are inappropriate (e.g., due to low signal/noise ratios or variable replicate recoveries). There were elevated DLs for all laboratory data sets, but no changes were high enough to result in non-detectable concentrations of mercury.
2. *Laboratory Duplicates* – This checks for reproducibility of laboratory results. ALS' DQOs were used to assess RPDs; for most parameters the DQO is an RPD of less than 40% between duplicate samples. Apart from barium exceeding the DQO in lab report L1987928, there were no other deviations.
3. *Method blanks (MB)* – This checks for false positives. The MBs met the DQO of less than the DL for QC samples analyzed in each batch of samples (**Table 3-1**).
4. *Matrix spike (MS)* – This checks for matrix interference affecting accuracy. No issues were identified.
5. *Laboratory Control Samples* (LCS) / Certified Reference Material (CRM) / Internal Reference Material (IRM) – This checks for accuracy of the method. No issues were identified.

SINLAB – Tissue Stable Isotopes

Regarding analyses of stable carbon and nitrogen isotopes (SIA) by SINLAB (available upon request), no deviations from laboratory DQOs were reported. Some minor discrepancies arose due to labeling errors in the field or sampling submissions. One Finlay Reach sample was indicated on the chain of custody as submitted twice though only one sample was submitted and was analyzed as one sample.

North/South Consultants – Fish Aging

With respect to fish aging, a subset from each submission was aged by two technicians (available upon request). Both otoliths and fin rays were submitted for aging depending on fish species for a total of 210 individual age structure samples. For the 26 QA/QC samples, six ages were different. Generally, the ages were the same or were within one year. Higher replicability between technicians is largely attributed to the condition of the aging structure and to the age of the fish. 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.

Of the samples that were aged, several fish could not be aged. One Parsnip Reach fish otolith sample could not be aged as the otolith was unreadable. One otolith sample from Dinosaur was missing from the envelope. For Tezzeron Lake, several otoliths were broken, either in the envelope or at the laboratory, and two were received in "very poor" condition. Seven of 75 structures could not be aged. Most ageing structures for all samples were rated as of 'Fair' quality or better – 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.

3.2.2. Field

The results of field duplicate samples for moisture and total mercury are presented in **Table 3-2**. RPD results for moisture were all 3% or lower, indicating highly reproducible and consistent analytical results. For mercury, the results were generally on the order of 10% or less, which is also very good for tissue analyses (ALS' own RPD DQO for laboratory duplicates is 40%). Of the 13 field duplicate samples, only one result had an RPD exceeding 40% (a BLTR sample from Thutade Lake). As discussed further in **Section 3.4.2**, notwithstanding this QC result, the 2017 BLTR results for Thutade Lake appear anomalous relative to data collected in 2014 and 2015; while we have been working with ALS to verify the results, this process is ongoing.

3.2.3. Data Analysis

Several potential outliers were identified following the procedures described in **Section 3.1.1**. These outliers are presented and discussed within the context of the results (**Section 3.4**).

3.3. Results for Feeding Relationships and Mercury Concentrations

As discussed in **Section 1.4**, tissue mercury concentrations are lower in lake whitefish and rainbow trout than in lake trout and bull trout, because these species feed lower on the food web, consuming plankton and benthos, while trout mostly consume fish. SIA results for fish caught in 2015 – 2017 in Williston Reservoir, Dinosaur Reservoir, Thutade Lake (reference area), and Fraser Lake (reference area) are presented in **Section 3.1.2**. Species with higher $\delta^{15}N$ values on the y-axis indicate a higher trophic position, while $\delta^{13}C$ values on the x-axis 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 four waterbodies:

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.

- *Top Predators* – Lake trout, bull trout and burbot are situated in the upper middle of the Williston plot in **Figure 3-1**, 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* pelagic-driven (more negative value) and benthic-driven (less negative value) food chains.
- *Pelagic Pathway Feeders* – Kokanee and lake whitefish typically fall in this group, feeding primarily on zooplankton (i.e., pelagic based-food) and thus both fall within the same trophic level. This explains their close association at the lower right side of the graph with more depleted $\delta^{13}C$ values (-30 – 32). Only Williston had both species present, as either one or the other species was found in other waterbodies. These species have lower $\delta^{15}N$ and $\delta^{13}C$ values (**Figure 3-1**) than trout, suggesting that they are feeding more directly on the pelagic phytoplankton-to-zooplankton-to-fish pathway.
- *Benthic Pathway Feeders* – Mountain whitefish and rainbow trout are typically situated in the lower right of the stable isotope plots with more enriched $\delta^{13}C$ values (-25 to -28). Notwithstanding the results for Williston Reservoir[3], mountain whitefish typically feed on benthic invertebrates, which is consistent with where they show up in the Dinosaur, Fraser Lake and Thutade Lake plots (**Figure 3-1**). Rainbow trout feed on a range of prey, including hatching insect larvae, which spend most of their life residing in the sediment, and on invertebrates of terrestrial origin (e.g., flies and spiders with $\delta^{13}C$ values around -28‰). While not benthic feeders *per se*, the mixed diet of hatching insects and terrestrial invertebrates often results in them having $\delta^{13}C$ values near -28‰.

The SIA results for Williston Reservoir warrant some additional discussion. Studies that incorporate stable isotopes of tissues often include sampling of the lower trophic level organisms from the water column and benthic habitats from each area of interest. These would include representative samples of zooplankton and benthic invertebrate groups (e.g., chironomids, amphipods, other insect taxa). As discussed in **Section 3.1.2**, characterizing $\delta^{15}N$ and $\delta^{13}C$ values in lower trophic organisms helps to elucidate feeding relationships, but takes a considerable effort to implement. Given the resources available for this study, a greater emphasis was placed on characterizing fish mercury concentrations than on understanding the subtleties of trophic relationships. Consequently, we can only point out what we see based on the fish SIA results and on our past experience with this tool. Nevertheless, using SI data can help in interpreting differences in mercury concentrations of fish between areas (e.g., Dinosaur vs Williston) that may not have otherwise been apparent, as we will demonstrate.

For example, the results for Williston (upper left box, **Figure 3-1**) for species like mountain whitefish and longnose sucker, appear to be skewed more towards more depleted (negative) $\delta^{13}C$ values than might be expected, corresponding to the pelagic food chain. The apparent dietary shift towards pelagic (e.g.,

[3] 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.

zooplankton) in these normally benthivorous species suggests that the benthic food chain in Williston (and possibly Dinosaur) contributes much less to overall fish production than the pelagic food chain.

SI signatures of bull trout, lake trout and burbot are also slightly more depleted and correspond to $\delta^{13}C$ signatures of lake whitefish and kokanee, suggesting that these species are important prey or dietary items of these piscivorous species.

Arctic grayling and rainbow trout had more enriched (positive) $\delta^{13}C$ values, suggesting a stronger reliance on tributary streams and dietary items of a partially terrestrial origin. Interestingly, the 2012 *Williston Fish Index in the Vicinity of the W.A.C. Bennett Dam* (Plate et al. 2012) reported decreasing numbers of rainbow trout, longnose sucker and Arctic grayling between 1974 and 2012. While inter-species competition and dietary shifts are important from an ecological perspective and may have influenced fish mercury concentrations over the years, it is the current trophic relationships (i.e., as reflected in the SIA results) that drive current fish mercury concentrations within the Williston – Dinosaur watershed.

Combined results of recent (2014 to 2017) fish mercury sampling programs undertaken by Azimuth are shown in **Figure 3-2**. Note that there is a wide range in mercury concentrations within each species (note that the y-axis is shown on a log scale). 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. This figure depicts all Hg data collected across Williston and Dinosaur reservoirs (limited data from Dinosaur) for 12 species (including some 'downstream' fish from Peace River and a single spring salmon (*O. tshawytscha*; SPRL)) relative to Hg data from 'reference lakes' collected to data, primarily Thutade Lake (bull trout – kokanee complex) and Fraser Lake (lake trout – lake whitefish complex). It basically summarizes the distribution of recent mercury concentration across all species between Williston (combined over reaches) and reference lakes. The vertical spread in the distribution within a species/lake reflects differences in fish size. Thus, it is important to note that if one species appears to have generally higher or lower mercury concentrations than another (e.g., kokanee), this difference may simply be due to larger or smaller fish having been sampled. These relationships are explored in greater detail within this section.

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 3-2**). This explains the great similarity in mercury concentrations for this species – even among waterbodies. Similarly, mountain whitefish and rainbow trout, which also had similar isotopic ratios as described above, 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, looking across this figure, the range and magnitude of mercury concentrations appear to be fairly similar among Williston Reservoir and reference area lakes for most species. A full statistical analysis will be undertaken in 2018 to fully explore these relationships. While there are exceptions – such as kokanee and bull trout from Thutade Lake (lower relative to Williston), there are ecological or size-related reasons as to why this appears to be the case. Should mercury concentrations from Williston Reservoir fish species be 'elevated' relative to other lakes because it is a 'reservoir', then no species should be immune from this and all species would be elevated in Williston. This is clearly not the case. As noted above, the mercury – size and age relationships (where age data are available) as surrogates for growth rate and stable isotope information will be explored for each species, with the specific view to address whether or not mercury concentrations in key fish species (i.e., bull trout, lake trout, lake whitefish, kokanee) are higher in Williston reservoir than in nearby, regional reference lakes.

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 mainly on Williston's Parsnip Reach and Fraser Lake (a reference area). Only a few lake trout were collected from Finlay Reach as part of our partnership program. This will be expanded on during the 2018 strategic survey. The 2017 program targeted the Peace Reach (strategic survey) and fishing derbies in the Parsnip Reach (Duz Cho derby out of Mackenzie) and Dinosaur Reservoir (Father's Day derby in Hudson's Hope). A summary of catch results, by length interval, for both 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
2016	Reference	Fraser Lk	Fraser Lake	32	0	0	6	5	8	10	3	0	0
2016	Williston	Williston	Parsnip Rch	42	0	0	2	2	1	3	16	15	3
2016	Williston	Williston	Finlay Rch	4	0	0	0	0	0	1	3	0	0
2017	Dinosaur	Dinosaur	Dinosaur Res	22	0	0	10	6	4	2	0	0	0
2017	Williston	Williston	Parsnip Rch	10	0	0	0	0	0	5	2	1	1
2017	Williston	Williston	Peace Rch	27	0	7	14	5	1	0	0	0	0

The length-frequency plot in **Figure 3-3** 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. This is because many of these tissue samples were acquired during the 2016 and 2017 Duz Cho fishing derby. While the derby provided good numbers of fish, the size range was biased towards larger fish. While prizes were offered in 2017 for smaller fish, this effort was not as successful as we had hoped. The 2017 samples from Peace Reach, on the other hand, appear biased towards smaller fish where nearly all of the fish captured here were smaller than what were captured from Parsnip Reach in 2016. This will have large implications on differences and the pattern of mercury concentration related to fish size/age among reaches. It is noteworthy that a lake trout acoustic tagging study was conducted in the Peace Reach in 2016 and was successful catching larger size classes (Ted Euchner, April 2018; Personal Communication). Thus, larger fish are present in the Peace Reach – but we were not successful at capturing them. This is a data gap that we will try to fill in 2018.

Fewer fish have age data (**Figure 3-3**) due to either circumstance (e.g., non-lethal sampling in Finlay Reach) or to limited resources (i.e., greater emphasis on mercury sampling). While the age range of fish from Parsnip and Fraser lakes was reasonably similar, the ranges for Peace Reach and Dinosaur were narrower and limited to younger fish (**Figure 3-3**).

The length-weight relationship for lake trout depicted in the upper left-hand graph of **Figure 3-4** shows a linear and quite standard relationship. The exception was for two size-related outliers that were identified but have been retained for now. Data from all waterbodies appeared to show a consistent trend (despite disparate size classes sampled from each), although there may be subtle differences among the waterbodies if tested statistically.

The age-length relationship for lake trout (**Figure 3-4**; middle box) suggests similarities but also some differences between the areas. For example, Fraser Lake and Parsnip Reach lake trout both appear to grow rapidly until age 8 – 10 at which time there an asymptote is reached, whereby growth slows considerably and appears to plateau, with only relatively slow growth (in length and weight) from age 12 – 25. While not fully overlapping in size range, Parsnip Reach fish appear to be generally slightly larger at a similar age than trout from Fraser Lake for fish of similar ages (i.e., 10 to 25 years old), indicating faster growth rates in fish from Williston. We also observed this trend in bull trout between Williston and Thutade lakes, which will be explored in the next section.

The latter is important as faster growth has been shown to result in lower mercury concentrations, especially in younger, rapidly growing fish. 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. Thus, 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). These data suggest that growth of lake trout in Williston Reservoir relative to Fraser Lake is higher possibly indicating an abundant food resource (lake whitefish and kokanee?) – but this is not reflected in a greater accumulation of mercury in Williston Reservoir trout.

Lastly, the two length-weight outliers (circled in red and labeled) appear consistent with the rest of the data, suggesting that perhaps the weight portion of data for those fish may be incorrect.

Mercury-Related Relationships

The general length-mercury relationship in upper right box (**Figure 3-4**) shows a fairly strong trend, particularly in fish greater than 500 mm in length with sharply increasing mercury in tissues with increasing fish size (note; two outliers, both from Dinosaur, were identified but retained for now). When viewed across all areas, including the reference lake Fraser, there does not appear to be a large difference in this fundamental relationship. In fact, Fraser Lake trout may have slightly higher mercury concentrations at a similar size as Williston Reservoir fish. This suggests that both Fraser Lake and Williston Reservoir fish are exposed to dietary prey with a similar magnitude of mercury concentration. Slightly higher concentrations at equivalent size in Fraser Lake fish may be due to slower growth rates – as explained above. This lends further support to quite similar fish mercury concentrations across trophic levels between the two types of systems – a reservoir and a lake.

Of note however, there is an unusually wide variation in mercury concentrations within relatively narrow size classes of fish (i.e., of 50 to 100 mm intervals), where for example, mercury concentrations range over 5x within narrow intervals (700 – 800 mm), ranging from <0.3 mg/kg to >1.2 mg/kg. This may be due to different dietary histories driven by differences in feeding locations (e.g., within reservoir vs within tributary) by individual fish. Note that, similar to the age-length results above, both of the two length-weight outliers (circled in red) are consistent with the prevailing length-mercury trend (i.e., which suggests that the weight portion of the length-weight data is incorrect for both fish).

Patterns in the length-mercury relationship within Williston Reservoir reaches (**Figure 3-5**) show an apparently consistent trend despite distinct size differences among Parsnip, Finlay and Peace reaches. While the overlap in size-distribution across all three reaches is poor, there is nothing to suggest that one reach is distinctly different than other. While more similar size distributions across all three reaches would be ideal to test for statistical differences in fish mercury concentrations, these data suggest that differences, if any are identified, are likely to be small. Furthermore, T. Euchner (April, Pers. Comm) has indicated that results of their radio-telemetry work demonstrate that lake trout move between reaches, lending support that the reservoir may contain a large, homogeneous population. That said, the potential importance of within-reservoir differences in the length-mercury relationship should be revisited after additional data are collected from Finlay Reach in 2018.

Patterns in the length-mercury relationship between Williston and the Fraser Lake reference area (**Figure 3-5**) show some interesting patterns. While mercury concentrations in smaller lake trout appear higher in Williston, that pattern reverses for fish between 500 to 800 mm, where concentrations appear higher in Fraser Lake.

The $\delta^{15}N$-mercury and length-$\delta^{15}N$ relationships (**Figure 3-4**) 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 lake trout from Fraser Lake relative to Williston Reservoir. This may reflect a slightly longer or complex food chain in Fraser Lake than in Williston and may help to explain their slightly higher mercury concentration at a similar size than Williston fish. 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. In addition to the growth rate differences discussed previously, these apparent differences in trophic position could also explain the mercury results described above.

Interestingly, the two outliers from Dinosaur identified in the length-mercury relationship (see green circled point in **Figure 3-4**), which had low mercury concentrations for their size, also have the lowest $\delta^{15}N$ values in the data set. This suggests that the reason for their atypical mercury concentrations is due to feeding preference rather than to an erroneous entry for length or mercury concentration for those fish. These individuals are targeting dietary items that are very low on the food web with low mercury concentrations, unlike their counterparts in the lake, illustrating that dietary choices by individual fish may play a role in the broad range of mercury concentrations observed within narrow size intervals.

Data Gaps

- While we are lacking smaller size classes in Parsnip Reach and larger size classes in the Peace Reach, the apparent lack of obvious differences in the length-mercury relationship among reaches suggests that this may not be a crucial gap. However, this conclusion should be revisited after more data are collected for Finlay Reach. We may attempt to fill these gaps in 2018 if the opportunity presents itself.
- Only 4 fish caught in Finlay Reach so far; need all size classes (5+ fish in each) in Finlay Reach.
- The 2018 strategic investigations will focus on the Finlay Reach.
- Additional reference area data would be helpful to put the Williston results into better context.

3.4.2. Bull Trout

Catch Results and Meristics (**Figure 3-6** and **Figure 3-7**)

The 2016 target program focused on Williston's Parsnip Reach and Thutade Lake (reference area), while the 2017 program focused on the Peace Reach and Thutade Lake for a second year, to fill data gaps. For Williston Reservoir, additional bull trout were also sampled from various locations in Finlay Reach through both opportunistic (CCE in 2016 and 2017) and in-kind FLNRORD (2015 and 2016) efforts. Bull trout were also caught in Parsnip Reach in 2015 through in-kind efforts by FLNRORD. We also included recent (2014 and 2015) bull trout data collected from Thutade Lake during baseline studies for the Kemess Underground Project (Hatfield and Bustard 2015, 2016). 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	Thutade Lake	11	0	0	0	0	0	5	5	1	0
2015	Reference	Thutade Lk	Thutade Lake	16	0	0	0	0	1	4	9	2	0
2015	Williston	Williston	Parsnip Rch	6	0	0	1	1	0	1	3	0	0
2015	Williston	Williston	Finlay Rch	20	0	0	0	4	3	3	10	0	0
2016	Williston	Williston	Parsnip Rch	13	0	0	3	5	1	3	1	0	0
2016	Williston	Williston	Finlay Rch	39	0	0	1	6	9	6	13	4	0
2017	Dinosaur	Dinosaur	Dinosaur Res	1	0	0	0	1	0	0	0	0	0
2017	Downstream	Peace R	Peace DS	1	0	0	1	0	0	0	0	0	0
2017	Reference	Thutade Lk	Thutade Lake	13	0	0	0	1	3	3	4	1	0
2017	Williston	Williston	Finlay Rch	34	0	0	3	13	3	4	7	1	0
2017	Williston	Williston	Peace Rch	16	0	2	7	3	2	0	1	0	0

A substantial amount of bull trout tissue mercury data from Williston Reservoir has been generated in this study. Finlay Reach has 93 samples (collected from a number of rivers/creeks), while fewer data are available for Parsnip and Peace reaches (19 and 16, respectively), despite these being the focus of targeted sampling efforts in 2016 and 2017, respectively. One of the challenges of the strategic sampling is that the goal is to collect a range of size classes from a number of species with different habitat preferences. The success of the opportunistic and in-kind FLNRORD efforts in Finlay Reach has been due to the singular focus on bull trout in prime bull trout habitat (i.e., tributary mouths or well into the tributaries). Forty samples are available for Thutade Lake.

The length-frequency plot (**Figure 3-6**) shows the number of bull trout collected by reach or waterbody across the range of size classes. Finlay has the most complete data set. Despite having far fewer fish, the Parsnip Reach data set covers a fairly wide size range. Peace Reach, however, has few only smaller fish. The Thutade Lake reference data set has good coverage of the larger size classes but is also lacking smaller fish. Far fewer age data (**Figure 3-6**) are available as much of the bull trout sampling has been conducted using non-lethal methods.

