Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP)

Final Report, Wekweètì 2016

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Cover Photo: Paul Vecsei, Golder Associates Ltd.

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Summary

The purpose of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) is to continue to build and maintain a successful community-based monitoring program that meets the needs of the Tłı̨chǫ people in determining whether fish, water, and sediment quality are changing over time, and whether fish and water remain safe to consume. The TAEMP rotates science-based fish, water and sediment sampling through each of the four Tłı̨chǫ communities so that every community has samples collected and analysed once every four years. The TAEMP continues to provide a means of addressing community concerns related to observed changes in the environment and builds on work carried out since 2010. As a successful community-driven program, it meaningfully involves community members in conducting contaminants-related research, including the collection of samples and observations using both Tłı̨chǫ and scientific knowledge to address the question: “Are the fish safe to eat and is the water safe to drink?”

In 2016, community members in Wekweètì were informed of the TAEMP through face-to-face community meetings, where support staff and community members discussed the TAEMP camp near Wekweètì in 2012, and re-visited concepts related to Tłı̨chǫ and scientific knowledge relevant to water, sediment and fish, and concerns regarding potential contaminants. A key outcome of the workshops was advance planning of a 5-day on-the-land monitoring camp on Snare Lake at a location selected by community members from Wekweètì, a location that was further west of where the camp was placed in 2012 which provided better shelter and options for boat launch/landing. At the planning meetings, and at the on-the land camp, elders and community members had opportunities to describe fish health near Wekweètì, as well as their concerns about aquatic ecosystem health and the need for adequate monitoring near the community. At the on-the-land camp in September 2016, biologists and community members collected fish tissue samples for analysis of a variety of metals, including mercury. Elders and community members ensured safe camp operations and transport by boats and provided direction on where fish nets were set and where water samples were collected. Sites sampled in 2012 were revisited, and three new water/sediment sampling locations were added further west of the camp as per community members’ request. Youth were provided basic hands-on training in science-based sampling methods. Water and sediment samples were analysed for metals, as well as chemical and physical properties.

A results meeting open to the public was held in Wekweètì in March 2017, and a presentation providing a comparison of the 2012 to 2016 results for fish, water and sediment was given. Fish tissue analysis indicated mercury levels were low in both *Łiwezǫ̀ǫ̀* (Lake Trout; LKTR) and *Łih* (Lake Whitefish; LKWF), with łiwezǫ̀ǫ̀ samples having the highest concentrations overall. None of the species’ tissue samples showed levels of mercury that were considered abnormal for northern lakes. Comparison of 2016 results to 2012 results showed no appreciable change in mercury concentration. Water and sediment results supported the expectation that water and sediment quality is “good” (i.e. not abnormal) in Snare Lake. Two elders who participated at the camp along with TAEMP support staff also visited Alexis Arrowmaker School and shared information with students in Tłı̨chǫ language (with translation) about the fish camp, and a slide show was given on fish ecology by the fish biologist who was at camp.

Introduction

The purpose of the Tłįchę Aquatic Ecosystem Monitoring Program (TAEMP), or "fish camp" as it is known, is to continue to successfully implement an aquatic ecosystem monitoring program based on Tłįchę Knowledge (i.e. traditional knowledge, or TK) and scientific knowledge in order to determine whether fish health, water, and sediment quality are changing over time at locations near Tłįchę communities. There are historic, currently operating, and proposed developments in Wek'èezhìı, and there is concern in Tłįchę communities that contamination of nearby aquatic ecosystems may occur or has already occurred. As a result of these concerns and a general lack of information (WWF 2016, 2015), there is a need to collect information and have ongoing monitoring of the aquatic ecosystems in Wek'èezhìı in anticipation of continuing pressures on watersheds.

It is important to have Tłįchę community members (including elders and youth) directly involved in monitoring and provide a genuine opportunity for community members to exchange knowledge with research scientists in appropriate community and on-the-land settings. By meaningfully involving community members in conducting science-based contaminants-related research, including the collection of samples and observations using both Tłįchę and scientific knowledge, the TAEMP provides a means to help to address the question: "Are the fish safe to eat and is the water safe to drink?"

The TAEMP rotates sampling through each of the four Tłįchę communities once every four years. With the conclusion of the 2014 camp near Whatì, the TAEMP completed its initial baseline sampling phase. In 2016, the first round of comparative sampling began with the return of the TAEMP to the community of Wekweètì. The comparative sampling phase (2015-2018) will continue to build on work carried out since 2010 and allow for comparative analysis of sampling results collected in each of the four communities. The comparative sampling will provide a way to continue to address community concerns related to changes in the environment.

TAEMP partners include: community members (e.g. elders, fishers and youth), the Wek'èezhìı Renewable Resources Board (WRRB), the Tłįchę Government (TG), the Wek'èezhìı Land and Water Board (WLWB), the Department of Fisheries and Oceans (DFO), the Government of the Northwest Territories (GNWT) Department of Environment and Natural Resources Water Resources Division (GNWT ENR) and the Department Health and Social Services (GNWT HSS), and Environment and Climate Change Canada (ECCC).