The length-weight relationship (**Figure 3-7**) for bull trout is strong and without major outliers. The age-length relationship (**Figure 3-7**) is somewhat variable, but the trend suggests similar growth rates for fish from Finlay Reach and Thutade Lake (i.e., based on lengths for fish aged 7 – 13 years). In contrast, bull trout from the Peace Reach had apparently slower growth rates than those observed for the Finlay Reach (i.e., based on lengths for fish aged 5 – 8 years). There are too few age-length data from other areas to make any preliminary observations. As discussed previously for lake trout, differential growth rates can influence tissue mercury concentrations, so these patterns may be important factors driving spatial differences (or the lack thereof) in mercury concentrations. The higher variability seen in the relationship for age-length relative to length-weight (**Figure 3-7**) is the main reason why mercury-related relationships are not typically based on age.

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

The general length-mercury relationship for bull trout is shown in **Figure 3-7** in the upper right box. In general, mercury concentrations for bull trout are lower than for lake trout, because they are smaller and younger than lake trout. The vast majority of fish have mercury concentrations that are <0.50 ppm ww. Note that there is a great deal of variability in mercury concentration within narrow size intervals (50 – 100 mm ranges), similar to or great than what was observed for lake trout. Bull trout have a more dynamic and variable life history than lake trout, utilizing both lake and stream environments, as well as undertaking long feeding and/or migratory movements for reproduction, sometimes moving far up tributary streams.

Key observations include:

- The general relationship between mercury and fish length is fairly flat for fish < 600 mm, with mercury concentrations ranging from approximately 0.08 to 0.32 mg/kg ww across all reaches. This is followed by a rapid transition to concentrations reaching 1.0 mg/kg ww as early as a 700-mm fish. This pattern is likely driven predominantly by changes in growth rates (**Figure 3-7**), which taper sharply after 600 mm. Variation among individuals of similar size, however, is also likely to be influenced by shifts in dietary preferences/trophic position (see below). For example, switching to a 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.
- Looking across reaches or between Williston and Thutade does not reveal any major differences, at least not within the range of variability that seems to persist across all size

classes. The general moderately positive correlation between mercury and increasing fish size is consistent among all populations with good overlap both within and between populations for Williston and Thutade.

- The pattern for Thutade Lake is particularly variable however, with tissue mercury concentrations spanning an order of magnitude [0.05 to 0.5 mg/kg ww] for fish ~700 mm. This pattern and unusually low mercury concentrations, even for large fish, was not observed in 2016. To illustrate this, we highlighted (i.e., circled dots) the 2017 results on the lower right panel of **Figure 3-7**. This plot clearly shows much lower mercury concentrations for bull trout in Thutade Lake caught in 2017 *versus* those caught in 2014 and 2015. In fact, <u>all fish</u> measured in 2017 had lower mercury concentrations (i.e., all <0.10 ppm; 3 – 5 x lower) than the lowest mercury concentration recorded from here in 2016. This is an unusual result and if the same populations were sampled, this magnitude of change within a single year is not possible. While different sampling teams collected the data (i.e., 2014/2015 were collected by Hatfield and Bustard and 2017 by CCE), CCE is experienced at fish mercury sampling and contributed the majority of the Finlay Reach samples over the past few years. We have discussed the results with ALS Laboratories and they have double-checked their analyses and stand by their results. They are also not explained by anomalously low $\delta^{15}N$ values (see below). Notwithstanding, we still consider these data somewhat anomalous and we cannot rule out a laboratory error. Nevertheless, the 2017 data should be interpreted with caution.
- In contrast to Thutade Lake, the 2017 tissue mercury results for Peace Reach and Finlay Reach are consistent with the general length-mercury results from previous years (**Figure 3-7**).
- Potential differences in the length-mercury relationship among the three reaches within Williston were explored in **Figure 3-8** (left plot). The trend in size-Hg appears consistent for Peace and Finlay reaches, despite differences in size. As discussed last year, while data are somewhat limited for Parsnip Reach, tissue mercury concentrations for bull trout in that reach appear higher, particularly for fish <600 mm, than in the rest of Williston. If true, possible reasons for this are hard to know and may be related to different life history or feeding strategies and migratory patterns.
- Potential differences in the length-mercury relationship between Williston and the Thutade Lake reference area are explored in more detail in **Figure 3-8** (right plot). Given the aforementioned anomalous results for Thutade Lake, those data are highlighted as they clearly influence the interpretation of the results. Looking at the 2014/2015 data for Thutade Lake only (i.e., red points without black circles), the results suggest similar, possibly slightly lower tissue mercury concentrations in bull trout from Thutade Lake relative to Williston. The 2017 Thutade data are clearly lower than Williston. Again, these differences should be interpreted cautiously until there is higher certainty in the validity (or lack thereof) of the 2017 results for Thutade Lake bull trout and once additional reference area fish are gathered.

The length-$\delta^{15}N$ and $\delta^{15}N$-mercury relationships (**Figure 3-7**) show how trophic position (based on $\delta^{15}N$ values) changes with size and how that influences tissue mercury concentrations. 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. Based on the length-$\delta^{15}N$ relationship, bull trout from Thutade Lake have comparable $\delta^{15}N$ values relative to similar sized fish from Williston. However, the low mercury concentrations for the 2017 Thutade Lake bull trout clearly standout in the $\delta^{15}N$-mercury relationship. Notwithstanding the 2017 results for Thutade Lake, these results highlight that while trophic status is somewhat important in determining tissue mercury concentrations in bull trout, other factors such as growth rates and prey item mercury concentrations may also play important roles.

Data Gaps

- Parnsip Reach is lacking fish in general, but at least covers a wide size range. Given the indication of potential differences between Parsnip and the other two Williston reaches, additional samples across all size classes would be helpful to support statistical analysis next year. We will attempt to gather more bull trout samples in 2018 through working with First Nations and/or a short, dedicated bulll trout survey conducted by EDI on the Parsnip River.
- Finlay Reach has the most comprehensive data set to date, missing only samples from the 301 to 400 mm size class. While it would be nice to fill that size class, the existing data would likely be sufficient for characterizing the reach.
- Peace Reach has low sample numbers limited to smaller size classes. While additional data would be ideal, the existing data appear to match the length-mercury relationship for Finlay Reach (i.e., while there is little overlap in size, there are no apparent differences between the two reaches).
- Unfortunately, there is uncertainty regarding the 2017 Thutade Lake samples. Therefore, we are considering expending further effort there in 2018, rather than relying on 2014/2015 data for Thutade Lake (mercury and age only). While it would be nice to completely characterize SIA data, we can settle for characterization of smaller BLTR size classes to augment the 2014/2015 data.
- Additional reference area data would be helpful to put the Williston results into better context. Thus, we are attempting to acquire at least two more reference data sets for bull trout.

3.4.3. Lake Whitefish

Catch Results and Meristics (**Figure 3-9** and **Figure 3-10**)

In 2016 the strategic, targeted program focused on Williston's Parsnip Reach (EDI) and in Fraser Lake (FLNRORD), while in 2017 effort shifted to Peace Reach (EDI, CCE, and Azimuth). A few additional samples were obtained from Dinosaur (2016) and the Peace River (2017). Lake whitefish catch results to date by size class and location 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	Dinosaur	Dinosaur	Dinosaur Res	2	0	0	0	0	0	1	1	0	0
2016	Reference	Fraser Lk	Fraser Lake	20	0	0	2	9	2	6	1	0	0
2016	Williston	Williston	Parsnip Rch	24	0	1	2	19	1	1	0	0	0
2017	Downstream	Peace R	Peace DS	3	0	0	0	0	2	0	0	1	0
2017	Williston	Williston	Peace Rch	28	0	0	2	8	13	5	0	0	0

Length-frequency histograms for lake whitefish by area are shown in **Figure 3-9**. The most extensive data sets are for Fraser Lake (n=20), Parsnip Reach (n=24) and Peace Reach (n=28). While there are some differences in size range among the areas (e.g., Fraser Lake data set includes more large lake whitefish), there is reasonable overlap in the size classes at each of those areas. Modal size of lake whitefish occurred at 325 mm from Peace Reach and 275 mm from Parsnip Reach in 2016 and appeared to have a generally smaller size distribution. It is not known if this is a real difference or simply due to sample variability. No age structures were sampled for lake whitefish at any of the areas, so we cannot use age to determine if size differences are growth-related.

The length-weight relationship for lake whitefish was strong (**Figure 3-10**, upper left box), with the exception of three potential outliers (all from Parsnip Reach) that were retained further assessment (as discussed in **Section 3.1.3**). Apart from the outliers, length-weight trends appear fairly consistent across areas (i.e., lakes/reaches).

While there is evidence that lake whitefish populations in Williston are decreasing (e.g., Plate et al. 2012), it is not clear how these changes might be affecting population structure. Given the limited sample sizes and likely biased nature (i.e., trying to obtain samples fairly evenly across the range of size classes) of size structure data collected in fish mercury studies, it would not be appropriate to use these data to make inferences regarding temporal changes in lake whitefish population size structure in Williston.

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

The general length-mercury relationship (**Figure 3-10**) was variable and with an apparently weakly positive relationship between fish size and mercury concentration, unlike what was observed for lake trout and bull trout. This is fairly typical for lake whitefish given the fact that they don't have a major dietary shift from invertebrates to fish (like most trout do) so they subsist on relatively low mercury food and thus do not bioaccumulate mercury to the same degree as piscivorous species. This is also reflected in their much lower range of tissue mercury concentrations ranging from 0.05 ppm to 0.20 ppm, with few fish exceeding this concentration.

Given the lack of overlap in distribution of mercury data at discrete size intervals amoung different geographic areas, there appear to be spatial differences among the three main areas sampled (Fraser Lake, Parsnip Reach and Peace Reach; upper right box). In general, Parsnip Reach fish have slightly higher mercury concentrations than Peace and Fraser Lake fish, which are similar to one another. This may account for some of that variability observed and this will be explored in more detail in next year's report. One lake whitefish from Dinosaur (collected by Carleton University in 2016) stood out as a potentiel length-mercury outlier. Two of the three length-weight outliers from Parsnip Reach (circled dots), with the highest mercury concentrations, actually appear to fit well with the rest of the Parsnip data; the other one, with the lowest mercury concentration of all the Parsnip data, did not.

The length-$\delta^{15}N$ relationship (**Figure 3-10**, lower left box) showed that $\delta^{15}N$ values (an indicator of trophic position) did not vary substantially over the size range sampled and among areas, confirming that the diet of whitefish is probably consistent geographically and over the size/age of fish captured. None of the potential outliers stood out from the main body of data. The $\delta^{15}N$-mercury relationship (**Figure 3-10**, lower right box) was not strong overall, but there may be some underlying spatial differences (e.g., a possible positive trend for Parsnip Reach) that account for at least some of the observed variability. Two outliers stood out in the plot (i.e., the same ones that did not appear to fit with the length-mercury relationship). Overall, the SIA results suggest that trophic position of lake whitefish is fairly consistent over the size range fish sampled and across areas.

Data Gaps

- While full representation of all size classes was not obtained in Parsnip Reach, there are lots of fish in the 251 to 300 mm size class. Consequently, as discussed last year (Azimuth 2017), a size-class based approach can be used to assess spatial differences in lake whitefish tissue mercury concentrations. Focusing on a common, but narrow, size class will account for potential length-related differences without requiring data across the entire size distribution. While this might lose some information, the lack of a strong 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.
- No samples have been obtained yet for Finlay Reach. Efforts in the strategic survey of this reach in summer 2018 will at least attempt to fill the targeted size class (i.e., 251 to 300 mm) in addition to whatever other size classes are captured.
- Twenty-seven lake whitefish were captured in Peace Reach in 2017, with most in the 251 to 300 mm size class. A sufficient number of fish in the 251 to 300 mm size class were captured in 2017.
- Only two lake whitefish were captured from Dinosaur Reservoir. Based on historical data, lake whitefish are not particularly abundant in here (Murphy and Blackman 2004, Diversified Environmental Services and Mainstream Aquatics 2011). Given that fish mercury concentrations in general appear lower in Dinosaur compared to Williston, this gap is a low priority to fill.
- Fraser Lake is the only reference area sampled for lake whitefish to date. A sufficient number of fish in the 251 to 300 mm size class were sampled in 2016. 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.
- At least one more reference lake for lake whitefish is being targeted by FLNRORD in 2018. Azimuth also has data from Tezzeron Lake in 2016 that when published, will also be brought into the 2018 report.

3.4.4. Kokanee

Catch Results and Meristics (Figure 3-11)

Targeted studies to date have focused on Parsnip Reach (2016), Peace Reach (2017) and Thutade Lake (reference area; 2016 and 2017). The lack of success in Parsnip and Peace reaches (both sampled in late summer) suggest that kokanee may either be difficult to capture or only available seasonally in those areas. We are aware that abundance of kokanee has expanded exponentially in Williston Reservoir over the last decade in particular (Langston 202), but with apparent considerable differences in relative abundance among reaches. For example, in an aerial survey of the reservoir Langston (2012) observed that Peace Reach tributaries had the lowest number of kokanee spawners during fall (<1% of all spawners), while the Parsnip tributaries had the second lowest (<8%). The greatest distribution and highest numbers were observed in the Omineca Arm (60–89%, depending on the year) and Finlay Reach (2–36%) tributaries.

Additional fish were opportunistically caught in Finlay Reach (2016, 2017) by CCE. Kokanee catch results to date by size class and location 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	Finlay Rch	13	0	2	10	1	0	0	0	0	0
2017	Reference	Thutade Lk	Thutade Lake	9	0	8	1	0	0	0	0	0	0
2017	Williston	Williston	Finlay Rch	15	0	1	14	0	0	0	0	0	0
2017	Williston	Williston	Peace Rch	3	0	3	0	0	0	0	0	0	0

The length-frequency plot (**Figure 3-11**) shows most kokanee caught were in a narrow size range (200 to 240 mm). While more fish were captured within this size range, not all were analysed because of the low and similar mercury concentrations for this species regardless of size. This dominant modal size range (200 – 240 mm) is typical and expected, given that this landlocked salmon species seldom exceeds 250 mm in length and attains a maximum age of only 3 or 4 years, like its anadromous form. Very few weight measurements and no age measurements are available, so the length-weight and age-length relationships are not presented or discussed.

Mercury-Related Relationships (Figure 3-12)

The overall length-mercury relationship is shown in **Figure 3-12**. Despite the relatively low tissue mercury concentrations at all sizes and areas, there is nevertheless a trend of larger kokanee having slightly higher mercury concentrations. While not evident in Finlay Reach (and too few data are available for Peace Reach), the trend does appear to be present in Thutade Lake. There is also evidence of lower mercury concentrations in Thutade Lake relative to Williston, however this may simply be related to differences in fish size. For example, about 85% of all fish captured from Thutade Lake were <220 mm in length, while 85% of all kokanee captured Finlay Reach were >220 mm; but this may only partially explan why mercury concentrations from Finlay Reach kokanee exceed that of Thutade, which are all lower than Finlay, but similar to Peace Reach fish (**Figure 3-12**). This will be explored in greater detail next year.

Neither δ^{15}N-mercury nor length-δ^{15}N relationships were evident overall for kokanee, suggesting the lack of size-related feeding preferences. This is consistent with what we know about life history of kokanee, whose dietery prefernce is zooplankton. The Thutade Lake mercury results also appear to be anomalous and may be artefactual. For example, the data show apparent *inverse* trends between δ^{15}N and length and between mercury concentrations and δ^{15}N values, when the opposite should be true. This is, within this data set larger fish appear to be feeding lower in the food chain, yet higher trophic position fish have lower mercury concentrations. Given the suspicions we have regarding the bull trout mercury data from Thutade Lake in 2017, this needs to be explored further.

Data Gaps

- No kokanee were captured during the strategic survey of Parsnip Reach in 2016.
- Limited size classes caught in Finlay Reach (24 of 28 fish from the 201 mm to 250 mm size class).
- Few kokanee were caught in Peace Reach in 2017, which is consistent with what was found by Langston (2012).
- Twenty-one kokanee caught in Thutade Lake (2016/2017), but mean size and range lower than from Finlay Reach.
- May need to implement kokanee-specific program that targets known spawning streams. Present data set precludes making among-reach comparisons within Williston. Additional data from Peace or Parsnip Reach would be needed to make any comparisons; focus could be on 201 to 250 mm size class.

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 in Williston Reservoir during the 2016 and 2017 programs and submitted for mercury analysis: mountain whitefish, rainbow trout, burbot, and longnose sucker. Many of these fish were provided by our First Nations 'champions' from Tsay Keh Dene, Kwadacha and Saulteau from a variety of lakes and watersheds, including the Peace River downstream of Dinosaur River and the Sustut River, part of the Pacific Ocean drainage, where two spring salmon were tested. As expected given the incidental nature of these catches, sample sizes and fish sizes were low/narrow and varied across species and areas (**Figure 3-13**).

Length-weight relationships for non-target species are presented in **Figure 3-14**; despite the small sample sizes, the relationships were generally quite strong. Age data were only available for fish caught in 2017 in the Peace Reach. No assessment of outliers for either length-weight or age-length relationships has been conducted at this time; this may be done if / when further data on these species are collected.

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 (**Figure 3-14**) for any species/reach combination. With the exception of burbot, mercury concentrations were also uniformly low for mountain whitefish, Arctic grayling (*Thymallus arcticus*), rainbow trout and longnose sucker (generally <0.2 mg/kg ww). This is consistent with what has been found for similar species elsewhere in BC as well as in Canada (Depew et al. 2014). Burbot can attain moderate age (>15 y) and a large size. Burbot are a carnivorous species that 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. In this study, mercury concentrations were mostly above 0.20 mg/kg ww, although concentrations between Williston Reservoir and Fraser Lake were very similar, including one individual captured from the Peace River drainage.

In general, there were no strong mercury – size relationships for any species, possibly due to the narrow range of fish sizes captured and because low-mercury food is consumed by species such as suckers, whitefish and rainbow trout.

Similar results were observed for the $\delta^{15}N$-mercury and length-$\delta^{15}N$ relationships (**Figure 3-15**).

We also measured tissue mercury data from fish that were opportuniticially collected, including individual fish from Moberly Lake such as largescale sucker (0.15 ppm) and northern pike (*Esox lucius*; 0.16 ppm). We also tested a single anadromous spring salmon from the Sustut River (0.10 ppm), a tributary of the Skeena River that drains to the Pacific Ocean (**Figure 3-14**). Two Arctic grayling from the Finlay River both had low tissue mercury concentrations (<0.05 ppm), which is typical for this insect eating species.

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, creel survey data suggested that northern pike (*E. 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. This will be further explored in the 2018 sample collection efforts.

Table 3-1. Laboratory QA/QC summary for 2017.

Program	Lab ID	Analytes	Date sampled[1]	Laboratory QC Summary									
				Detection Limits		Laboratory Duplicates [2]		Method Blanks		Matrix Spike		LCS / CRM	
				Parameters	Qualifier	Parameters	Qualifier	Parameters	Qualifier	Parameters	Qualifier	Parameters	Qualifier
Peace Reach - EDI	L1987928	Moisture and Metals	Aug 20-25 (2017)	Some Elevated DLS - Moisture and Metals	n/a	Total Barium	RPD > DQO heterogen	None		None		None	
Saulteau Community	L2020037	Moisture and Mercury	Various Dates (2017)	Some Elevated DLS - Moisture and Mercury	n/a	None		None		None		None	
Parsnip Derby	L1987932	Moisture and Mercury	Aug 26-27 (2017)	Some Elevated DLS - Moisture and Mercury	n/a	None		None		None		None	
Finlay Reach	L2010859	Moisture and Metals	Various Dates (2017)	Some Elevated DLS - Moisture and Metals	n/a	None		None		None		None	
Dinosaur Derby	L1987923	Moisture and Mercury	June 18 (2017)	Some Elevated DLS - Moisture and Mercury	n/a	None		None		None		None	
Thutade Lake	L1987924	Moisture and Mercury	May 28-30 (2017)	None		None		None		None		None	

Notes:

[1] Various Dates - Range falls over multiple weeks/months

[2] Laboratory Duplicates RPDs are set by the lab (generally 20 +/- for moisture and 40-60 +/- for metals including mercury)

LCS / CRM = laboratory control sample / certified reference material

n/a = laboratory QC program not included as part of the analyses.

Table 3-2. Field duplicate quality control sample results for 2017.

Peace Reach Fish - 2017											
			LKWF-EDI-Hg-03			LKWF-EDI-Hg-12			LKTR-EDI-Hg-06		
Parameter	**Lowest Detection Limit**	**Units**	**Original**	**Duplicate (DUP-EDI-Hg-01)**	**RPD (%)**	**Original**	**Duplicate (DUP-EDI-Hg-02)**	**RPD (%)**	**Original**	**Duplicate (DUP-EDI-Hg-03)**	**RPD (%)**
Moisture (%)	0.50	%	76.30	76.7	-1	75.5	76.7	-2	74.2	76.7	-3
Total Metals (mg/kg)											
Mercury (Hg)	0.001	mg/kg	0.11	0.10	9	0.13	0.13	3	0.16	0.14	12

			LKTR-EDI-Hg-10			MW-EDI-Hg-08			BT-EDI-Hg-05		
Parameter	**Lowest Detection Limit**	**Units**	**Original**	**Duplicate (DUP-EDI-Hg-04)**	**RPD (%)**	**Original**	**Duplicate (DUP-EDI-Hg-05)**	**RPD (%)**	**Original**	**Duplicate (DUP-EDI-Hg-06)**	**RPD (%)**
Moisture (%)	0.50	%	73.40	74.3	-1	71.7	73.4	-2	78.0	76.8	2
Total Metals (mg/kg)											
Mercury (Hg)	0.001	mg/kg	0.19	0.19	-1	0.15	0.11	29	0.15	0.15	-1

			LKTR-EDI-Hg-20			BT-EDI-Hg-13			BT-EDI-Hg-16		
Parameter	**Lowest Detection Limit**	**Units**	**Original**	**Duplicate (DUP-EDI-Hg-07)**	**RPD (%)**	**Original**	**Duplicate (DUP-EDI-Hg-08)**	**RPD (%)**	**Original**	**Duplicate (DUP-EDI-Hg-09)**	**RPD (%)**
Moisture (%)	0.50	%	77.10	77.9	-1	77.5	76.5	1	74.4	73.1	2
Total Metals (mg/kg)											
Mercury (Hg)	0.001	mg/kg	0.18	0.17	5	0.15	0.15	0	0.20	0.15	26

			BB-EDI-Hg-04		
Parameter	**Lowest Detection Limit**	**Units**	**Original**	**Duplicate (DUP-EDI-Hg-10)**	**RPD (%)**
Moisture (%)	0.50	%	78.8	79.6	-1
Total Metals (mg/kg)					
Mercury (Hg)	0.001	mg/kg	0.34	0.30	10

Thutade Lake and Finlay Reach Fish - 2017											
			TL-BLTR-10			TL-BLTR-11			PESIKA-BT-09		
Parameter	**Lowest Detection Limit**	**Units**	**Original**	**Duplicate (TL-DUP-01)**	**RPD (%)**	**Original**	**Duplicate (TL-DUP-02)**	**RPD (%)**	**Original**	**Duplicate (PESIKA-BT-09-DUP)**	**RPD (%)**
Moisture (%)	0.50	%	63.7	70.1	-10	61.8	65.6	-6	77.5	73.0	6
Total Metals (mg/kg)											
Mercury (Hg)	0.001	mg/kg	0.11	0.20	-55	0.12	0.12	7	0.13	0.13	-5

Notes:
RPD = Relative Percent Difference (see text)
RPD values in grey exceed 40%.
Total Mercury provided as wet weight

Figure 3-1. Stable isotope results (mean ±SD for δ15N and δ13C values) by fish species and waterbody for Williston Reservoir (2015-2017), Dinosaur Reservoir (2017) Fraser Lake (2016) and Thutade Lake (2014-2017).

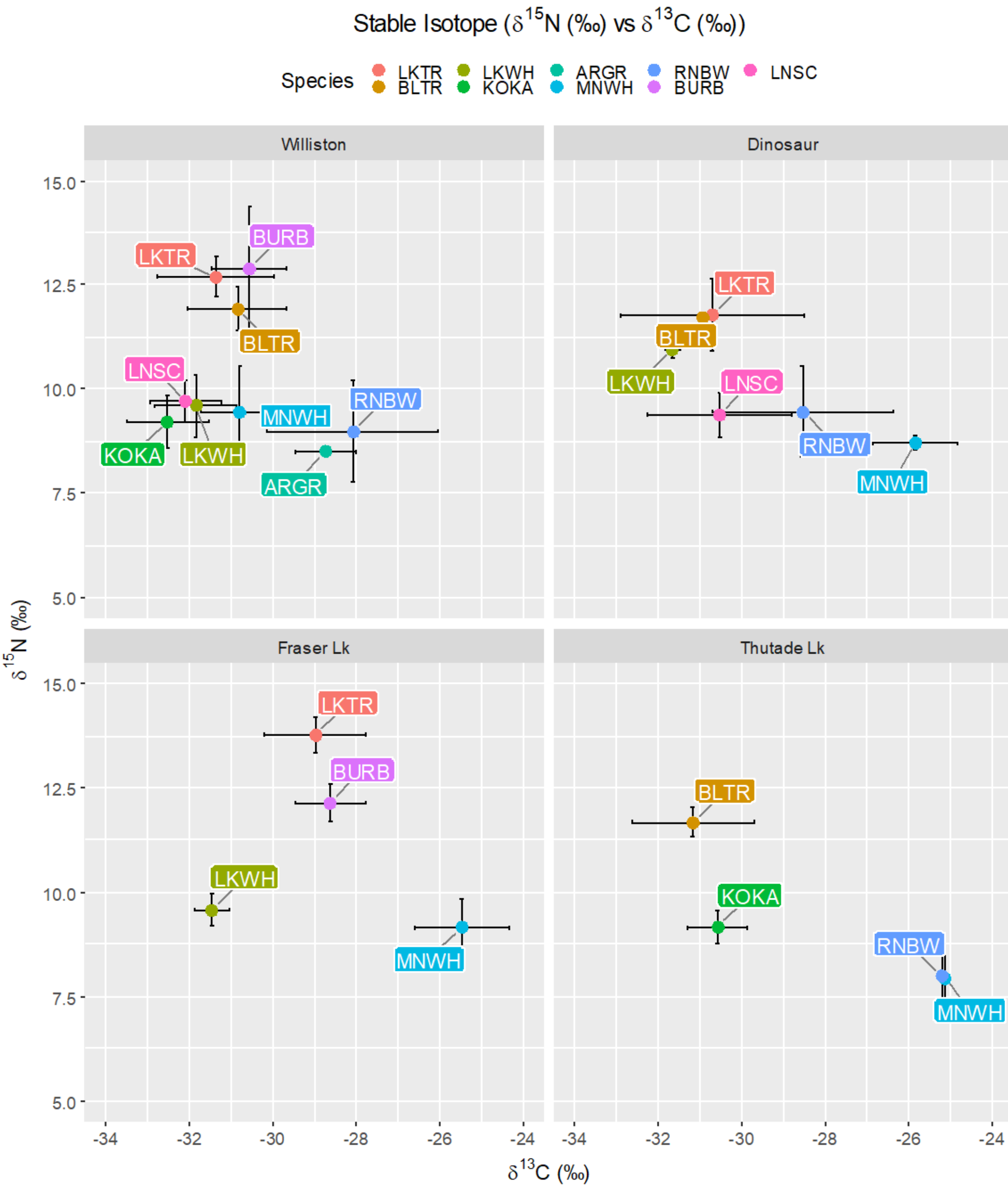


Figure 3-2. Mercury results by fish species and waterbody for Williston Reservoir (2015-2017), Dinosaur Reservoir (2017), Fraser Lake (2016) and Thutade Lake (2014-2017).

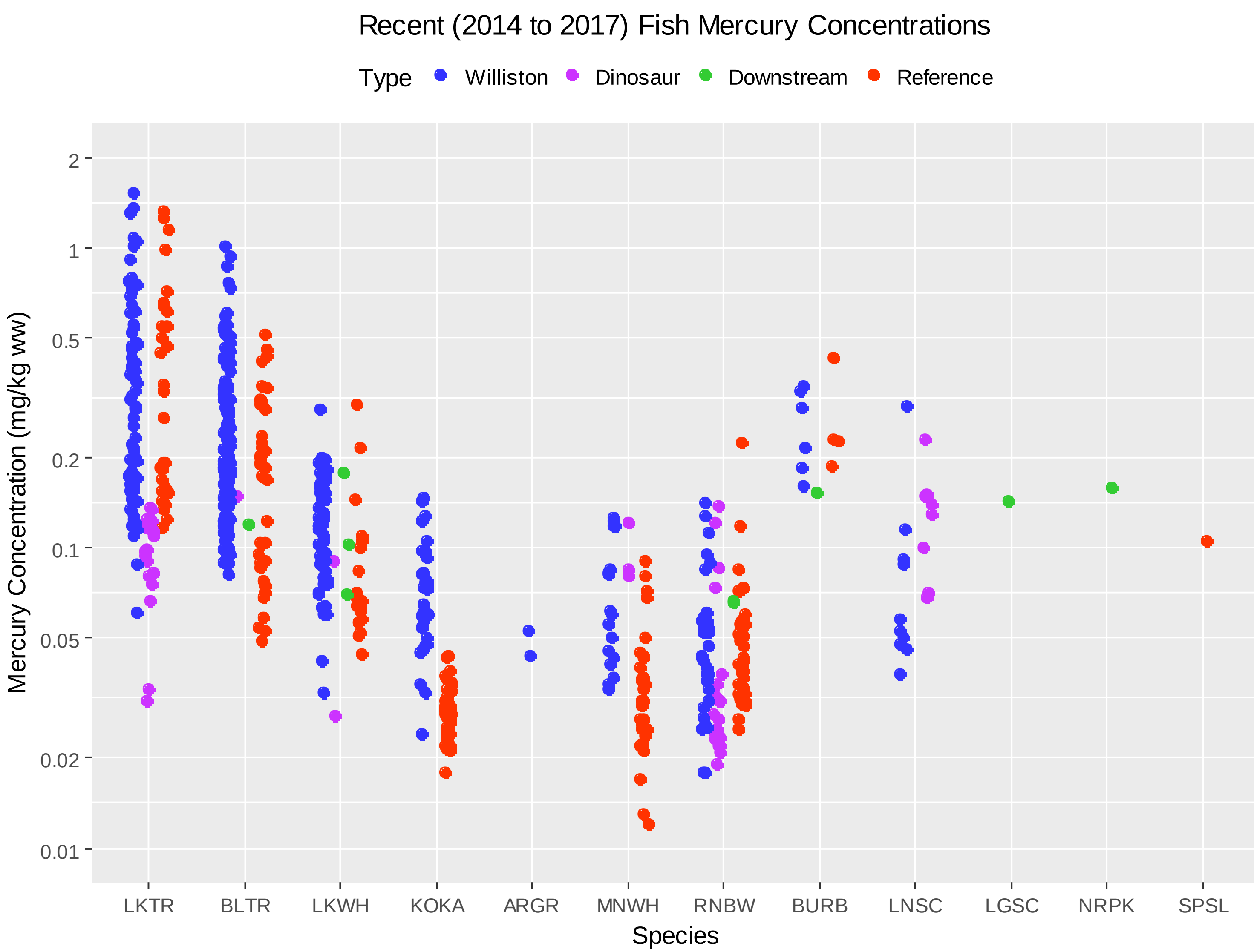
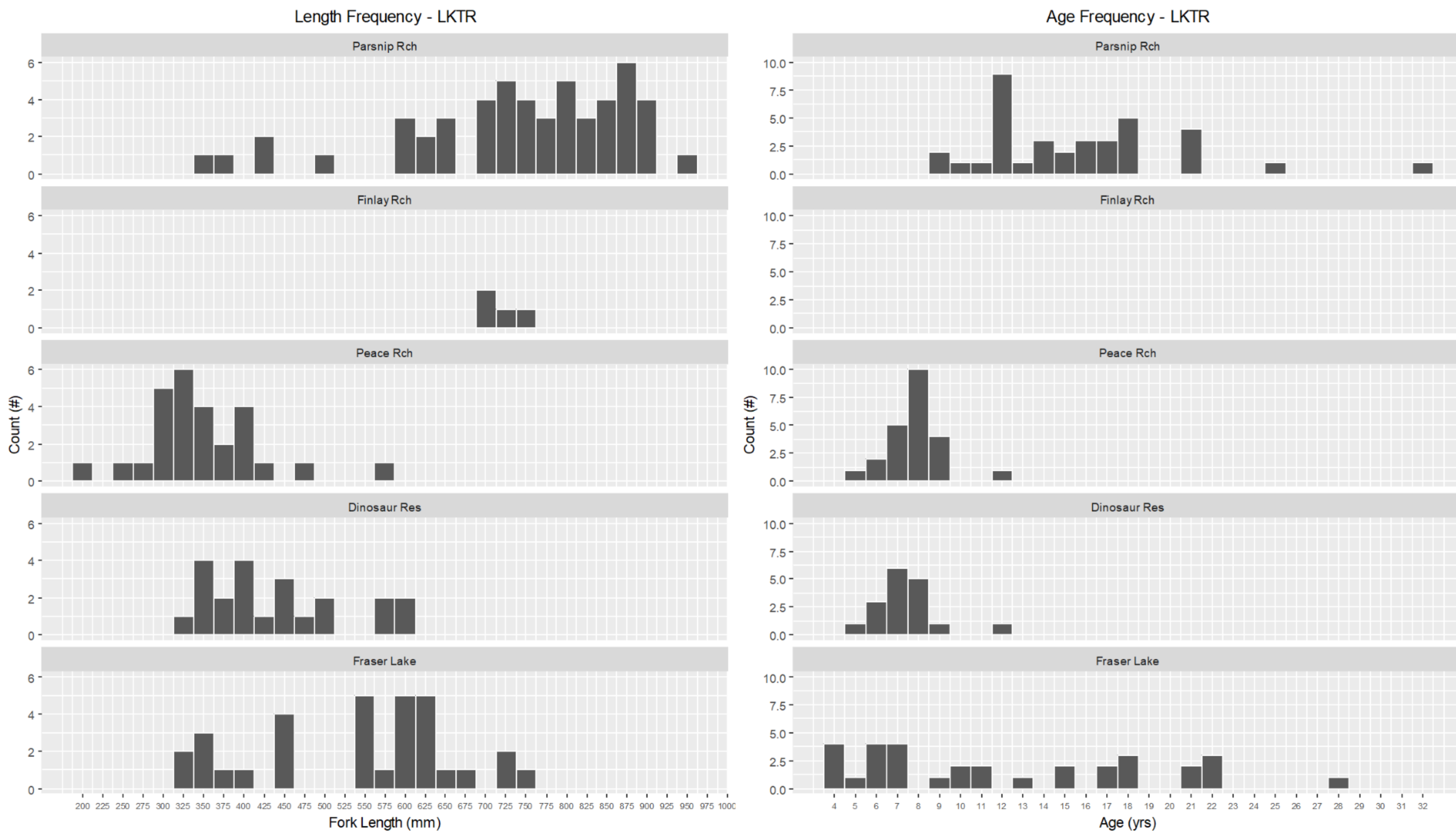
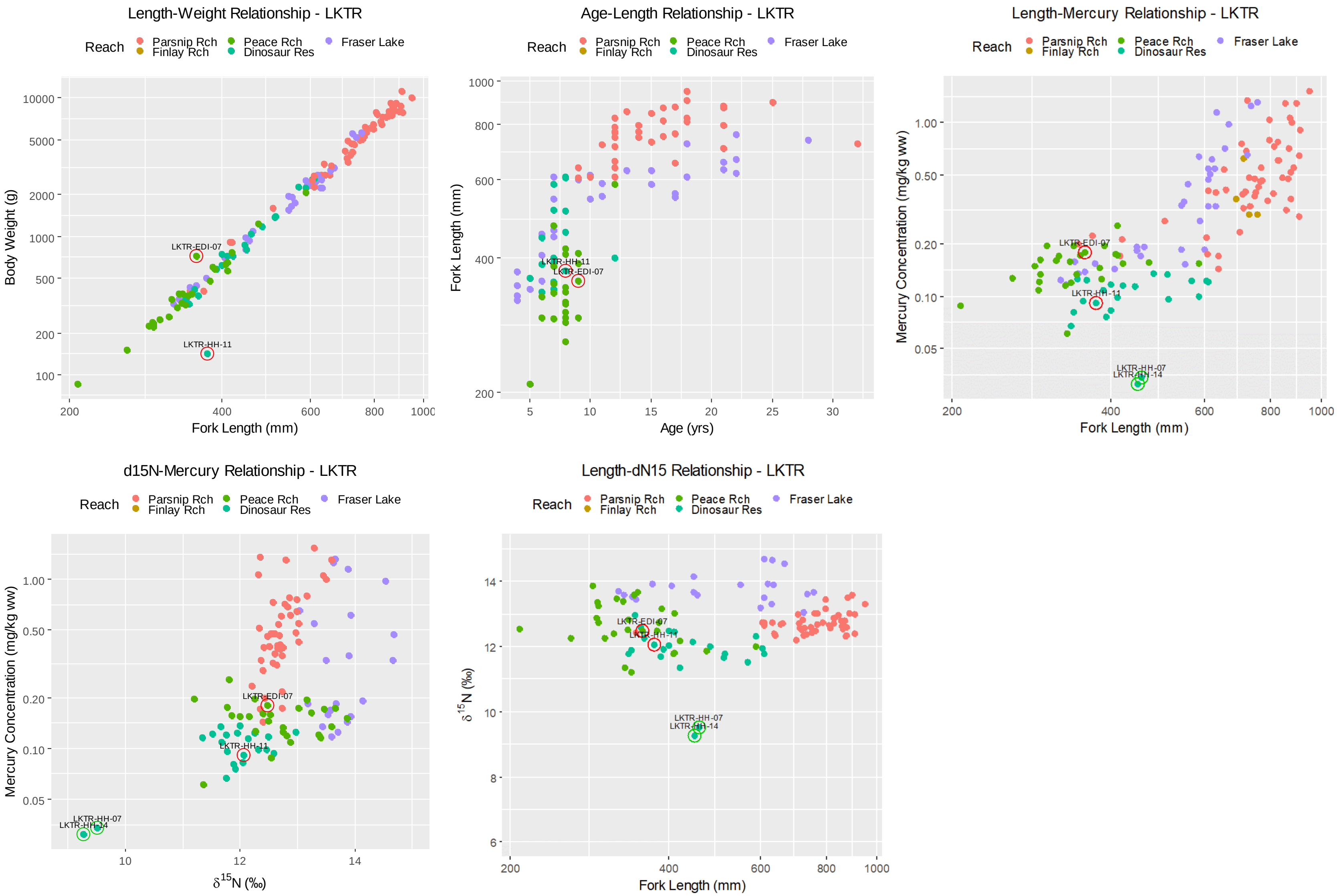


Figure 3-3. Length frequency, age frequency and meristics data summary (see next page) for lake trout.