Methods

The 2016 TAEMP consisted of three main phases:

1. Introductory and planning workshops in Wekweètì;
2. On-the land camp near Wekweètì on Snare Lake where samples were collected; and,
3. Results workshop in Wekweètì.

Translation was provided during all project activities by Jonas Lafferty and James Rabesca. See Appendix 1 for lists of participants in each phase.

1. Introductory / Planning Workshops

Prior to the on-the-land camp, workshops were held in late August and early September of 2016 to discuss the TAEMP with community members in Wekweètì. The meetings provided a means to reacquaint community members with objectives and the approach of the TAEMP (i.e. the TAEMP had last taken place near Wekweètì in 2012), and begin planning for the on-the–land camp. Community members discussed the concept of indicators and their perspectives on the health of the ecosystem with visiting researchers. During the planning meetings, selection of participants was also discussed, and preliminary selection was determined based on relevant expertise/need/availability.

2. On-the-land Monitoring Camp – Snare Lake

a. Overall

To assess fish, water, and sediment quality, samples were collected using standard science-based techniques during a 5-day on-the-land "fish camp" where elders, youth, and research scientists cooperated in the implementation of an aquatic ecosystem-based monitoring program. The camp (and associated planning meetings previously mentioned) allowed for continued sharing of science and traditional knowledge-based approaches to monitoring, and building/maintenance of relationships and mutual respect.

The camp provided an opportunity for researchers and community members to work collaboratively to combine aspects of Tłı̨chǫ knowledge with scientific-based monitoring methods. It provided teaching opportunities in Tłı̨chǫ ways of understanding the aquatic ecosystem, assessing the health of the ecosystem, and catching, preparing, and preserving fish. The camp also provided an opportunity to "de-mystify" scientific monitoring methods by having community members directly involved in sample collection, and through on-shore demonstrations of sampling methods. The camp also provided youth with hands-on experience with science-based sampling methods and approaches to aquatic ecosystem monitoring and provided youth with opportunities to ask visiting researchers / support staff questions about science and possibilities for training and employment in the environmental monitoring field.

b. Water Quality

Surface water samples were taken as "grab samples". Field Staff used fresh disposable vinyl gloves at each sample site to minimize the potential for contamination from the sampler's hands. Different sample bottles were used for each laboratory analysis group including: physicals, nutrients, total and dissolved metals, and microbiological analysis. All bottles (except sterile bottles) were rinsed three times with sample water before filling.

Standard physical and chemical parameters were used as water quality indicators, including: temperature, pH, conductivity, clarity, turbidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), alkalinity, dissolved Oxygen, major nutrients, ions, and trace metals. These parameters are comparable to Aboriginal Affairs and Northern Development Canada (AANDC; now Indigenous and Northern Affairs Canada) Water Resources' datasets for the Frank Channel on Great Slave Lake, the closest water quality monitoring station. Water sampling was led by the TG Wildlife Coordinator and the WLWB Regulatory Technician; procedures were followed to minimize contamination, such as implementation of appropriate

Quality Assurance/ Quality Control (QA/QC) procedures, in accordance with instructions from the GNWT Taiga Environmental Laboratory (Taiga) located in Yellowknife. Unfortunately, challenges with the lab did not allow for replicate samples, field blanks or travel blanks.

Samples were placed in an electric cooler to preserve the integrity of the water samples. Microbiological analysis is particularly time-sensitive and samples for this analysis were delivered to the lab after supports staff returned to Yellowknife. Taiga performed all analyses, and Taiga is a member of the Canadian Association of Environmental Analytical Laboratories (CAEAL), a national organization established to ensure consistent laboratory quality assurance.

c. Sediment Quality

Sediment sampling used methods outlined in Metal Mining Technical Guidance for Environmental Effects Monitoring (Environment Canada, 2012), and samples were analysed for standard physical and chemical properties as well as trace metals. Lake sediments were sampled using an Ekman grab sampler (dredge) suitable for collecting soft, fine grained sediments typically observed in the area.

Sediment samples were collected using an Ekman, transferred to a stainless-steel tray, then placed into sterile glass jars/Ziploc bags. Sediment samples were stored in an electric cooler along with the water samples and provided to Taiga for analysis after support staff returned to Yellowknife. If two distinct layers of sediment were captured by the Ekman, they were sampled and submitted for analysis separately.