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
2017	LKTR	Williston	Parsnip Rch	Parsnip Rch	10	605-905	705	10	2291-8754	4378	10	1.01-1.37	1.17	8	9-25	13
2017	LKTR	Williston	Peace Rch	Peace Rch	24	208-587	348	24	85-2080	490	24	0.83-1.61	0.98	23	5-12	8
2017	LKTR	Williston	Peace Rch	Carbon Lake	3	330-410	360	3	321-565	424	3	0.82-1.08	0.91	0	NA	NA
2017	LKTR	Dinosaur	Dinosaur Res	Dinosaur Res	22	335-610	443	22	141-2631	1012	22	0.27-1.26	0.98	17	5-12	7
2016	LKTR	Williston	Parsnip Rch	Parsnip Rch	42	347-949	751	42	400-11249	5753	42	0.8-1.5	1.2	28	12-32	16
2016	LKTR	Williston	Finlay Rch	Omineca River	4	690-755	721	0	NA	NA	0	NA	NA	0	NA	NA
2016	LKTR	Fraser Lk	Fraser Lake	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 δ^{15}N measurements are available for the fish from Finlay Reach. Outliers are circled and labeled.

Figure 3-5. Length-mercury relationship for lake trout (LKTR) comparing patterns within-Williston (left) and between Williston and the Fraser Lake reference area (right).

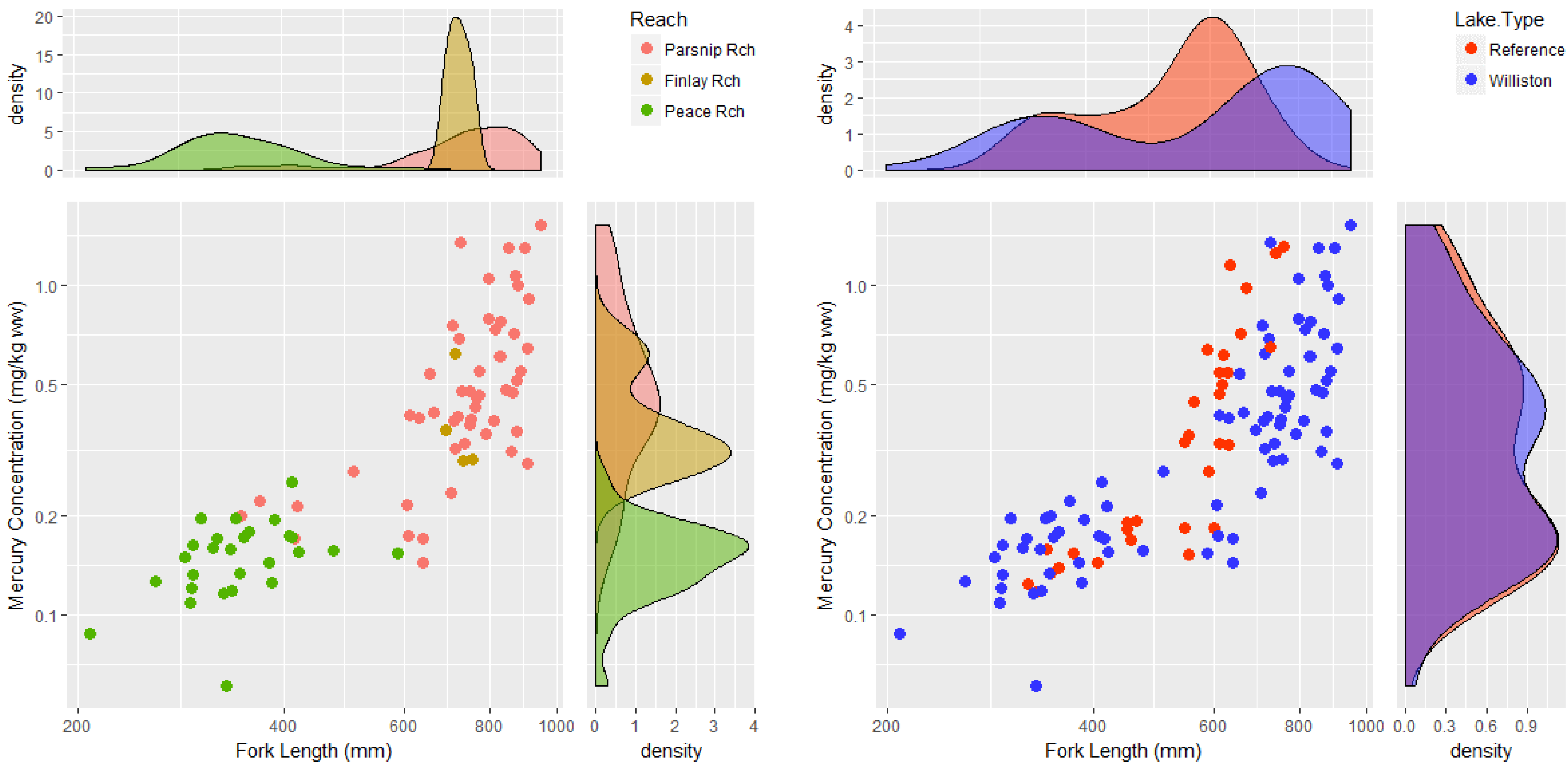
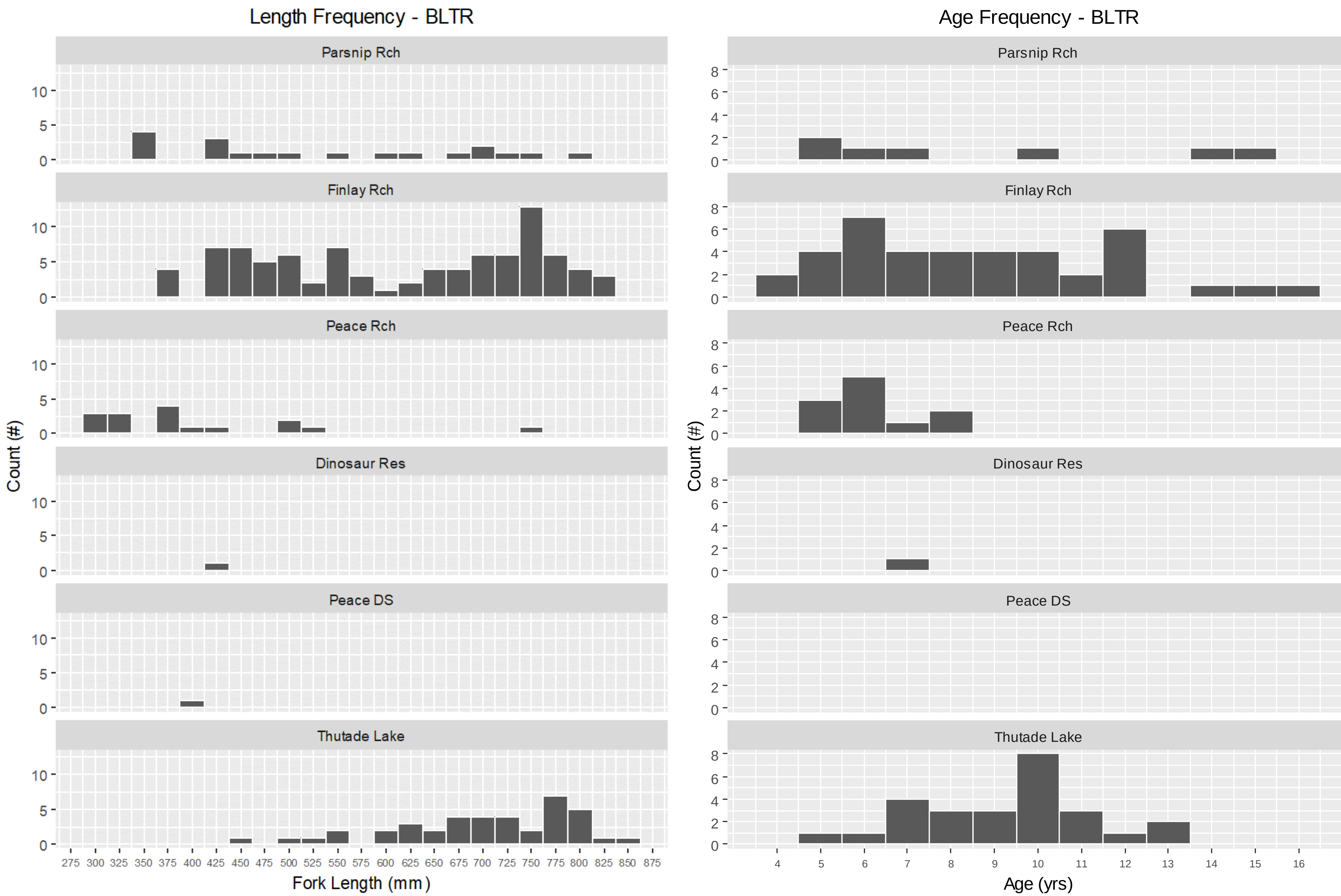


Figure 3-6. Length frequency, age frequency and meristic data summary for bull trout (BLTR).



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
2017	BLTR	Williston	Finlay Rch	31	365-825	564	0	NA	NA	0	NA	NA	0	NA	NA
2017	BLTR	Williston	Peace Rch	16	296-745	403	16	245-4050	867	16	0.9-1.21	1.02	11	5-8	6
2017	BLTR	Dinosaur	Dinosaur Res	1	430-430	430	1	803-803	803	1	1.01-1.01	1.01	1	7-7	7
2017	BLTR	Peace R	Peace DS	1	400-400	400	1	518-518	518	1	0.81-0.81	0.81	0	NA	NA
2017	BLTR	Thutade Lk	Thutade Lake	13	440-803	652	0	NA	NA	0	NA	NA	0	NA	NA
2016	BLTR	Williston	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	Finlay Rch	39	384-835	638	19	900-4850	2918	19	0.72-1.67	1.26	21	4-16	9
2015	BLTR	Williston	Parsnip Rch	6	340-790	611	3	300-4460	2270	3	0.57-0.9	0.74	6	5-15	10
2015	BLTR	Williston	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	Thutade Lake	16	540-850	733	16	1400-5650	3991	16	0.89-1.08	0.98	16	5-13	9
2014	BLTR	Thutade Lk	Thutade Lake	11	605-830	706	11	1850-5400	3300	11	0.76-1.07	0.9	10	7-13	9

Figure 3-7. Key mercury-related relationships for bull trout (BLTR).

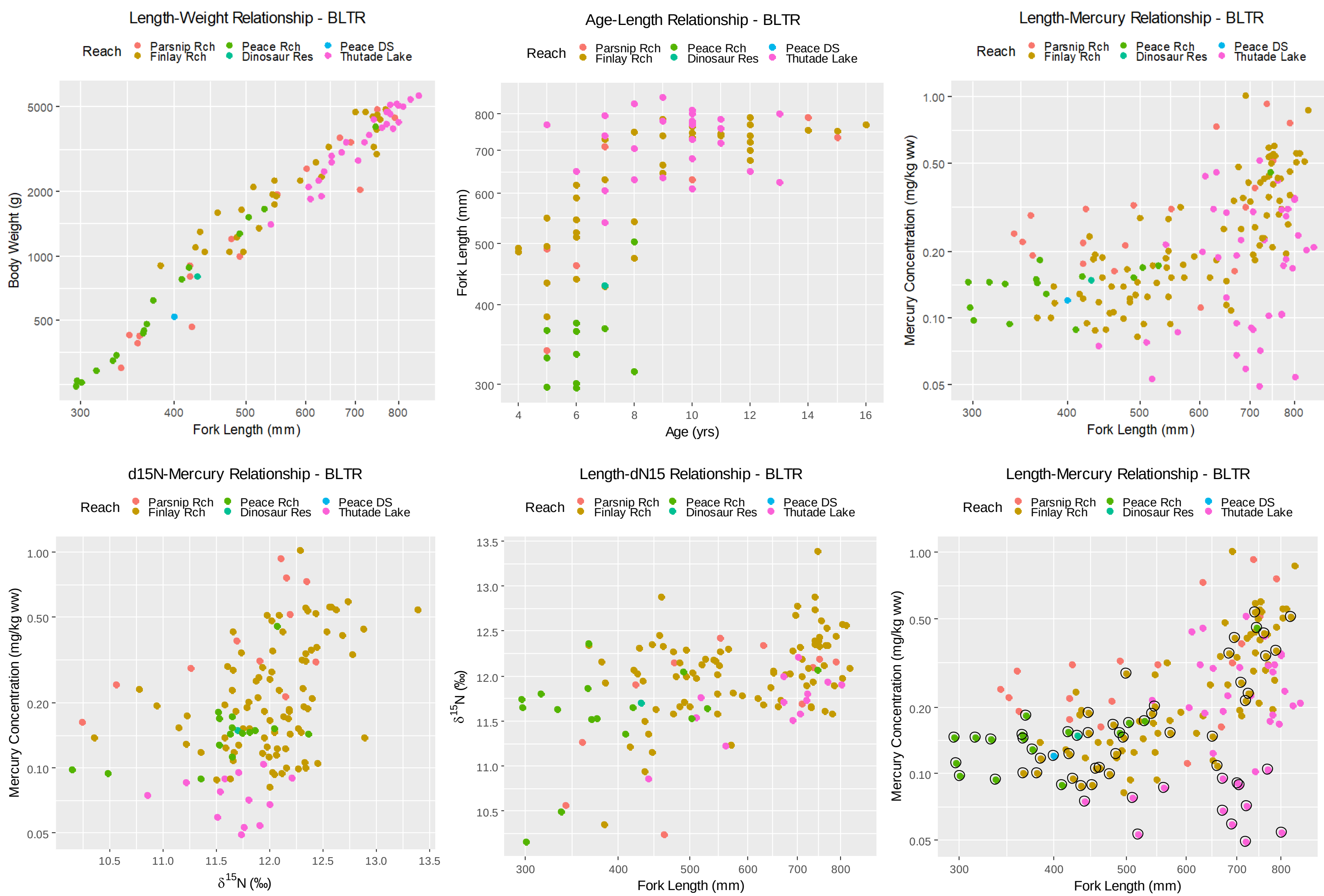


Figure 3-8. Length-mercury relationship for bull trout (BLTR) comparing patterns within-Williston (left) and between Williston and the Thutade Lake reference area (right; for >600 mm fish only; with 2017 fish from Thutade Lake highlighted).

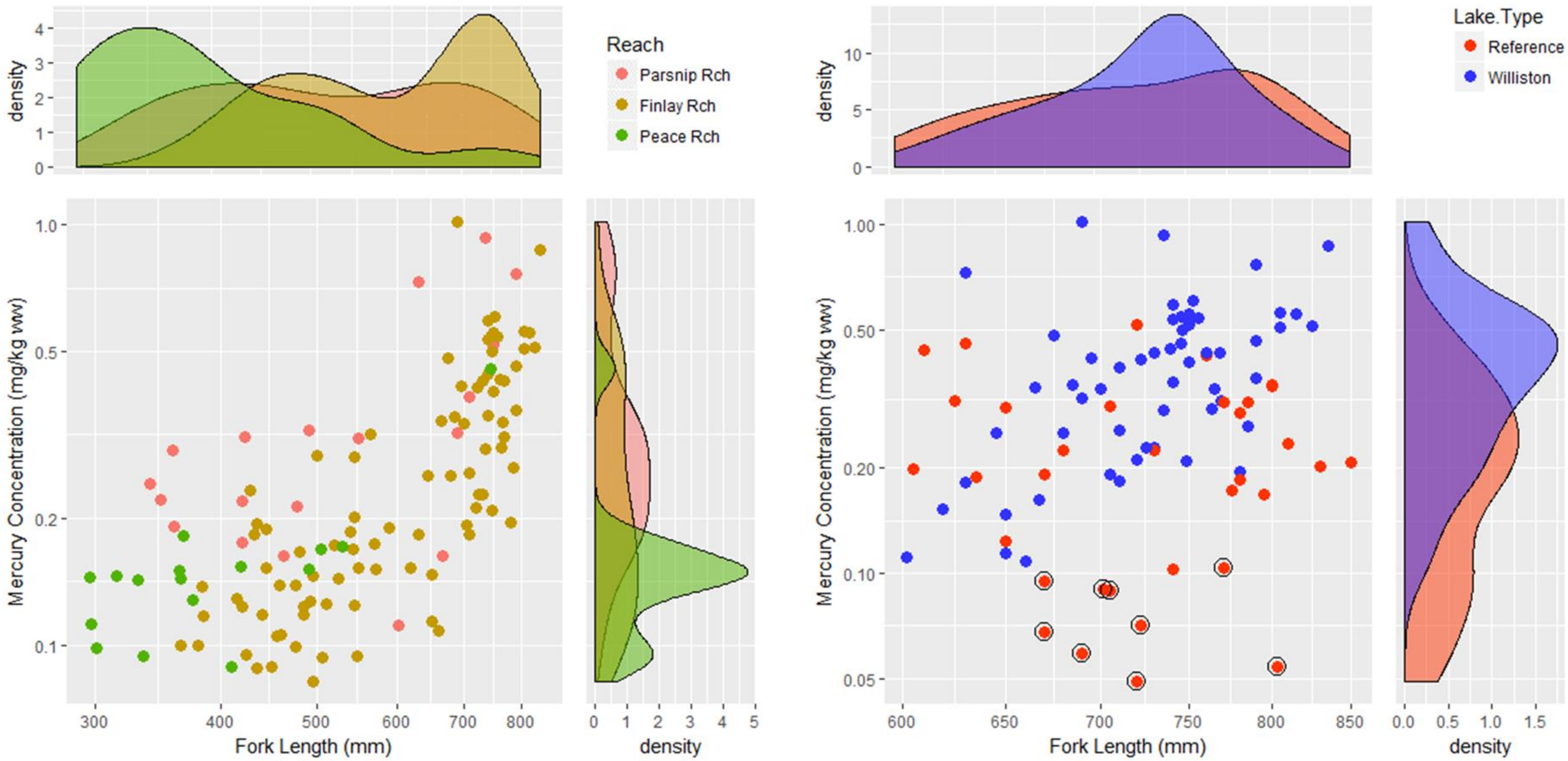
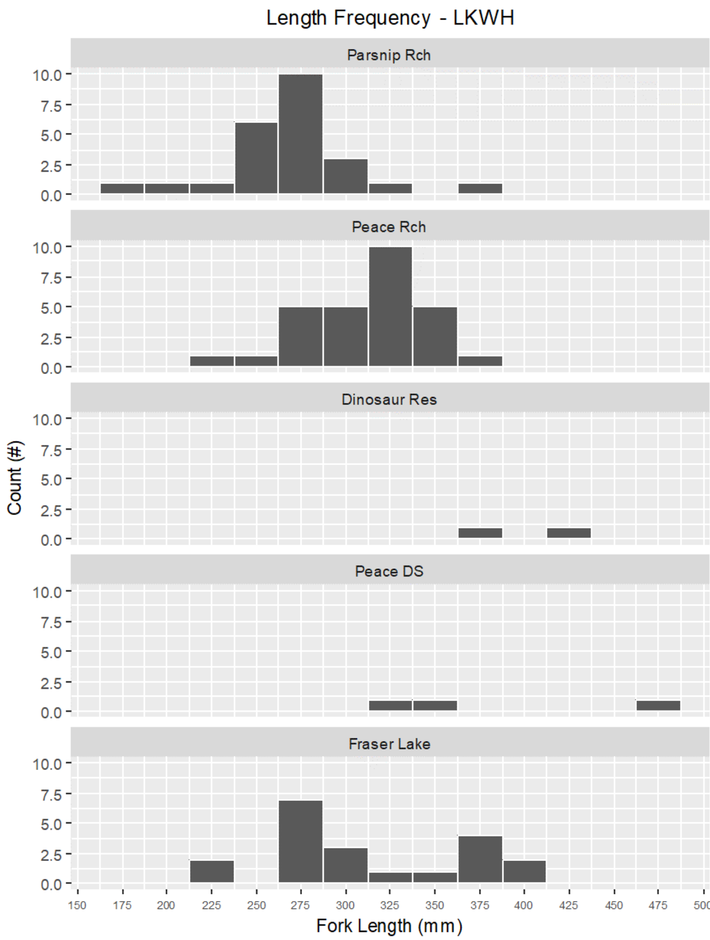


Figure 3-9. Length frequency and meristic data summary for lake whitefish (LKWH).



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
2017	LKWH	Williston	Peace Rch	Peace Rch	28	231-385	313	28	90-745	362	28	0.73-1.33	1.10	27	3-22	12
2017	LKWH	Peace R	Peace DS	Moberly Lake	3	320-470	377	3	337-1231	668	3	1.03-1.19	1.11	0	NA	NA
2016	LKWH	Williston	Parsnip Rch	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	Dinosaur Res	Johnson Creek	2	385-415	400	2	480-560	520	2	0.78-0.84	0.81	0	NA	NA
2016	LKWH	Fraser Lk	Fraser Lake	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).

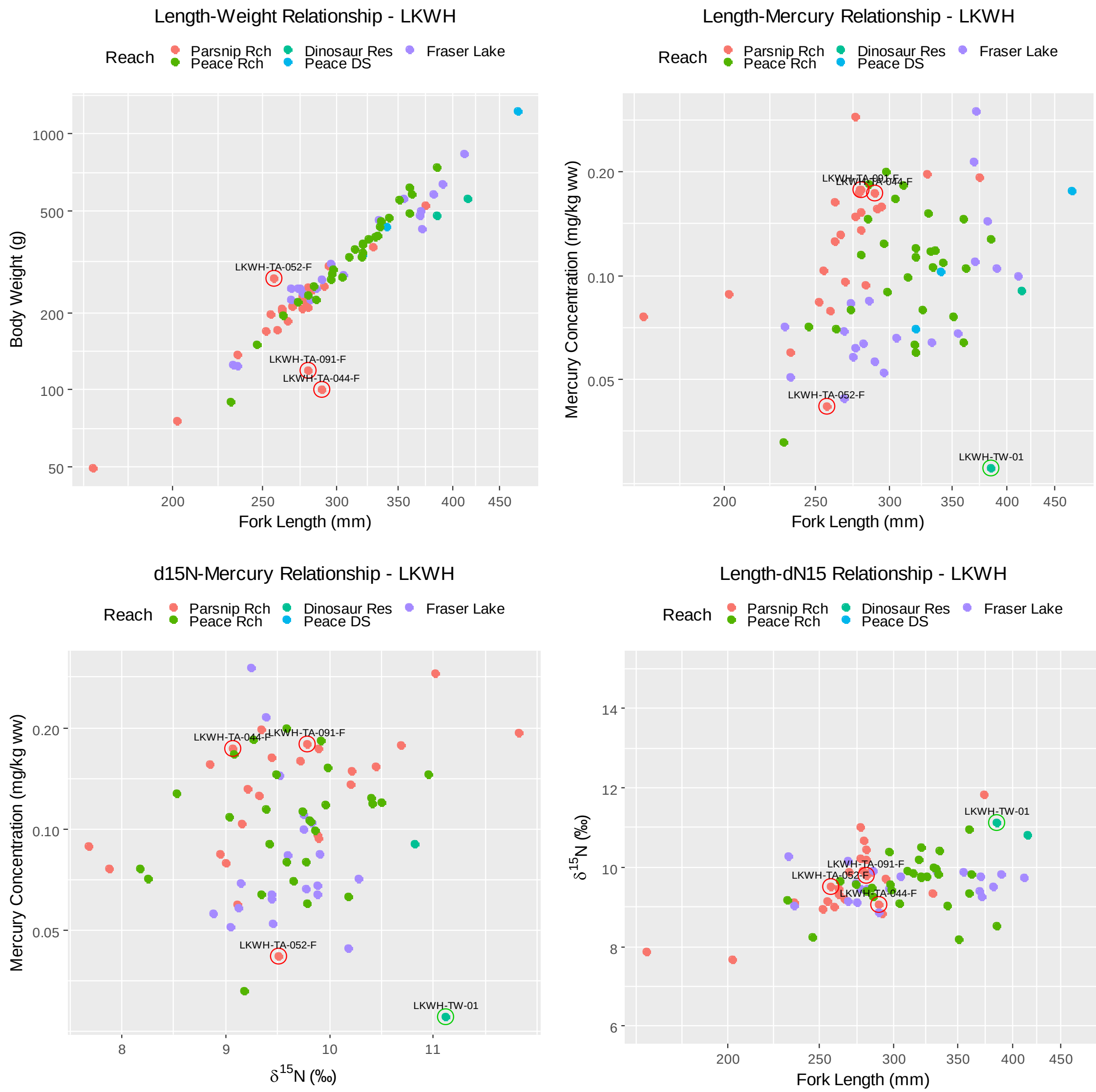
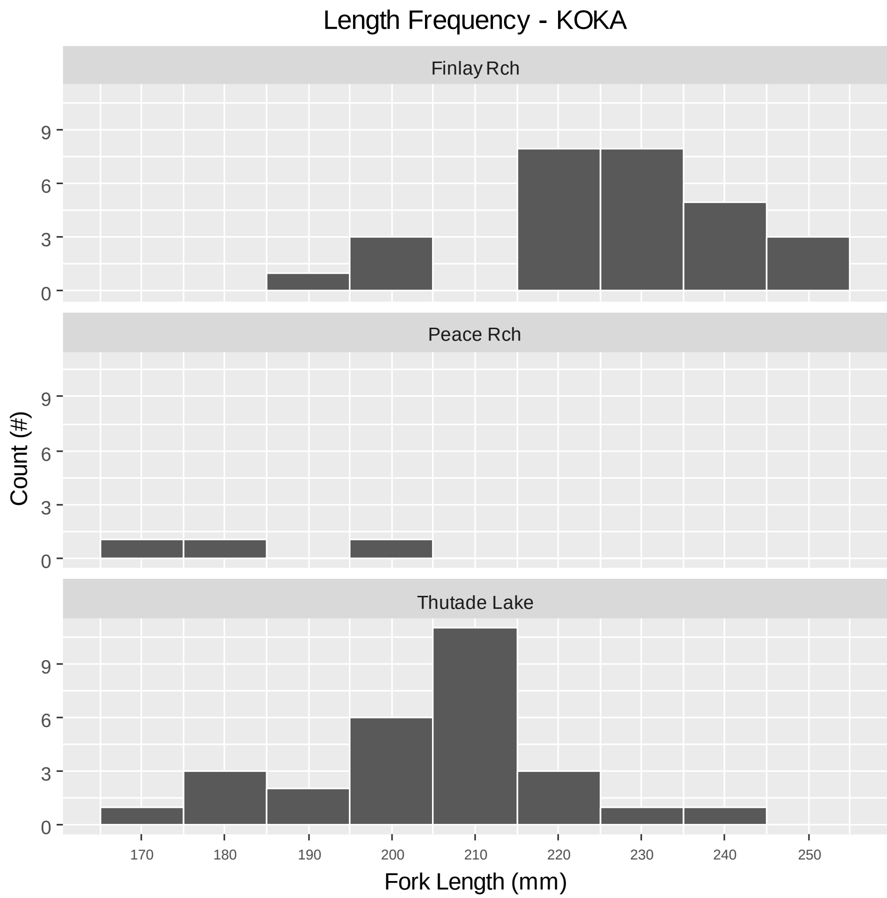


Figure 3-11. Length frequency and meristic data summary for kokanee (KOKA).



Year	Sp	Waterbody	Reach	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
2017	KOKA	Williston	Finlay Rch	Aley Creek	10	196-235	223	0	NA	NA	0	NA	NA	0	NA	NA
2017	KOKA	Williston	Finlay Rch	Stevenson Creek	5	221-249	233	0	NA	NA	0	NA	NA	0	NA	NA
2017	KOKA	Williston	Peace Rch	Peace Rch	3	168-197	182	3	55-80	68	3	1.05-1.2	1.14	3	3-4	3
2017	KOKA	Thutade Lk	Thutade Lake	Thutade Lake	16	170-218	199	0	NA	NA	0	NA	NA	0	NA	NA
2016	KOKA	Williston	Finlay Rch	Osilinka River	13	195-255	229	0	NA	NA	0	NA	NA	0	NA	NA
2016	KOKA	Thutade Lk	Thutade Lake	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).

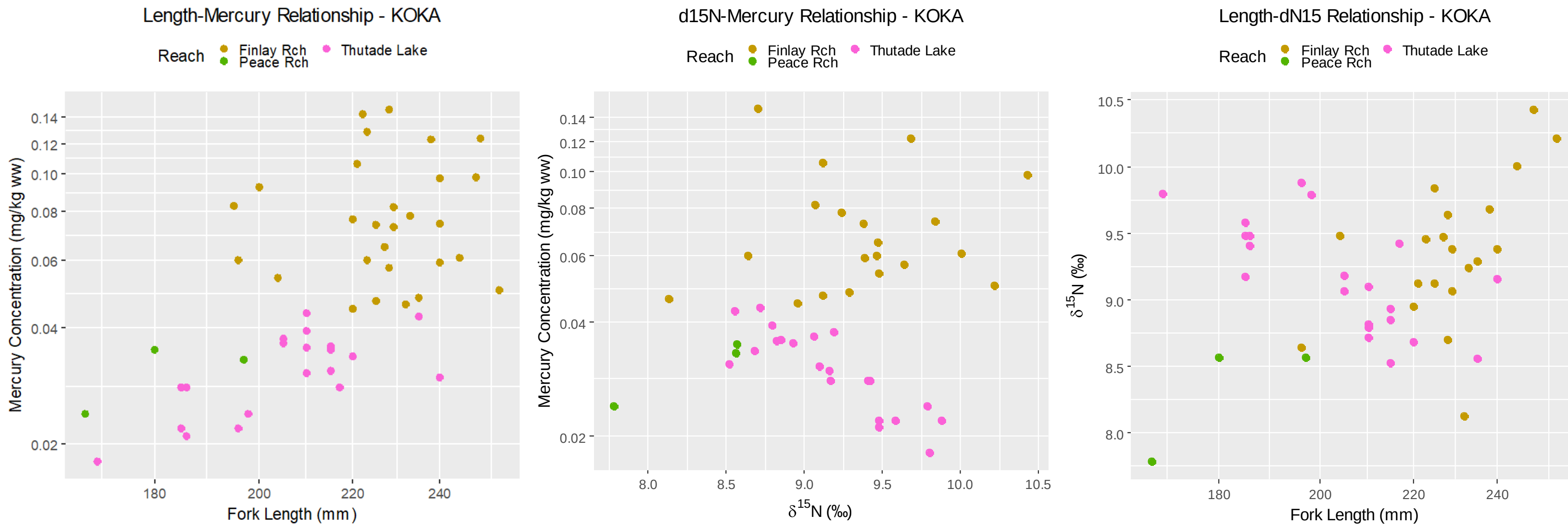
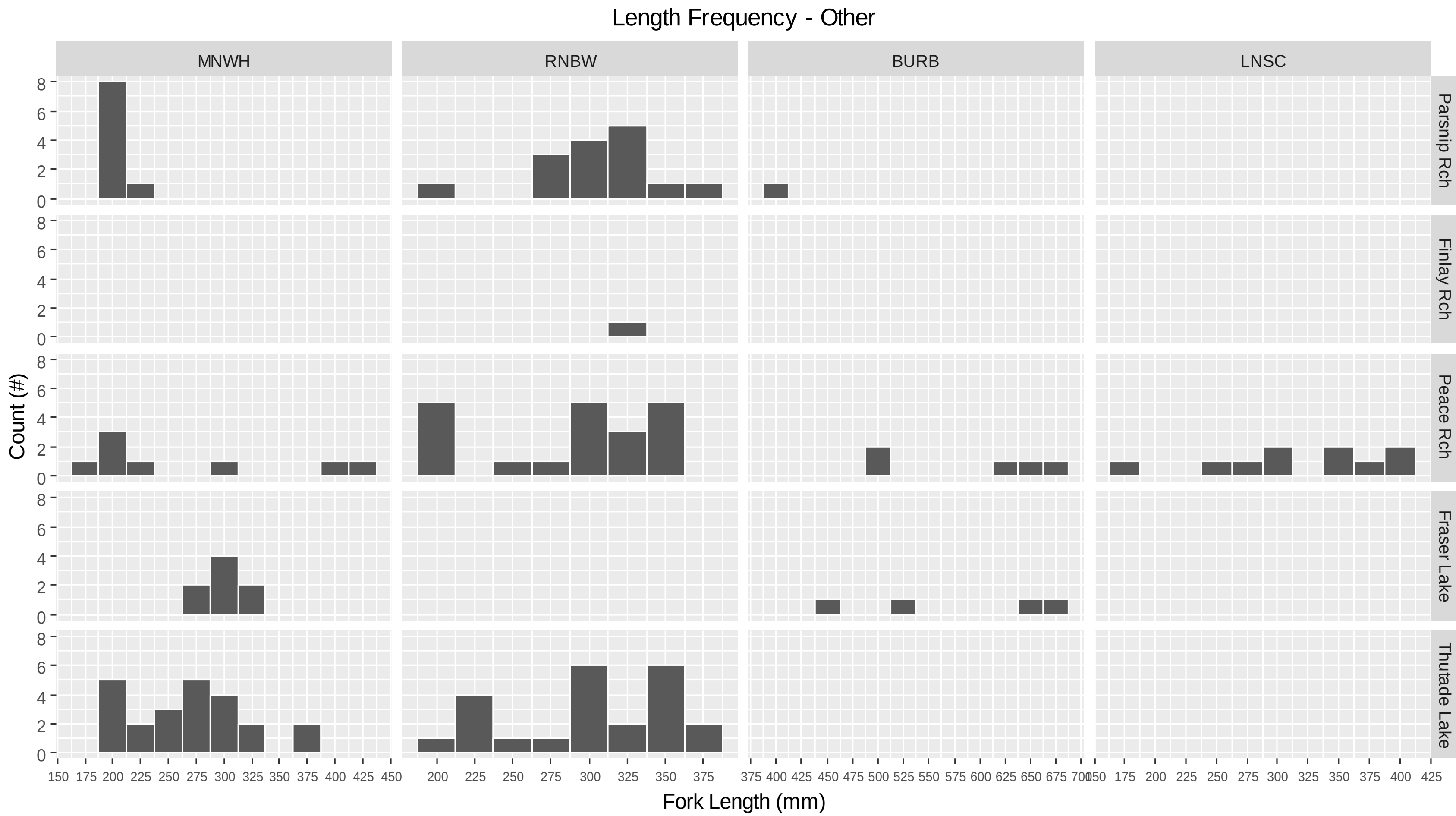


Figure 3-13. Length frequency and meristic data summary (see next page) for mountain whitefish (MNWH), rainbow trout (RNBW), burbot (BURB), and longnose sucker (LNSC).



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
2017	ARGR	Williston	Finlay Rch	Finlay River	2	320-330	325	0	NA	NA	0	NA	NA	0	NA	NA
2017	MNWH	Williston	Peace Rch	Peace Rch	8	176-418	262	8	50-815	259	8	0.78-1.12	0.97	8	3-13	7
2017	MNWH	Thutade Lk	Thutade Lake	Thutade Lake	21	190-375	268	0	NA	NA	0	NA	NA	0	NA	NA
2017	RNBW	Williston	Parsnip Rch	Parsnip Rch	2	320-326	323	2	295-317	306	2	0.9-0.91	0.9	0	NA	NA
2017	RNBW	Williston	Parsnip Rch	Carp Lake	2	300-370	335	2	311-480	396	2	0.95-1.15	1.05	0	NA	NA
2017	RNBW	Williston	Parsnip Rch	War Lake	2	310-360	335	2	303-481	392	2	1.02-1.03	1.02	0	NA	NA
2017	RNBW	Williston	Finlay Rch	Finlay River	1	320-320	320	0	NA	NA	0	NA	NA	0	NA	NA
2017	RNBW	Williston	Peace Rch	Peace Rch	7	191-323	226	7	75-325	135	7	0.96-1.15	1.05	6	3-7	4
2017	RNBW	Williston	Peace Rch	11 Mile Creek	2	340-340	340	2	390-401	396	2	0.99-1.02	1	0	NA	NA
2017	RNBW	Williston	Peace Rch	Carbon Lake	10	290-360	322	10	245-389	324	10	0.77-1.15	0.98	0	NA	NA
2017	RNBW	Thutade Lk	Thutade Lake	Thutade Lake	16	204-386	297	0	NA	NA	0	NA	NA	0	NA	NA
2017	BURB	Williston	Peace Rch	Peace Rch	5	490-680	589	5	790-2030	1393	5	0.55-0.73	0.65	5	6-12	10
2017	LNSC	Williston	Peace Rch	Peace Rch	10	187-405	318	10	70-745	412	10	1.07-1.24	1.14	9	2-22	8
2017	LGSC	Williston	Peace Rch	Peace Rch	3	427-483	449	3	820-1520	1163	3	1.05-1.37	1.26	3	12-16	14
2017	NRPM	Williston	Peace Rch	Peace Rch	4	289-394	330	4	330-795	501	4	1.21-1.49	1.34	3	9-14	12
2016	MNWH	Williston	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	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	0	NA	NA
2016	RNBW	Williston	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	Peace Rch	Table Creek	1	250-250	250	1	130-130	130	1	0.83-0.83	0.83	0	NA	NA
2016	RNBW	Thutade Lk	Thutade Lake	Thutade Lake	7	300-350	319	0	NA	NA	7	0-0	0	0	NA	NA
2016	BURB	Williston	Parsnip Rch	Parsnip Rch	1	400.2-400.2	400	1	384.3-384.3	384	1	0.6-0.6	0.6	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