Appropriate QA/QC procedures were followed according to Taiga instructions. Field Staff used fresh disposable vinyl gloves at each sample site to minimize the potential for contamination from the sampler's hands. Different sample bottles were used for each laboratory analysis group including: physicals, nutrients, total metals, mercury, and microbiological analysis. All bottles (except sterile bottles) were rinsed three times with sample water before filling. Water sampling was led by the TG Wildlife Coordinator and the WLWB Regulatory Technician.

d. Fish Sampling

Fish were collected through gillnets set at locations as determined by community members given the knowledge of where fish species can be caught; nets provided fish for sample collection as well as for consumption at camp. Five gillnet sets were conducted over the course of the camp on Snare Lake (Figure 1, Table 1). The 3.0-inch nets were used to target larger fish such as łiwezǫ̀ǫ̀ (Lake Trout; LKTR) łih (Lake Whitefish; LKWH). The number and duration of gillnet sets were subject to safety considerations and occurred close to camp.

The fish caught were identified to species, were measured to total and fork length (TL and FL) to the nearest millimeter (mm) and weighed (g). Additional data collected included: gender, stage of maturity, and a general description of the contents of the stomach, any parasites and/or deformities. The sample size targets for tissue (for contaminants) and otoliths (for aging) were 20 łiwezǫ̀ǫ̀ (LKTR) and 20 łih (LKWH) to replicate samples sizes from 2012. The species sampled also represented those typically consumed by community members, and sampling of the three species also provided a way to account for differences between benthic (bottom feeding) and predatory (feeding on smaller fish) strategies.

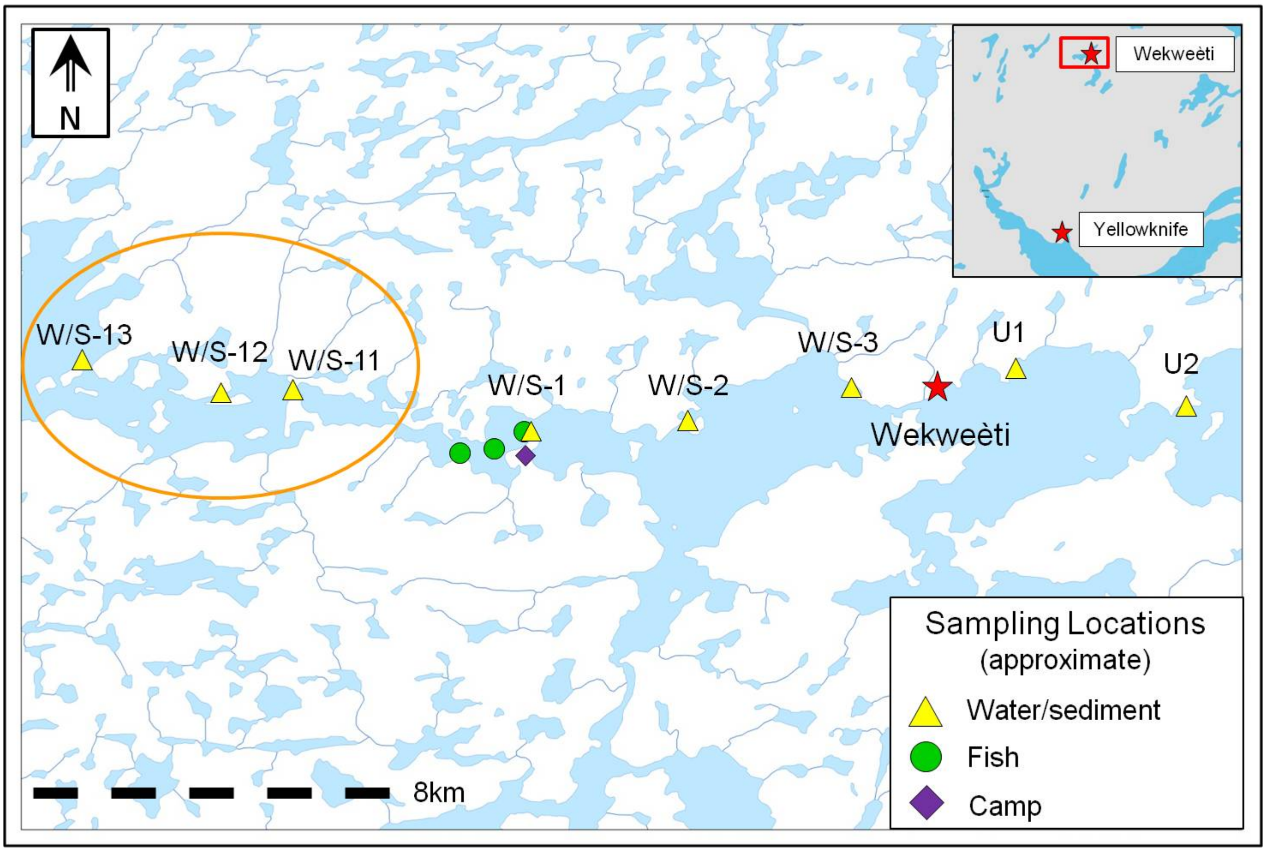


Figure 1 Location of the on-the-land camp, and locations where samples of fish, water, and sediment were collected on Snare Lake during the on-the-land component of the Tłįchǫ Aquatic Ecosystem Monitoring Program (TAEMP) near the community of Wekweètì, September 2016. Water/sediment locations circled furthest west were added in 2016, where others overlapped with locations sampled in 2012.