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

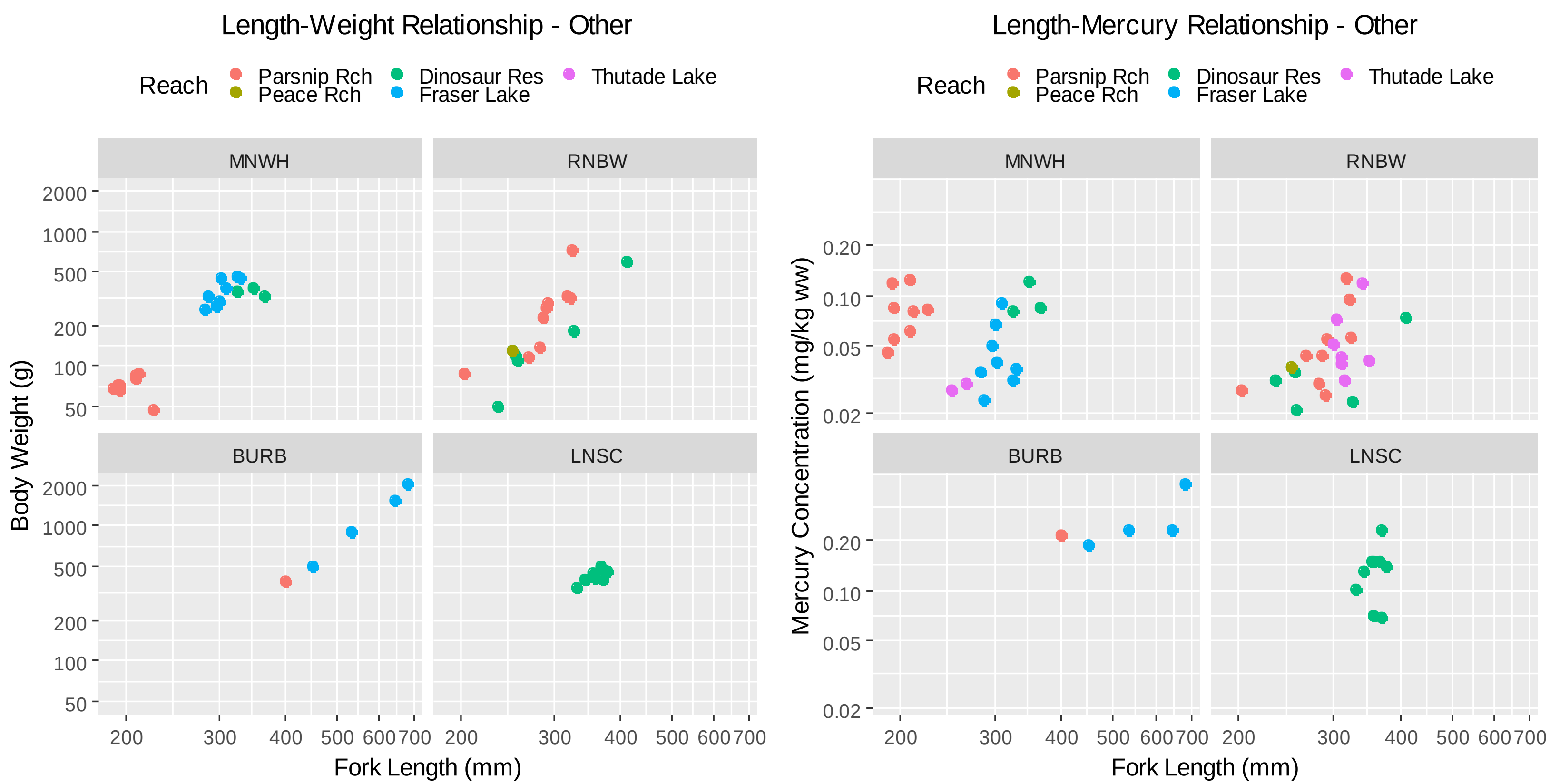
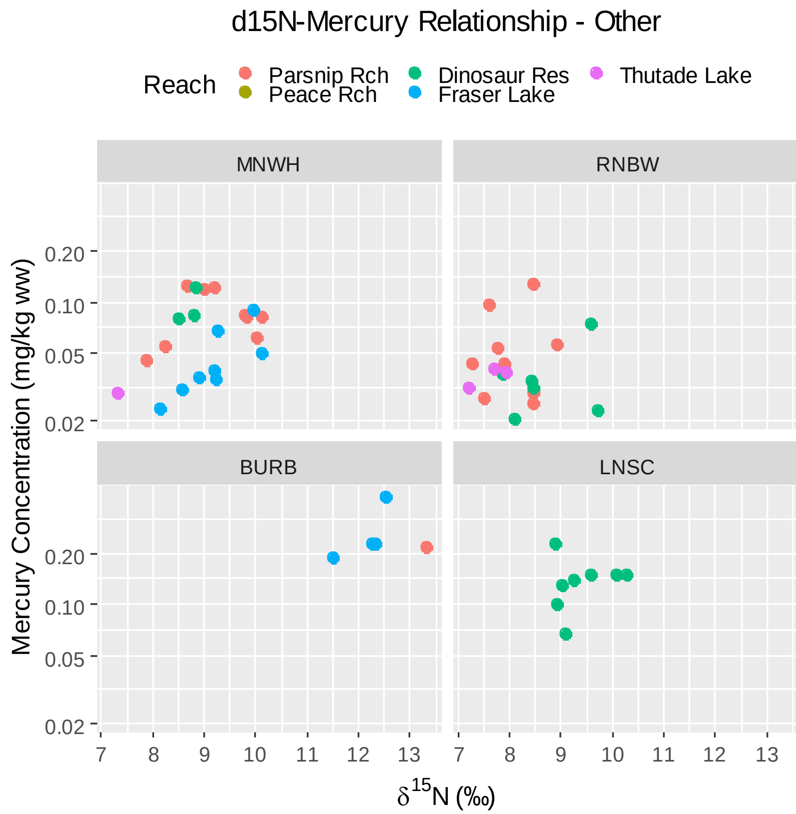
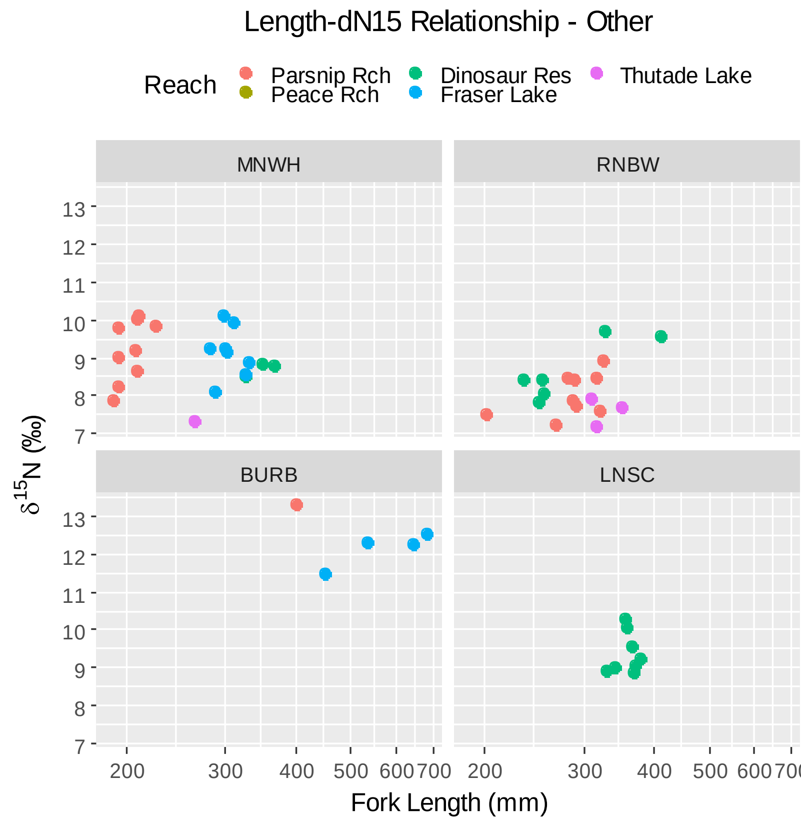


Figure 3-15. Nitrogen ($\delta^{15}N$)-mercury and length-nitrogen ($\delta^{15}N$) relationships for mountain whitefish (MNWH), rainbow trout (RNBW), burbot (BURB), and longnose sucker (LNSC).





4. DATA GAPS AND RECOMMENDATIONS

As described in **Section 2.1**, this is the second of a three-year investigation to characterize fish mercury concentrations within the Williston - Dinosaur Watershed. This 2017 report builds on the 2016 report (i.e., data from both years are integrated where appropriate), providing greater and more in-depth insight into relationships between mercury in tissue and fish species, size-age classes and geographic extent, by comparing Peace Reach with Parsnip and Finlay Reach, as well as data from Dinosaur Reservoir. This report, like the 2016 report is not strictly a 'Data Report', as we have made efforts to summarize the existing data (tables) and visualize trends (plots) in mercury data, as well as by incorporating stable carbon and nitrogen isotope data ($\delta^{15}N$ and $\delta^{13}C$, respectively; See **Section 3.1.2**). However, we have not yet undertaken a detailed comparison of all data using sophisticated statistical techniques. This will be undertaken in 2018, once we have compiled all of the data gathered in this program.

This Section describes key data gaps and recommendations to inform the next phase of this investigation during our final year of investigation in 2018. Additional resources have been allocated to in-depth data analysis and reporting for the final, 2018 data report for data from each of the three major reaches of Williston and Dinosaur reservoirs, as well as from several regional, reference lakes.

The updated status of sample collection by species, current as of fall 2017 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. Existing data show a strong length-mercury relationship, especially for larger size fish. While we would like additional smaller fish in Parsnip Reach and additional larger fish in Peace Reach, there is little evidence of among-reach differences in the length-mercury relationship, so these data gaps do not appear crucial. Nevertheless, we will attempt to collect further samples. Strategic sampling of the Finlay Reach is the main focus of 2018 sampling, which will be augmented by continued opportunistic efforts by CCE within Finlay Reach or perhaps elsewhere. While planned reference sampling at Cunningham Lake by FLNRORD was not conducted due to the diversion of resources to fire fighting in 2017, we are optimistic that additional reference lake samples will take place in 2018. To that end, we are looking more broadly across FLNRORD's planned work in 2018 to identify opportunities to obtain reference lake samples, for both lake trout-lake whitefish and bull trout-kokanee.
- *Bull Trout* – We are also 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 from each of the reaches. Beyond this size, tissue mercury concentrations rise sharply for larger fish, with available data (i.e., age-length relationship and SIA results) suggesting that changes in growth is likely driving this pattern, perhaps related to a switch in diet from invertebrates to fish as fish exceed 500 mm. Tissue mercury concentrations for bull trout are lower than for lake trout at a comparable size, with a more variable mercury-size relationship. Thus, making 'general' conclusions for this species is difficult. Notwithstanding, there may be potential differences within the reservoir. For example, Parsnip Reach trout appear to have slightly higher mercury concentrations than trout from Finlay and Peace reaches. Also, bull trout from Thutade Lake between 300 – 600 mm appear to have higher mercury concentrations than similar size bull trout

from Williston Reservoir. However, beyond this size, there is very little to distinguish between the two waterbodies. This suggests a slightly 'flatter' Hg-size relationship for Thutade Lake fish. Note that the 2017 results for Thutade Lake bull trout are anomalous relative to 2016 with uniformly much lower mercury concentrations than all other fish tested in 2015 and 2016. We are looking into this. The main focus of the strategic program in 2018 will be Finlay Reach; we also hope to obtain more fish from Parsnip Reach, either through a community-led collection program or a small targeted study of a tributary stream, such as Parsnip River. While mainly smaller fish were caught in the Peace Reach in 2017, the length-mercury relation appears consistent with that of the Finlay Reach, so additional effort is not planned here in 2018. We will continue to work with FLNRORD to identify other lake trout and bull trout systems so we can obtain additional reference lake samples. In addition, we will attempt to find other recent data collected in the province to further increase the number of reference lakes for our comparisons.

- *Lake Whitefish* – Due to the limited size distribution caught in 2016, last year we recommended targeting the most common size class among areas (i.e., 251 to 300 mm). Based on that approach, both the Parsnip and Peace reaches have sufficient data for lake whitefish. Finlay Reach will be the focus of the core reservoir sampling program in 2018 and we anticipate obtaining a full complement of samples from there. The lack of mercury data for Dinosaur Reservoir is considered a low priority gap because: 1) fish mercury concentrations are generally low in Dinosaur relative to Williston; and 2) lake whitefish are not particularly abundant in Dinosaur (Murphy and Blackman 2004, Diversified Environmental Services & Mainstream Aquatics 2011) so a considerable effort would need to be made. To date, Fraser Lake is the only reference lake for lake whitefish. As discussed above for lake trout and bull trout, we will be working with FLNRORD and other groups to obtain data for additional reference lakes.
- *Kokanee* – Similar to lake whitefish, we are taking a size-class-based approach for kokanee (201 – 250 mm) due to limited success obtaining fish from the whole size distribution. Apart from Finlay Reach, additional samples are needed throughout Williston and Dinosaur reservoirs. As the core reservoir sampling program for 2018 will target Finlay Reach, obtaining additional samples will rely on identifying other opportunities to collect fish (e.g., targeted sampling at spawning streams). The need to fill gaps in samples from Parsnip, Peace and Dinosaur is considered a low to moderate priority given the low overall tissue mercury concentrations in these fish.
- *Other Species* – Creel survey results indicated that several other species may commonly be consumed, such as ling (burbot) and rainbow trout from lakes directly connected to the reservoir (e.g., McLeod Lake) or northern pike from Moberly Lake, downstream on the Peace River. Fish tissue samples will continue to be collected from these species and archived / analysed to better characterize mercury concentrations in commonly consumed species within this watershed. Results of 2018 creel survey's will supplement data gathered over the last two years to provide an indication of the preferred species consumed, locations fished and frequency of fish consumption.

Table 4-1. Sampling status by species for the Williston-Dinosaur watershed fish mercury investigation after the 2017 program.

Waterbody (Reach)	Lake Trout	Bull Trout	Lake Whitefish	Kokanee
Williston-Dinosaur				
Williston (Parsnip)	Good numbers for large fish Could use smaller size classes. Unchanged in 2017	No change from 2016. Need more samples from all size classes. But population size in this reach may be low.	Have lots of 251-300 mm size class; sufficient fish for a size-class based approach.	Not captured in 2016 program; Low abundance here; pursue size-class based approach?
Williston (Finlay)	No change from 2016. Reservoir proper not targeted by CCE as yet; Need full size range	Added a few small size fish; mostly from tributary streams, not Reservoir proper	No change from 2016. No samples yet; need full range.	Have lots of 201-250 mm size class; sufficient fish for a size-class based approach.
Williston (Peace)	29 trout captured; Most are smaller, younger fish	16 bull trout captured; most small fish	27 Whitefish captured most in 250 - 300 mm range	3 fish captured. Pursue size-class based approach.
Dinosaur	22 Lake trout captured in Derby but smaller than in Williston	. Need full range but bull trout may be rare here	Have sufficient data for most species from 2012/16	Have sufficient data for most species from 2012/16. Abundance of kokanee uncertain
Reference Lakes				
Thutade Lake	NA	Augmented 2014/15 data with 9 fish in 2017, with SIA information; sufficient for size-class approach	NA	Lots of 201-250 mm size class; sufficient fish for size-class based approach.
Fraser Lake	Good size range and sample numbers in each.	NA	Adequate numbers for 251-300 and 351-400 mm size classes; sufficient for a size-class approach targeting 251-300 mm	NA
New	Need new reference areas for regional context.Planned for 2018	Need new reference areas for regional context.Planned for 2018	Need new reference areas for regional context.Planned for 2018	Need new reference areas for regional context.Planned for 2018

Colour Legend: **Sufficient Data - No Gaps** (green) | **Need More Data to Fill Gaps** (yellow) | No data as yet - need to fill (red outline)

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

As 2016: No change in status in 2017 relative to 2016

5. REFERENCES

Azimuth 2015. Williston Reservoir Watershed – Fish mercury consultation and next steps. A report prepared by Azimuth Consulting Group Partnership, Vancouver BC for the Fish and Wildlife Compensation Program – Peace. Ft. St. John BC. March 2015.

Azimuth. 2016. Williston Reservoir Watershed – 2015 Reconnaissance Fish Mercury Sampling Program. A report prepared for Fish and Wildlife Compensation Program – Peace Region, Prince George, by Azimuth Consulting Group, Vancouver BC. June 2016.

Azimuth. 2017. Williston – Dinosaur Watershed Fish Mercury Investigation – 2016 Report. A report prepared for the Fish and Wildlife Compensation Program (FWCP) – Peace Region, Prince George, by Azimuth Consulting Group, Vancouver BC. June 2017.

Baker, R.F., R.R. Turner and D. Gass. 2002. Mercury in Environmental Media of Finlay Reach, Williston Reservoir, 2000-2001 Data Summary. A report prepared by EVS Environment Consultants North Vancouver for BC Hydro, Burnaby, March 2002.

Berry, M.J. and N.V. Ralston. 2009. Mercury toxicity and the mitigating role of selenium. EcoHealth 5: 456 – 459.

Bodaly, R.A, R.E. Hecky and R.J.P. Fudge. 1984. Increases in fish mercury levels in lakes flooded by the Churchill River diversion, northern Manitoba. Canadian Journal of Fisheries and Aquatic Sciences 41: 682-691.

Bodaly, R.A., K.G. Beaty, L.H. Hendzel, A.R. Majewski, M.J. Paterson, K.R. Rolfhus, A.F. Penn, B.D. Hall, C.J. Mathews, K.A. Cherewyk., M. Mailman, J.P. Hurley, S.L. Schiff, and J.J. Venkiteswaran. 2004. Experimenting with hydroelectric reservoirs. Environmental Science and Technology. 38: 346A–352A.

Bodaly, R. A., W.A., Jansen, A.R. Majewski, R.J.P. Fudge, N.E. Strange, A.J. Derksen and A. Green. 2007. Post-impoundment time course of increased mercury concentrations in fish in hydroelectric reservoirs of Northern Manitoba, Canada. Archives of Environmental Contamination and Toxicology 53: 379–389.

Cabana, G. and J.B. Rasmussen. 1994. Modeling food chain structure and contaminant bioaccumulation using stable nitrogen isotopes. Nature 372: 255-257.

Cabana, G., A. Tremblay, J. Kalff and J.B. Rasmussen. 1994. Pelagic food chain structure in Ontario Lakes: A determinant of mercury levels in lake trout (*Salvelinus namaycush*). Can. J. Fish. Aquat. Sci. 51: 381-389.

Cizdziel, J. V., Hinners, T.A., Pollard, J.E., Heithmarand, E.M. and C.L. Cross. 2002. Mercury concentrations in fish from Lake Mead, USA, related to fish size, condition, trophic level, location, and consumption risk. Arch. Environ. Contam. Toxicol. 43: 309-317.

Diversified Environmental Services and Mainstream Aquatics Ltd. (Diversified and Mainstream). 2011. Site C Clean Energy Project Fisheries Studies. 2010 Dinosaur Reservoir fisheries studies and literature review. A report prepared by Diversified Environmental (Ft. St. John BC) and Mainstream Aquatics (Edmonton AB) for BC Hydro, Vancouver BC. December 2011.

ERM. 2015. Aboriginal health risk assessment of mercury in bull trout harvested from the Crooked River, British Columbia. A report prepared by ERM Consultants, Vancouver BC for the West Moberly First Nations. March 2015.

First Nations Food and Nutrition and Environment Study (FNFNES). 2011. Results from British Columbia 2008 and 2009. Published by the University of Northern BC, University de Montreal and Assembly of First Nations. Authored by Laurie Chan, Olivier Receveur, Donald Sharp, Harold Schwartz, Amy Ing and Constantine Tikhonov. Ottawa, 2011.

Hall, B.D., R.A. Bodaly, R.J.P. Fudge, J.W.M. Rudd and D.M. Rosenberg. 1997. Food as the dominant pathway of methylmercury uptake by fish. Water, Air and Soil Pollution 100: 13-24.

Hatfield Consultants and David Bustard and Associates Ltd. 2015. Kemess Underground Project Fish and Aquatics Baseline Report. Prepared for AuRico Gold Inc. by Hatfield Consultants and David Bustard and Associates Ltd.

Hatfield Consultants and David Bustard and Associates Ltd. 2016. Kemess Underground Project Supplementary Fish and Aquatics Studies Conducted in 2015. Prepared for AuRico Gold Inc. by Hatfield Consultants and David Bustard and Associates Ltd.

Herwig, B.R., D.A. Soluk, J.M. Dettmers and D.H. Wahl. 2004. Trophic structure and energy flow in backwater lakes of two large floodplain rivers assessed using stable isotopes. Can. J. Fish. Aquat. Sci. 61: 12-22.

Hecky, R.E. and R.H. Hesslein. 1995. Contributions of benthic algae to lake food webs as revealed by stable isotope analysis. Journal of the North American Benthological Society 14: 631-653.

Kidd, K.A., M.J. Paterson, R.H. Hesslein, D.C.G. Muir and R.E. Hecky. 1999. Effects of northern pike (*Esox lucius*) additions on pollutant accumulation and food web structure, as determined by $d^{13}C$ and $d^{15}N$, in a eutrophic and an oligotrophic lake. Can. J. Fish. Aquat. Sci. 56: 2193-2202.

Langston, A. 2012. Williston watershed kokanee spawner distribution and enumeration studies. A report prepared for the Fish and Wildlife Compensation Board – Peace Region. FWCP Report 357.

Munthe, J., R.A. Bodaly, B.A. Branfireun, C.T. Driscoll, C.C. Gilmour, R.R. Harris, R. Horvat, M. Lucotte, and O. Malm. 2007. Recovery of mercury-contaminated fisheries. Ambio 36: 33-44.

Murphy E.B. and B.G. Blackman 2004. Dinosaur Reservoir Fish Collection Summary 2001. Peace/Williston Fish and Wildlife Compensation Program Report No.287. 12pp.

Plate, E.M., R.C. Bocking and D.J. Degan. 2012. Williston Fish Index in the Vicinity of W.A.C. Bennett Dam. Peace Project Water Use Plan GMSMON-4. Prepared for BC Hydro by LGL Ltd and Aquacoustics Inc.

Post, D.C., A. Layman, D. Albrey, G.S., Arrington, J. Takimoto, P. Quattrochi and C.M. Montana. 2006. Getting to the fat of the matter: models, methods and assumptions for dealing with lipids in stable isotope analyses. Oecologia 152: 179 – 189.

Ralston, N.V., C.R., Ralston, J.L. Blackwell and L.J. Raymond. 2008. Dietary and tissue selenium in relation to methylmercury toxicity. NeuroToxicology 890: 1-10.

Schetagne, R. Therrien, J. and R. Lalumiere. 2003. Environmental monitoring at the La Grande complex. Evolution of fish mercury levels. Summary report 1978-2000. Direction Barrages et Environnement, Hydro-Québec Production and Groupe Conseil GENIVAR Inc., 185 pp. and Appendix.

Simoneau M., M. Lucotte, S., Garceau and D. Laliberté. 2005 Fish growth modulates mercury concentrations in walleye (*Sander vitreum*) from eastern Canadian lakes. Environmental Research 98: 73-82.

Stockner, J., A. Langston, D. Sebastian and G. Wilson. 2005. The limnology of Williston Reservoir: British Columbia's largest lacustrine ecosystem. Water Quality Resources Journal Canada 40(1): 28–50.

Vander Zanden, M.J. and J.B. Rasmussen. 2001. Variations in d15N and d13C trophic fractionation: Implications for aquatic food web studies. Limnology and Oceanography 46: 2061-2066.

APPENDIX A

Fish Collection Permit 2017

Ministry of Forests, Lands and Natural Resource Operations

FISH COLLECTION PERMIT

Research

vFCBC Tracking #: 100210245
ATS Project #: 250883

Permit #: PG17-274313

Permit Holder: Leslie Chamberlist
EDI Environmental Dynamics Inc.
301 George Street
Prince George BC V2L 1R3

Authorized Persons: Tim Antill, Jason Yarmish, Vicki Smith, Mark Asquith, Alison MacPhail, Ryan Buck, David Powe, Alissa Nyheim-Rivet, Eric O'Bryan

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: 6/19/2017 to 10/31/2017
Permitted Waterbodies: Omineca Pack River 230-906800
Omineca McLeod Lake 230-906800
Omineca Peace Reach of Williston Lake 230
Omineca Parsnip River 236
Omineca Parsnip Reach of Williston Lake 230
Omineca Crooked River 230-906800-94600
Omineca Nation River 237 Omineca
Permitted Sampling Techniques: (subject to permit terms and conditions) AG, DN, EF, GN, Other

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) YES, 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 27, 2017 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: Additional Information

2.2 Sampling Locations

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

2.6 Lethal Sampling Program Description

Fish sampling is proposed for the Peace and Parsnip Reach of Williston Lake, as well as select major tributaries. Target species include lake trout, bull trout, lake whitefish and kokanee. The collection of fish tissue from the Peace Reach is the primary objective of the 2017 program. Table 1 identifies the target number of individuals and length ranges for each species. Tissue from additional fish species will be collected opportunistically (Table 2). Bull trout will be sampled using non-destructive biopsy techniques; all other fish species will be lethally sampled. Table 2 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 Williston 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 by size of target fish samples for mercury analysis in Williston Lake, by species and size range.

Length Range (Fork Length, mm)	Lake Whitefish	Lake Trout	Bull Trout	Kokanee
100-199	12			12
200-299	12			12
300-399	12	7	7	
400-499		7	7	
500-599		7	7	
600-699		7	7	
> 700		7	7	
Total	**36**	**35**	**35**	**24**

Table 2. Target fish species and opportunistic fish capture species, sample quantity, and lethal sampling requirement (Project total).

Area/Source	Species	Target Sample Size	Lethal Sampling
Peace/Parsnip Reach and Tribs	Bull Trout	35 from lake 50 from tributary systems	Biopsy
	Lake Trout	35 from lake	Yes
	Lake Whitefish	36 from lake 50 from tributary systems	Yes
	Kokanee	24 from lake 50 from tributary systems	Yes
	Rainbow Trout	20	Yes
	Burbot	20	Yes
	Mountain whitefish	20	Yes
	Arctic Grayling	20	Biopsy 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

APPENDIX B

Environmental Dynamics Inc. Catch Summary Log – Peace Reach

ENVIRONMENTAL DYNAMICS INC.

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

November 01, 2017

EDI Project No: 17P0039

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

Attention: Randy Baker

RE: Williston Reservoir, Peace/Parsnip Reach Fish Tissue Collection - 2017

In 2017, EDI Environmental Dynamics Inc. (EDI) was responsible for collecting fish tissue from a number of fish species within 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 three separate events, the Hudson's Hope Fishing Derby, Duz Cho Fishing Derby, and a dedicated fish tissue sampling program on the Peace Reach of Williston Reservoir. This document provides a brief summary of methods and sampling results for fish tissue collected by EDI in 2017.

Hudson's Hope Fishing Derby

Fish tissue was collected during the annual Hudson's Hope Father's Day fishing derby on June 18, 2017. The fishing derby was located on Dinosaur Lake, near at Hudson's hope. An EDI biologist assisted with the official weigh-in of derby fish at the Dinosaur Lake Campground. 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. Otoliths for ageing were collected and placed in labeled envelopes. When time allowed, fish were gutted for the participants allowing for sexing, inspection of stomach contents, and general internal health assessment. Wearing clean nitrile gloves and using a sterile fillet knife and cutting surface, a small fillet sample (~10 g) 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 the day. Otoliths were collected for ageing from 31 individuals.

Participants in the fishing derby brought 36 fish to the weigh-in station; the catch consisted of 22 lake trout (*Salvelinus namaycush*), 13 rainbow trout (*Oncorhynchus mykiss*) and one bull trout (*Salvelinus confluentus*) (Table 1). The bull trout was an unintended mortality by an angler. The largest fish caught in the derby was a lake trout measuring 610 mm in length and weighing 2,631 g.

Overall, participants were very interested in the study and willing to offer their fish for tissue sampling. Participants were encouraged to catch and bring in lake trout less than 600 mm, as well as non-lake trout target sport fish species through the use of a cash reward program. The cash reward was a helpful at bringing in smaller fish, particularly for those caught by youth. Additional promotion prior to the fishing derby would have likely increased the number of fish targeted by the program.

Table 1. Size class and species of fish captured during the Hudson Hope Fishing Derby.

Length (mm)	Lake Trout	Bull Trout	Kokanee	Lake/ Mountain Whitefish	Rainbow Trout	Burbot	Northern Pikeminnow	Peamouth Chub	Total
100-199									
200-299					4				4
300-399	8				9				17
400-499	8	1							9
500-599	4								4
600-699	2								2
>700									
Total	**22**	**1**	**0**	**0**	**13**	**0**	**0**	**0**	**36**

Duz Cho Fishing Derby

The annual fishing derby hosted by Duz Cho Logging Ltd. (Duz Cho) was on August 26 and 27, 2017. 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. EDI and Cheryl Chingee from Northern Spruce Contracting Ltd. (Northern Spruce) assisted with the official derby weigh-in and collection of fish tissue. Sampling methods were similar to those described for the Hudson's Hope derby. Each fish brought into the weigh station was identified to species, given a unique alphanumeric identifying code, and fork length (mm) and total weight (g) was recorded. Otolith structures were collected for ageing and a general internal health assessment completed when time allowed. A fillet sample was collected from each fish and 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 40 lake trout (*Salvelinus namaycush*), four northern pikeminnow (*Ptychocheilus oregonensis*), four peamouth chub (*Mylcheilus caurinus*), and two rainbow trout (*Oncorhynchus mykiss*) (Table 2). Lake trout were captured from boats on the reservoir; however the rainbow trout, northern pikeminnow, and peamouth chub were all caught from shore in the Cut Thumb Bay campground area. The largest fish caught at the derby was a lake trout measuring 905 mm in length and weighing 8,754 g. Of the lake trout, 34 exceeded 700 mm in length. The smallest fish recorded was a northern pikeminnow (fork length 186 mm). Otoliths were collected from 27 individuals. Of the stomachs of 27 fish examined, 86% were empty. When present, the stomach content typically consisted of kokanee (*Oncorhynchus nerka*) and lake whitefish (*Coregonus clupeaformis*).

Overall, participants were very interested in the study and willing to offer their fish for tissue sampling. Some, but not all participants in the derby were aware of the consumption advisory in the reservoir. Many fishers practiced catch and release, however a number of individuals reported consuming fish at low to moderate levels, preferring to target smaller fish than those captured in the derby. A reoccurring comment was that the large lake trout were "too oily/fatty and not very good to eat".

As with the Hudson's Hope derby participants were encouraged to catch and bring in lake trout less than 600 mm and other target sport fish through the use of a cash reward program. The reward program was not actively used or known about, and additional promotion by the organizer prior to the fishing derby would have been a benefit. There was some criticism by a few individuals that the reward system promoted the "killing of more fish than necessary", even though the program was not actively used.

Table 2. Size class and species of fish captured during the Duz Cho Fishing Derby.

Length (mm)	Lake Trout	Bull Trout	Kokanee	Lake/ Mountain Whitefish	Rainbow Trout	Burbot	Northern Pikeminnow	Peamouth Chub	Total
100-199							2		2
200-299							2	4	6
300-399					2				2
400-499									
500-599									
600-699	6								6
>700	34								34
Total	**40**	**0**	**0**	**0**	**2**	**0**	**4**	**4**	**50**

Peace Reach Sampling Program

A crew consisting of EDI, Azimuth and Northern Spruce personnel completed a six day fish sampling program on the Peace Reach of the Williston Reservoir from August 19 to 25, 2017. The goal of the Peace Reach sampling program was to acquire tissue from a range of sizes for four target species; lake trout (n = 35), bull trout (n = 35), whitefish (n = 36) and kokanee (n = 24) (Table 3). Tissue from other species was collected opportunistically when captured (i.e. burbot (*lota lota*), largescale sucker (*Catostomus macrocheilus*), longnose sucker (*Catostomus catostomus*) and northern pikeminnow). Sampling was done using a fisheries specific jet boat from EDI. Fish sampling techniques included pelagic sets of two 64 m monofilament gill nets made up of eight panels of 57, 64, 70, 76, 89, 102, 114, and 127 mm mesh sizes; two 45 m nets made up of three panels of 25, 108, and 76 mm mesh; and one 30 m net of two panels of 76 and 108 mm mesh. Gill nets were initially set for 4-6 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.

During the program gill nets were set at 28 locations in the Peace Reach of the Williston Reservoir (Attachment 1 – Sample Site Map). The majority of sampling took place within large inlets associated with past river channels. These areas offered protection from weather conditions mid reach, while allowing for a range of habitats for targeted sets, including near river mouths. The crew spent three days camped in the Carbon Creek area in an attempt to maximize fishing effort by limiting travel time to and from the study area.

Fish handling and tissue sampling methods followed those identified in the Azimuth *Fish Tissue Collection & Recording Procedures* (2015) document. Non-destructive biopsy sampling was used for bull trout; while lethal sampling was used for all other species. 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 involved the collection fillet samples. 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. 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 as soon as possible. Ageing structures were also collected, otoliths from salmonid species and burbot, and fin rays from sucker species and northern pikeminnow.

Tissue was collected from a total of 115 fish from the Peace Reach during the dedicated sampling program (Table 3). Of the fish captured, 107 were by gillnetting and 8 by angling (five rainbow trout and three bull trout). Of the 15 target species-size classes, the desired number of fish was only achieved in four classes (Table 3). Certain size classes were disproportionally captured for lake trout and whitefish. Of the lake trout 55% were in the 300-399 mm size class, 50% of the whitefish were also in the 300-399 mm size class.

Table 3. Size class and species of fish captured during the Peace Reach sampling program.

Length (mm)	Lake Trout	Bull Trout	Kokane e	Lake/ Mountain Whitefish	Rainbo w Trout	Burbot	Largescale Sucker	Longnose Sucker	Northern Pikeminnow	Total
100-199	1		3 (12)*	5 (12)*	2			1		6
200-299	7	2	0 (12)*	13 (12)*	4			2	1	14
300-399	16 (7)*	8 (7)*		19 (12)*	1			6	3	47
400-499	4 (7)*	3 (7)*		1		1	3	1		9
500-599	1 (7)*	2 (7)*				1				4
600-699	0 (7)*	0 (7)*				3				3
>700	0 (7)*	1 (7)*								1
Total	**29 (35)***	**16 (35)***	**3 (24)***	**38 (36)***	**7**	**5**	**3**	**10**	**4**	**115**

*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 meter of net for every hour of soak time. Total CPUE for all fish was 0.902 fish/m-100 h (Table 4). Lake whitefish and lake trout had the highest CPUE (0.253 fish/m-h) while rainbow trout had the lowest (0.017 fish/m-h). The CPUE for opportunistic angling effort was not calculated.

Table 4. Gillnet catch per unit effort for species captured during the Peace Reach sampling program.

Species	Number of Individuals	Total CPUE (fish/m-h)
Bull trout	13	0.110
Lake trout	30	0.253
Rainbow trout	2	0.017
Kokanee	3	0.025
Lake whitefish	30	0.253
Mountain whitefish	7	0.059
Burbot	5	0.042
Largescale sucker	3	0.025
Longnose sucker	10	0.084
Northern pikeminnow	4	0.034
Total	**107**	**0.902**

Summary

Fish tissue was collected from 115 fish in the Peace Reach, 50 fish in the Parsnip Reach (Duz Cho Derby) and 36 fish from Dinosaur Lake. Samples were collected from a total of 201 fish. The 2017 program in the Peace/Parsnip Reach was successful in collecting tissue samples from a number of fish species, in a variety of size classes. However the not all the desired number of fish for each size class was 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.

As a general observation, lake trout captured in the Peace Reach/Dinosaur Lake tended to be smaller than those captured in the Parsnip Reach. During sampling in the Parsnip Reach in 2016 the largest proportion of lake trout captured (74%) were in the >700 mm class, whereas during the 2017 Peace sampling 55% of fish were in the 300-399 mm size class and there were no fish in size classes above 600 mm. This same trend can be observed in the size of lake trout sampled in the 2017 Duz Cho and Hudson's Hope Derbies, with larger fish captured in the Parsnip Reach over those from Dinosaur Lake. In addition, more fish were captured in fewer days with higher CPUE in the 2016 Parsnip Reach program than in the 2017 Peace Reach, suggesting that Parsnip Reach may be more productive than the Peace Reach.

Closure

We trust that this summary document meets your needs. 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:	Senior Review:
David Powe	Tim Antill, M.Sc., R.P.Bio., P.Ag.
Environmental Scientist	Senior Biologist

Attachments:

- Appendix A – Map of Sampling Locations

APPENDIX C

Creel Survey Data Sheets

FWCP Fish & Wildlife COMPENSATION PROGRAM

BC Hydro Reservoir Day – Fort St. John Meeting
Randy Baker, Azimuth Consulting Group
November 16, 2017

fwcp.ca

1

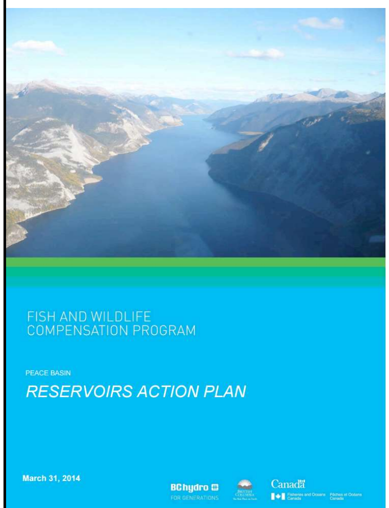
Outline

- Background for Project
- Overview of mercury in the environment
- Project scope and strategies
- Results from 2016; update on 2017 activities
- Open discussion
  - Importance of country foods in the diet
  - First Nations involvement opportunities
  - Creel survey/discuss fishing patterns
  - Residual concerns by First Nations, other fishers

2

FWCP

Background



- Consumption advisory since the early 1990s stating ‘normal consumption of bull trout and lake trout from Williston Reservoir does not pose a health risk, but high consumption might’
- FWCP-Peace implanted a 3-year fish mercury study (2016 – 18)
- Not much data…
  - Finlay Reach 2001 investigation by Azimuth
  - Crooked River 2012 (ERM)
  - Azimuth Reconnaissance 2015

3

Mercury ‘101’ Facts

- Mercury (Hg) is unique, exists as gas, liquid, solid
- Historically, many uses, but few today
- Hg occurs in small quantities in *everything, everywhere* – in air, soil, water, plants and all animals – but especially fish … why fish?
- Mercury occurs in water but in very low concentrations … more mercury in 1 meal of fish than in all the water you will drink in your life…
- The main form of mercury in fish is ‘methylmercury’ ($Hg\text{-}CH_3$)

4

Mercury '101' Facts

- Fish is dominant source of methylmercury exposure to all animals, including humans
- Inorganic mercury is transformed into methylmercury in sediment and flooded soils
- Reservoir creation causes methylmercury in fish to increase …. But only for a limited time
- There is as much mercury in a tin of store bought tuna as in most fish in nearby rivers and lakes
- In Canada, an extremely small number of people have been diagnosed with mercury intoxication

5

FWCP

Objectives and Outcomes

- Three-year program in collaboration with local Study Team partners and First Nation community representatives – Fish [Hg] and Creel data from up to 8 communities
- Engage with Northern Health, FN Health Authority
  - Communicate, liaise and provide periodic updates
  - Ultimate goal is to address fish mercury advisory on Williston Reservoir & watershed

6

FWCP

Program Overview

- Three-year program: 2016 focus on Parsnip Reach and Reference lakes (plus 'opportunistic' sampling from other areas)
- Key species: main focus on bull trout, lake trout, lake whitefish, kokanee (minor focus on others)
- Team: Azimuth, Chu Cho Environmental (CCE), Environmental Dynamics (EDI), Northern Spruce, 4 Evergreen + FLNRO + 8 FN
- Saulteau, McLeod, Kwadacha, Nak'az'dli, West Moberly, Tsay Key, Doig R., Prophet R.