Table 1 Details for gillnet sets used to collect all fish samples at the TAEMP on Snare Lake near the community of Wekweètì, September 19-23, 2016

Net set / pull date	Set Length (hrs)	Location (Lat/Long; deg., min., sec.)	Net Length / Width (m)	Mesh size (cm)
Sept. 20 / Sept. 20	6.0	Locations not available given issues with transcription of GPS locations. Figure 1 provides approximate locations of all sets	100 /1.8	10
Sept. 20 / Sept. 21	14.0	See above	100 /1.8	10
Sept. 21 / Sept. 21	3.5	See above	100 /1.8	10
Sept. 22 / Sept. 22	2.5	See above	100 /1.8	18
Sept. 22 / Sept. 22	2.5	See above	100 /1.8	10

Fish age was estimated by taking otolith samples and having North/South Consultants Ltd. (Winnipeg) cut and mount them on slides, with the annual growth rings counted by experts. Figure 2 shows examples of sagittal cross-sections of otoliths and how the annual growth rings (annuli) may be counted to estimate age; a red dot is positioned between each individual growth ring. Examples in Figure 2 show a łiwezǫǫ̀ (LKTR) estimated at 10 years on the left and a łih (LKWH) estimated at 8 years shown on the right.

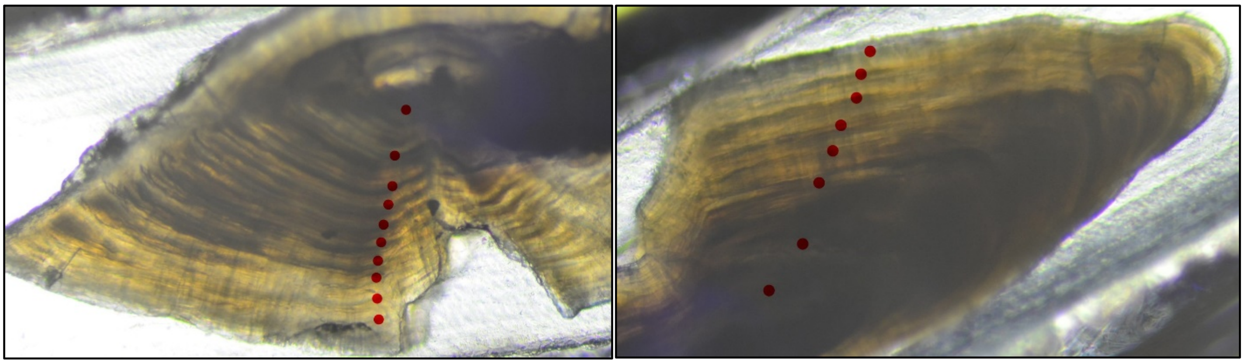


Figure 2 Two examples of otolith cross-sections, obtained from samples collected on Snare Lake, September 2016 (not to scale); a łiwezǫǫ̀ (LKTR) estimated at 10 years on the left and a łih (LKWH) estimated at 8 years shown on the right. Photos and interpretation provided by North/South Consultants Inc., and Golder Associated Ltd.

e. Fish Tissue Analysis

To determine current levels of contaminants in fishes consumed regularly by the community members in Wekweètì, fish tissue samples were collected from 20 łiwezǫǫ̀ (LKTR) and 20 łih (LKWH), the fish species regularly. Fish processing was led by Golder Associates Ltd. and ENR biologists, and samples were collected under the guidelines established by Environment Canada for sampling for metals (Environment Canada 2012) and the Golder Associates Ltd. technical protocol "Fish Health Assessment-Metals".

3. Results Workshop

After analyses of fish, water and sediment samples were completed and support staff had an opportunity to review the results, a public meeting was held in Wekweètì, to review the goals and objectives of the program, as well as present the results of the analyses, including a comparison to the 2012 results to see if any changes had occurred. Importantly, the results workshop provided an opportunity for community members to ask questions and gain clarification(s). An open format proved to be an effective and appropriate way to present results to participants and interested community members. Collaboration with GNWT HSS, along with other TAEMP partners, aided appropriate messaging and communication strategies regarding the presentation of results. This collaboration ensured community members are informed and educated on the status of contaminants, if any, in the fish they may be eating, and that nutritional guidance is provided to ensure these foods continue to remain healthy choices (AMAP 2011, GNWT HSS 2014, 2016,).