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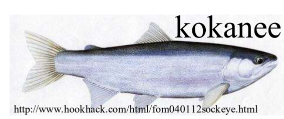
FWCP

Sampling Strategy

1. **Targeted:**
   - **Parsnip Reach –** Strategic + Derby [EDI, CCE] a
   - **Reference Areas** – *Fraser Lake* (FLNRO) target and *Thutade Lake* (CCE) targeting BLTR, KOKA
2. **Partnerships / Opportunistic**:
   - Finlay tributaries targeting BLTR (CCE, FLNRO, (Carleton Uni)
3. Community-Led – Opportunistic



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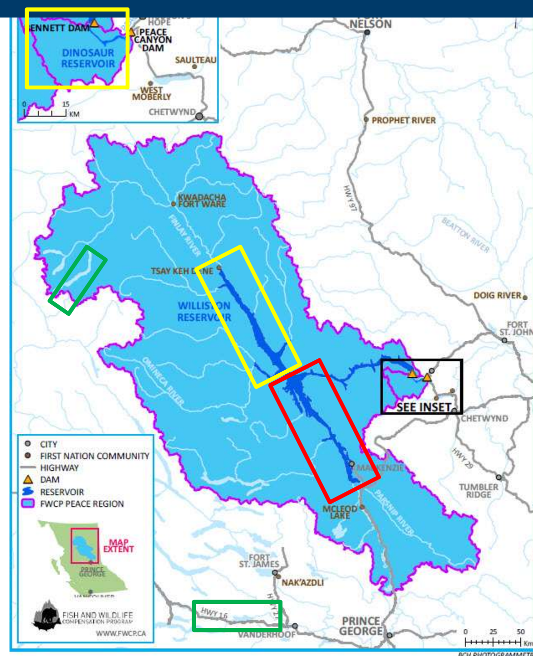
FWCP

2016 Program

- Williston Reservoir
  - Targeted
  - Opportunistic
- Dinosaur Reservoir
  - Opportunistic
- Reference Lakes
  - Thutade Lake
    - CCE
  - Fraser Lake
    - FLNRO



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Year 1: 2016 - 17

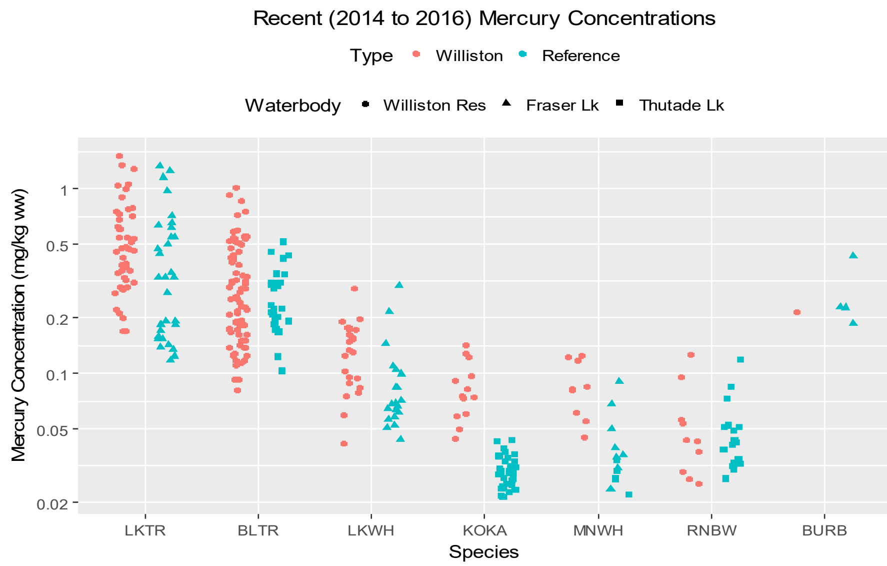
Mercury Investigations

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

FWCP

10

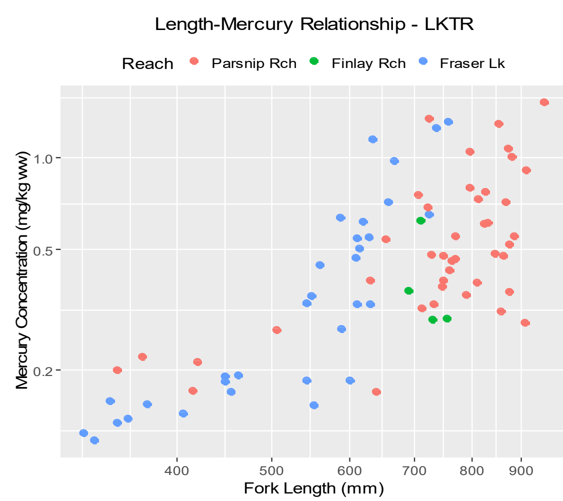
2016 Results



11

2016 Results – Lake trout

- Generally larger fish caught in Williston (Derby)
- Strong L vs Hg relationship
- Target smaller fish in 2017 (Derby?)
- Williston LKTR [Hg] *generally* similar to Fraser Lake



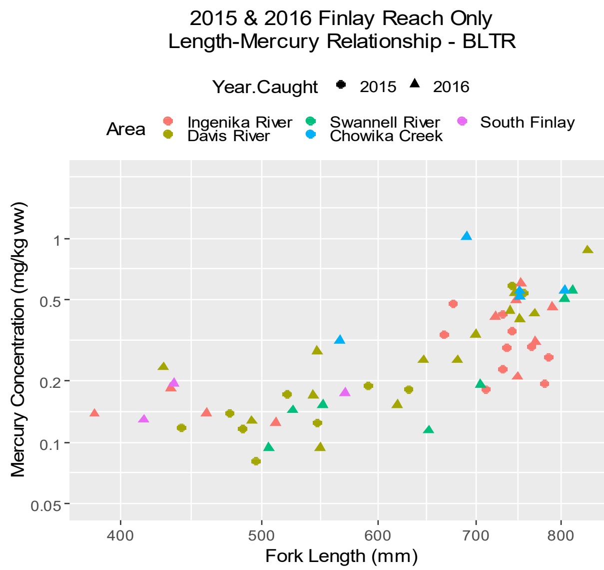
Note $\log_{10}$ scale

12

2016 Results – Bull trout

Finlay Reach

- Some rivers have too few data
- No obvious differences in fish [Hg] among rivers



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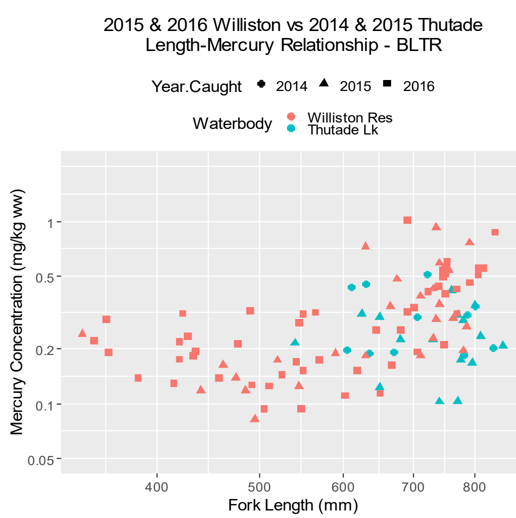
Note $\log_{10}$ scale

FWCP

2016 Results – Bull trout

Williston vs Thutade

- No small BLTR from Thutade
- No major apparent differences to reference lake
- [Hg] in bull trout lower than in lake trout at similar size



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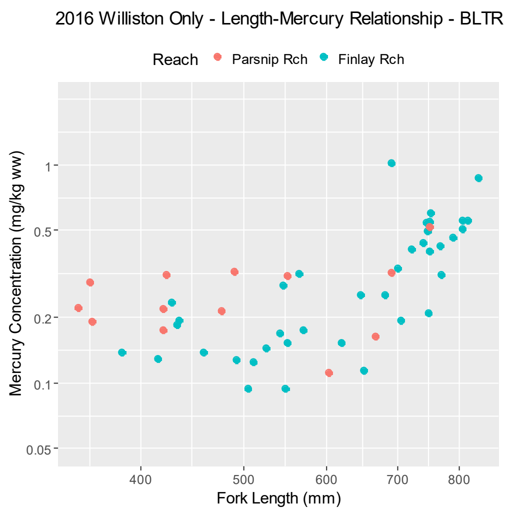
FWCP

2016 Results – Bull trout

- Parsnip vs Finlay

- Few fish from Parsnip
- Hg doesn't increase much until >600mm
- Hard to tell if differences in Hg exist between reaches
- BLTR [Hg] lower than LKTR at similar size



Note $\log_{10}$ scale

FWCP

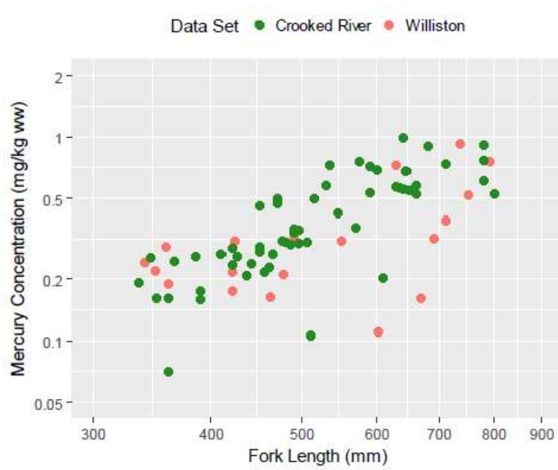
15

2016 Results – Crooked River

Bull trout

Crooked River (2012)

- Similar size – Hg distribution for small and large fish
- Medium size trout from Williston lacking – no good comparison; need more Parsnip fish
- Probably similar populations / diet



Note $\log_{10}$ scale

FWCP

16

Preliminary 'Take Home Messages'

- Mercury concentrations in Williston Reservoir fish appear similar to fish in nearby 'reference lakes'
- These concentrations are also similar to concentrations found elsewhere in Canada
- There is no 'redline' or threshold of exposure to people… Exposure to mercury (based on Creel survey) differs for each person and is a function of:
  - Species consumed (and thus Hg concentration)
  - How often are fish consumed?
  - Meal size? (# of grams)
  - What is your age/gender and body weight?
- Health 'guidelines' are inherently conservative

17 FWCP

2017 – Major Accomplishments

- Attended Fathers Day fishing derby in Hudson Hope; + Mackenzie fishing derby (August) to hold 'reverse' draw to gather fish from smaller sizes;
- Dedicated surveys on Peace Reach, Thutade Lake, Parsnip Reach (Chu Cho); no second MOE reference lake this year due to fires, budget constraints
- Planning for additional reference lake sampling
  - Bull trout – kokanee complex
  - Lake trout – lake whitefish complex … ideas welcome!

18 FWCP

2017 – Major Accomplishments

- Sought further opportunities for direct engagement with First Nations communities; revived ‘champions’ program
  - Communication, Education, Awareness, Training
  - Presented in McLeod Lake, Kwadacha, Tsay Keh, Saulteau First Nations, with some West Moberly councillors
  - ‘Champions’ from Kwadacha, Tsay Keh and Saulteau provided fish tissue samples and ‘Creel survey’ data
- Twice annual NH and FNH meetings (Jan 2018)

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FWCP

2017 / 18 – Next Steps

- Fish tissue samples from Peace Reach, Finlay Reach, Dinosaur Reservoir, Thutade Lake, plus community samples are nearly finished analysis
- Reporting will begin in December – January
- Presentation of 2017 results and ‘big picture’ results to date to FWCP Board in January
- Planning for final sampling in 2018 to fill data gaps
  - Additional reference lakes
  - Engagement with Prophet, Doig, Nakaz’dli First Nations
  - Comprehensive document production
  - What other opportunities exist for communities to participate?

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FWCP

APPENDIX D

Minutes of 9 March 2017 Meeting with Northern Health and First Nations Health Authority

Peace Region
3333 - 22nd Avenue
Prince George, B.C., V2N 1B4
chelsea.coady@bchydro.com
250-561-4884 fwcp.ca

FWCP Peace Mercury in Fish Investigations Project -DRAFT MEETING RECORD

Tuesday, January 9, 2018 9:00am – 11:30am

Location: BC Hydro Office, 3333 22nd Avenue, Prince George, BC, Meeting Room 1, 2nd Floor

Attendees: Paul Broda (FNHA); Blake Blok (FNHA); Allan Torng (NH); Angela VanVolkenberg (FNHA, by conference); Dionne Sanderson (FNHA, by conference); Sarah MacDougall (NH, by conference); Regrets – Raina Fumerton
Meeting Hosts: Randy Baker (Azimuth); Norm Healey (Azimuth) Chelsea Coady (FWCP)

Meeting Objectives: Present information and an update on the FWCP Mercury in Fish Investigation to Northern Health and First Nations Health Authorities and discuss potential next steps with Health Authorities.

Tuesday, January 9, 2018 – Start @9:00AM PST

TIME	*ITEMS*
9:00	Refreshments, Housekeeping, Introductions, Agenda Additions
9:10	Randy and Norm to provide a presentation on the FWCP Mercury in Fish Investigations Project: • Background on FWCP and the study • Mercury '101' Facts • First Nations Concerns • Importance of country foods • Study Objectives and Goals • Preliminary results 2016 & 2017 • Moving forward – advisories in Canada etc.
10:15	Group discussion on next steps and how to work together
11:15	Follow up on Action items from last meeting
11:30	Adjourn

Meeting Discussion:

9:00 – 9:10 Introductions

- Roundtable of introductions for those in person and on the phone.

9:10 – 10:15 Randy and Norm to provide a presentation on the FWCP Mercury in Fish Investigations Project

- Randy and Norm discussed human hair Hg results from First Nations Food, Nutrition and Environment Study (FNFNES; Chan et al. 2011). It was noted that the study results were most likely heavily weighted by Coastal First Nations communities, however, other interior First Nations contributed to the study.

- Norm identified that analyzing human hair Hg levels is the 'Gold Standard" for assessing human health risk of Hg which has not been done for the FWCP study.

- Allan made the point that there must be sufficient data to support any updated advisory or communications. It was identified that the two years of fish tissue Hg data that we currently have for the FWCP project is not sufficient to make conclusions about Hg levels in fish in the reservoir and that the proposed third year of the project is necessary. The project work plan would build in contingencies to ensure that the necessary level of data are collected if the in-kind contributions and opportunistic sampling being proposed is not achievable.
- It was identified that most First Nations fish in the tributaries and lakes attached to the reservoir and not within the reservoir proper.

- The question was raised regarding how these other communications materials in Canada (Que, Man, Ont) were evaluated for their effectiveness with the fish consumers.
  ACTION: Randy/Norm to explore if any effectiveness evaluations of the fish hg communications materials developed in other provinces (e.g. Hydro Quebec) have been done and share any findings with the group.

- General discussion regarding the approach to developing the communications materials. It was identified that a visual for the serving size would be beneficial for consumers. When developing communications materials, the audience for the materials (i.e. the consumers) should be engaged, potentially through focus groups to get feedback and input on the best approach to communicating information. Also need to anticipate the requirement to assess the efficacy of communications efforts once implemented. Blake noted that NH's experience from lifting drinking water advisories is that it takes a while for community beliefs to change. Dionne indicated that FNHA would support a broader geographical effort, including off-reserve First Nations, and the use of multi-media (e.g., internet, phone-based) tools.

- General discussion regarding approach to communicating information within the communities. If attempting to communicate with First Nations about fish Hg, could serve fish at a First Nations feast and eat it to demonstrate that it is safe to eat and gain trust from the First Nations. Could also have a local First Nations translator at the meetings to translate the information in local language. There are "Community Engagement Coordinators" within FNHA that could be a conduit to the communicating information to the communities. NH and FNHA would need to involve their communications professionals in developing communications messages and products. Paul recommended considering youth involvement and noted that there may be funding to support youth back-to-the-land initiatives, which could be tied to messaging the nutritional benefits of consuming fish and managing exposure to Hg in fish. Paul mentioned that FNHA is hiring a regional nutritionist and that position may be a resource for developing messaging on the nutritional benefits of fish consumption.
  ACTION: Paul to contact other 'health directors' from his contacts to determine if there are other health issues communications strategies in other First Nations communities that we can use to inform current strategy.

- Discussion on other contaminants of concern. Selenium, up to a point, is beneficial, but may cause adverse effects if concentrations are too high. Allan identified a provincial guidance document for assessing risks from selenium in fish.
  ACTION: Allan to send the selenium guidance document to Randy/Norm/Chelsea. STATUS: COMPLETE (Allan sent link to selenium guidance document January 12, 2018).

10:15- 11:15 Group discussion on next steps and how to work together

- The concept of developing a working group between Azimuth and FNHA and NH (later in 2018 or 2019) and potentially other agencies or partners was discussed and agreed that would be the best approach to working together collaboratively on any communications materials developed.
  DECISION: Group supported the idea of developing a working group to build from this work and come up with a strategy to apply to the FWCP Peace Region. The Working Group would include Azimuth, Health Authorities and potentially other partners.
  ACTION: Health Authorities (Paul and Allan) to discuss this project at next Inter-agency meeting and determine if other agencies should be part of the discussions and future working group and also if these communications should be extended to beyond the FWCP Peace Region (i.e. provincial communications).

- The geographic scope of the communications materials still needs to be determined. Although this project is specific to the FWCP Peace Region boundary, there is opportunity to expand the communications beyond that geographic scope. Whatever guidance is developed out of these results of this project should be easily expandable to a broader geographic scope (eg. Provincially).

- The question of whose responsibility it would be to lead and fund any communications materials was discussed. Chelsea identified that there was still a role for FWCP, since last piece of the project, however, collaboration by all is needed and asked if the agencies had or knew of funding available to support the process. It was identified that the FNHA Contaminants Program has funding to support projects that focus on studying contaminants of concern for First Nations. There could be an opportunity to fund some of the communications materials development with this funding.
  ACTION: Randy would include a task in the next year of the FWCP project work plan to develop a 'strawman' or general approach towards a regional strategy guiding future fish consumption recommendations with a positive focus on health benefits of fish consumption, as done in other provinces.

- Group discussed when should meet next. Randy suggested the fall for another face to face meeting, however, the group will continue to communicate about that the status of the actions from the meeting. There is opportunity for another conference call to check in with each other ahead of the next face to face meeting.
  ACTION: Group encouraged to keep the lines of communication open and provide any updates on the status of the meeting actions throughout the year ahead of the next scheduled meeting in the fall 2018.

11:15-11:30 Follow up on Action items from last meeting

Actions from March 9, 2017 Meeting

Status Box: Green = Complete; Peach = Partially Complete or In Progress; Clear = Not Started

Action #	Meeting	Topic	Action	Assigned	Status
1	March 9 2017	Information Sharing	Paul will try to share fish consumption results from First Nations dietary survey with Randy once available, if communities are in agreement.	Paul	**COMPLETE.** Paul identified the data most likely won't be useful for this project as it was a province-wide survey and not focussed on traditional foods or fish.
2	March 9 2017	Information Sharing	Randy to send Paul brief summary of information needs and what Azimuth is requesting from First Nations (i.e. opportunity to share project information/collect creel survey data/recruit more FN members to participate in data collection?) which he can share with Nicole.	Randy	**COMPLETE.** Randy sent package of information (4 files) to the group on September 1 2017
3	March 9 2017	FNHA communications	If Nicole agrees with the request, Paul to connect Nicole Cross and Randy to determine best approach for Randy to communicate to First Nations about the project and information needs and identify opportunities to engage with First Nations (Note: Nicole Cross is the Regional Director for Northern Region of FNHA).	Paul	**ON-GOING**. Paul identified that once we collectively have a specific proposed approach to engaging and communicating with First Nations about the project, Paul can present this information to Nicole and get her feedback.
4	March 9, 2017	Presentation	Randy to follow up with Raina and set up time to go over presentation.	Randy	**COMPLETE.** Randy and Raina had a telephone conversation on March 23, 2017.

References:

Beatty, J.M. & Russo, G.A. 2014. Ambient water quality guidelines for Selenium Technical Report Update. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-quality/wqgs-wqos/approved-wqgs/bc_moe_se_wqg.pdf.

Chan, Laurie & Receveur, Olivier & Sharp, Donald & Schwartz, Harold & ing, QAmy & Tikhonov, Constantine. 2011. First Nations Food, Nutrition and Environment Study (FNFNES): Results from British Columbia (2008/2009). http://www.fnfnes.ca/docs/FNFNES_Report_BC_FINAL_PRINT_v2-lo.pdf