Results

1. Introductory / Planning Workshops

On August 5, 2016, a half-day workshop was held with community members from Wekweètì to introduce, revisit, and discuss the TAEMP. Community members expressed concerns over scheduling of introductory meeting, with a desire for more time to review and discuss information. Visiting staff clarified attempts were made to schedule earlier, but staff and community members had previous commitments (e.g. related to Tłı̨chǫ Day on August 4th). Participants expressed interest in fish camp and having the opportunity to build on the fish camp in 2012. Participants agreed that monitoring fish, water, and sediment quality continues to be important to monitor changes near Wekweètì and agreed that elders, youth and scientists can take the opportunity to work together again. Participants clarified that cultural activities need to occur (e.g. grave site visits, dry fish demonstrations) and that time will be allocated accordingly. There was agreement on safety as priority; however, community members expressed concerns about the restrictive nature of safety requirements (e.g. boat captain training, insurance, school requirements) with regards to youth participation. Discussion continued how best to coordinate with school, TSCA, community members and support staff, and to find options for ensuring safety and meeting safety requirements. It was clarified that camp participants from Wekweètì would consist of 6-8 elders (preferably couples), 6 students, as well as cook/cook's helper, foreman/foreman's helper, and likely a chaperone. It was thought that some community members should go out to the camp site a day early to prepare. Participants provided input on repeat sampling, as well as re-use of the 2012 location for the camp, with concerns being voiced about the low water levels and the need for capable boat captains. Visiting staff clarified that community members want water/sediment sampling sites added further to the east and to the west of camp in order to capture locations that are important, and which couldn't be sampled in 2012 due to weather. It was understood that September was the available window for the camp, though community members voiced concerns about the weather in September and desired an earlier start date. Support staff clarified there were various commitments in September and difficulties coordinating schedules led to the last two weeks in September being proposed. There was agreement that camp should occur September 19-23 (Monday- Friday). It was agreed that the next planning meeting should occur during the first week in September.

On September 2, 2016, a second workshop was held in Wekweètì, to finalize planning for the fish camp and to deal with logistical issues. Concepts related to monitoring were re-visited, as well as the primary tasks which needed to be achieved at camp. Some community members initially considered as participants were not available, alternatives were discussed, and a list was developed. The camp location selected was further west of the 2012, as it offered better options for camp set up and boat landing/launch given the possibility of inclement weather in the fall. It was agreed that community members would examine and prepare the camp location on Sunday, September 18 (e.g. general inspection of site, set up of cook / meeting tents/ outhouses, gather firewood).

Participants at workshops also clarified the need for elders without health concerns that may cause challenges while out-on-the land. It was also agreed that TG staff in Wekweètì, in conjunction with community members would discuss selection of youth with staff at Alexis Arrowmaker School in Wekweètì, with the hope that 3 young men and 3 young women with an interest in the environment would be selected to participate. Given that Alexis Arrowmaker goes up to grade 10, it was understood that youth participants in Wekweètì would likely be younger than youth participants at other Tłı̨chǫ fish camps. The possibility of finding recent graduates to participate was also discussed. It was clarified that youth who would benefit most also include youth who need the opportunity to learn on-the-land skills, with the community to decide on who should participate; a chaperone for the youth would be present at camp.

2. On-the-land Monitoring Camp – Snare Lake

a. Overall

The on-the-land phase of the TAEMP occurred from September 19 to 23, 2016. Travel to the camp occurred on September 19, sampling and other activities occurred September 20-22, and participants returned to Wekweètì on September 23rd. The camp foreman and assistants visited the camp on Sunday September 18th to prepare the camp for participants. However, due to assorted complications, outhouses were not completed, and were constructed on the 19th. Community members also returned to the camp location on September 24th to complete tear-down of the camp. As decided at the second planning meeting, the 2016 camp was further west of the location used in 2012 as it was close to a number of sampling locations and culturally important sites, and provided better options for boat landing/launch and ample space for tents.

At camp, there were regular morning and evening meetings, i.e. briefing/debriefing. These meetings provided an effective means to discuss activities and voice concerns. For example, during morning meetings, roles and responsibilities for the day were clarified, safety concerns discussed, and the best approaches to the day's activities selected based on local expertise and sampling requirements. In the evening meetings, the day's activities were discussed, possibilities for improvement(s) voiced, and plans for the following day suggested.

Water and sediment sampling locations were located as close as possible to 2012 sampling locations, with 3 new locations added further west of the camp at the request of community members (Figure 1). Though concerns about weather were voiced during planning, overall the fall weather was spectacular and did not impact travel. It was only on the last day of camp that weather (and safety) considerations affected water/sediment sampling nearest Wekweètì. Through cooperation among participants, fish were caught in nets to provide food for the traditional camp, and to provide samples for analyses. Tissue samples were successfully collected from 20 łiwezǫ̀ǫ̀ (LKTR) and 20 łih (LKWH) (see Results section e. Fish Tissue Analysis, p 15).

The 5-day camp provided educational opportunities focused on ways of understanding aquatic ecosystems and assessing the health of the ecosystems (see also Results section g. Cultural / Educational Activities, p. 23). Participants worked collaboratively, and Tłı̨chǫ knowledge and science-based monitoring approaches were shared. For example, visiting support staff demonstrated how fish are processed in order to collect information. For example, tissue samples are used to determine concentrations of mercury and other contaminants in the fish; otoliths, or "ear bones", are used to determine the age of each fish; and body measurements including weight and length help to better understand fish health and growth rates. Youth from Alexis Arrowmaker School also collected water and sediment samples using scientific equipment and techniques. Prior to getting into the boats, on-shore demonstrations were given on how to properly take water and sediment samples using standard procedures, including how to lower the Ekman dredge into the water to pull up mud and sediment from the bottom of the lake.

Elders from Wekweètì led visits to grave sites in the area, sharing their Tłı̨chǫ knowledge and cultural practices with the youth and other participants. Elders also demonstrated how to repair nets and process fish, with youth assisting with cleaning and preparation of fish. An unfortunate challenge arose when students participating at the camp left a day earlier than expected in order to attend a regional hand games tournament. The loss of the students prevented youth from participating in a day of planned cultural activities, such as additional gravesite visits and stories provided by the elders, much to the disappointment of community members and support staff. The challenge was addressed, in part, by support staff and two elders visiting Alexis Arrowmaker School to present on fish and water-related subjects, both from Tłı̨chǫ knowledge and science perspectives. Though unfortunately youth were not available to visit cultural sites, support staff took the opportunity on the last full day to accompany community members in their gravesite visits. This provided considerable benefit to support staff who previously were unable to participate in cultural activities as a result of focusing on sampling and camp-related duties.

b. Water Quality

Final locations for all water and sediment samples collected in 2016 are provided in Table 2 (see also Figure 1). Locations from 2012 are not provided as they were not available; locations for 2016 were selected based on maps from 2012 and community members' knowledge of where sampling occurred. Nutrient and physical parameters were measured at all sample sites in 2012 and 2016 sampling programs and no noticeable difference was noted between the two sampling years. All nutrients and physical parameters were found to be similar at all sites.

Analysis of water samples indicated no noticeable difference between 2016 and 2012 with regards to nutrient and physical parameters measured at all sample sites; all nutrients and physical parameters were found to be similar at all sites. For example, water samples in 2016 indicated pH ranged from 7.12 to 7.17, and results showed very little difference between sampling sites (n=8); results fell within Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Freshwater Aquatic Life (FAL) guidelines (6.5-9.0) (CCME 2014). By comparison pH ranged from 7.04 to 7.17 in 2012 (n=5).

The pH results showed very little difference between sampling sites. The pH in 2016 was similar to the pH in 2012; pH in 2016 ranged from 7.12 to 7.17 and the pH in 2012 ranged from 7.04 to 7.18. Results fell within Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Freshwater Aquatic Life (FAL) guidelines (6.5-9.0) (CCME 2014).

Conductivity of the water ranged from 22.8 to 25.5 microsiemens per centimetre (µsie/cm) in 2016, and in 2012 the conductivity was similar with a range of 21.1 to 23.8µsie/cm.

Total Dissolved Solids (TDS) at each 2016 site had low measurable amounts ranging from 10 mg/L to 27mg/L, with 2011 results also being low ranging from 12 mg/L to 18 mg/L.

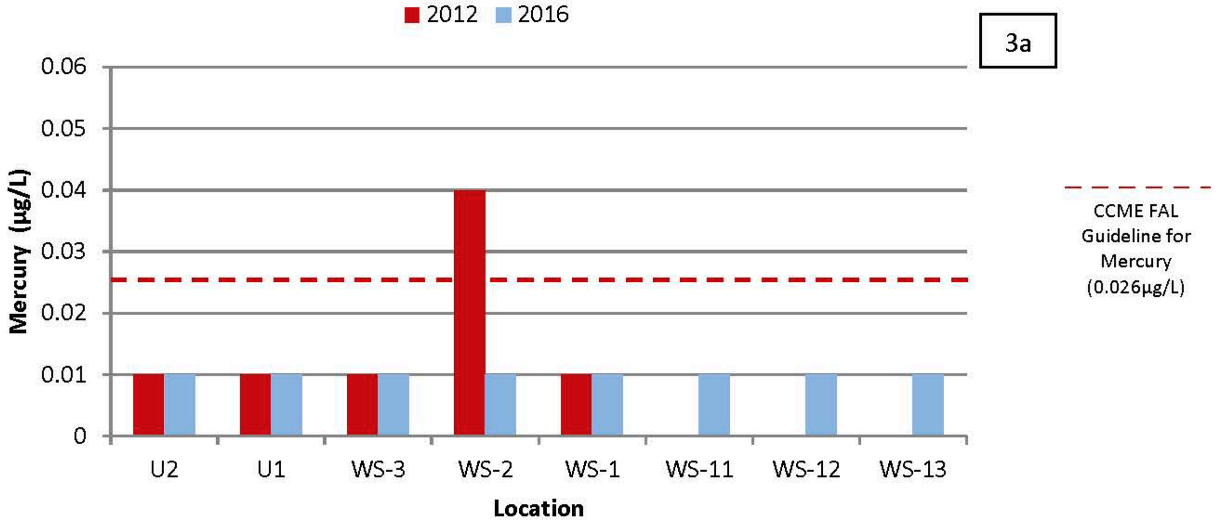
Total Suspended Solids (TSS) in 2016 for the majority of locations was 3 mg/L with only one location (U1) at 8mg/L. Similarly, in 2012 TSS for the majority of locations was 3 mg/L, with only one location (U2) at 8mg/L; MDL = 3 mg/L.

Most metal concentrations in Snare Lake were very low with many measuring below method detection limits (MDL). The 2016 water samples were all better than FAL guidelines, while 2012 water samples had a few metal concentrations greater than FAL guidelines (e.g. Mercury; Figure 3a). Overall, there was minimal difference between 2012 and 2016 (e.g. Arsenic; Figure 3b)

Table 2 Details for water and sediment sampling locations at the TAEMP on Snare Lake near the community of Wekweètì, September 2016.

ID	Description	2016 Location (Lat/Long; deg. min. sec.)
U2	Beach east/upstream of airport	N64^{0} 11’ 13.30” W114^{0} 03’ 58.5”
U1	Community water intake	N64^{0} 11’ 37.8” W114^{0} 08’ 49.2”
WS-3	Near sewage lagoon	N64^{0} 11’ 15.8” W114^{0} 13’ 10.5”
W/S-2	Camp location 2012 /gravesite	N64^{0} 10’ 53.3” W114^{0} 17’ 46.6”
W/S-1	Camp location 2016	N64^{0} 10’ 39.8” W114^{0} 22’ 16.0”
W/S-11	West of camp / traditional fishing area where net is set (narrows)	N64^{0} 11’ 01.4” W114^{0} 28’ 42.4”
W/S-12	West of camp / gravesite of elder where offerings are made when traveling to the barrenlands	N64^{0} 10’ 57.9” W114^{0} 30’ 56.6”
W/S-13	West of camp / near community cabin sites	N64^{0} 11’ 20.4” W114^{0} 34’ 38.2”

Note: Lat/Long are NAD 83



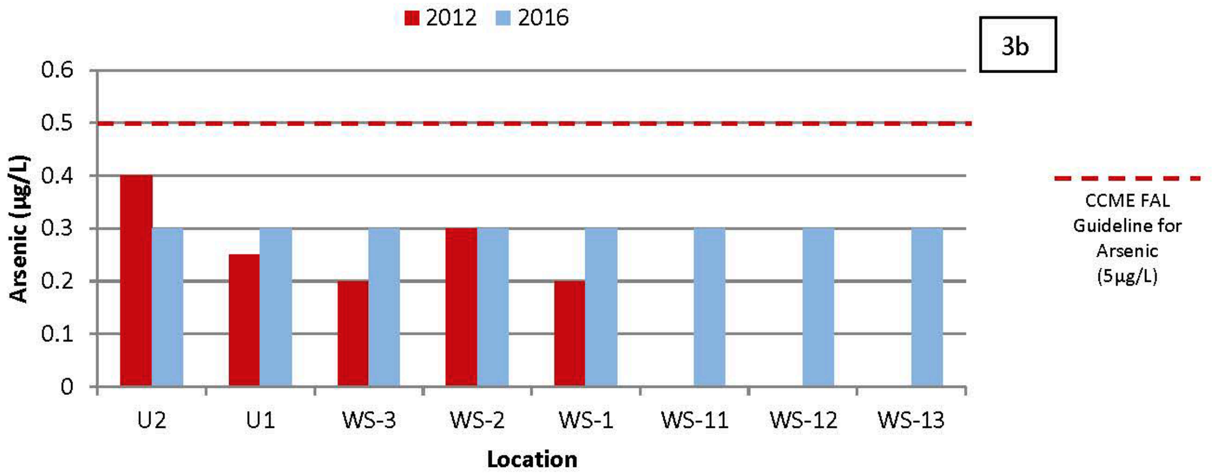


Figure 3 Comparison of the total concentrations of Mercury (3a) and Arsenic (3b) in surface water samples collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Wekweètì, September 2016 and September 2012. Sample locations are arranged from those more upstream located east of Wekweètì (U2), to downstream west of Wekweètì (W/S-13); refer to Figure 1. Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Freshwater Aquatic Life (FAL) provided for Mercury (0.026µg/L) and Arsenic (5µg/L).

c. Sediment Quality

The 2012 and 2016 sediment sample sites can be broken down into four different types: sand, silt, silt loam and sandy loam. The two sites upstream of Wekweètì are sandy (U1 and U2), the two sites downstream closest to the community are silty (W/S-3 and W/S-2), while (W/S-1), (W/S-12) and (W/S-13) are silty loam, and (W/S-11) is sandy loam (refer to Figure 1)

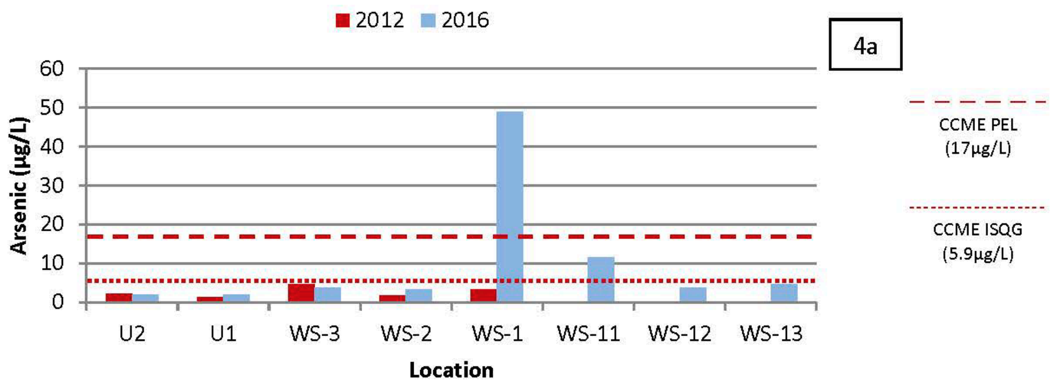
Sediment samples collected in 2016 from W/S-11 had an arsenic concentration of 11.58µg/L, which is above the CCME Sediment Quality Guidelines for the Protection of Aquatic Life interim Sediment quality guidelines (ISQG) of 5.9µg/L (CCME 2014); W/S-11 was not sampled in 2012. Location W/S-1 exceeded both ISQG and CCME probable effects levels (PEL; 17µg/L; CCME 2014) guidelines with a result of 48.87µg/L (Figure 4a).

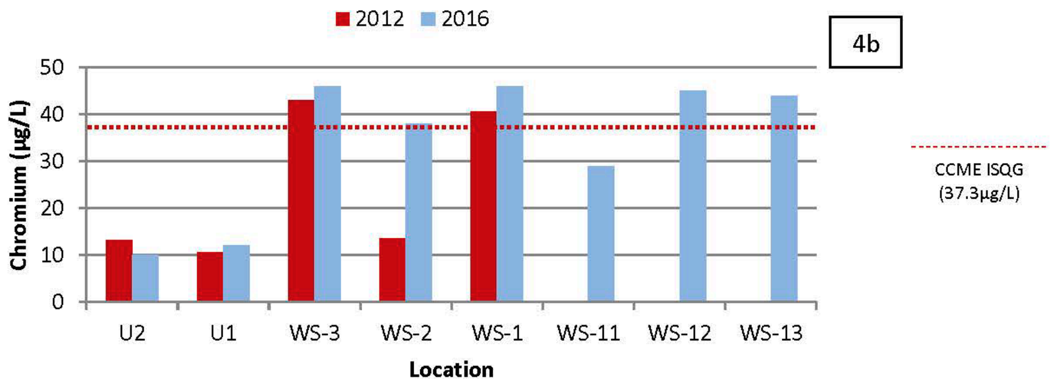
The 2016 cadmium method detection limit was 1µg/g which is higher than the ISQG for cadmium of 0.6µg/L. All of the 2016 sediment sample results for cadmium showed a "less than" detection result, but because "less than" values were treated as results equal to the detection limit, the results may represent a false exceedance. The 2012 sediment analysis method detection limit was 0.4µg/L, and none of the sediment samples collected in 2012 were above guidelines.

Chromium concentrations slightly exceed the ISQG of 37.3µg/L at all sites downstream of Wekweètì in 2012 and 2016 (refer to Figure 1), with the exception of W/S-2 in 2012 and W/S-11 in 2016 (Figure 4b); concentrations ranged from 37.3 to 46µg/L.

Copper concentrations exceeded ISQG of 35.7 µg/g in 2012 at all sampling locations with results ranging from 37.5µg/L to 81.65µg/L, and in 2016 all sediment samples were within guidelines ranging from 7µg/L to 23µg/L (Figure 4c). This could be indicative of contamination occurring during sample preparation in the field such as the equipment that was being used for sampling, or of contamination occurring during sample preparation in the lab.

In 2012, the concentration of lead in sediment near the sewage lagoon exceeded the ISQG (35µg/L) and PEL guideline (91.3µg/L) with a concentration of 103.7µg/L (Figure 5a). This was not seen in 2016 where all lead concentrations from all sites ranged from 4µg/L to 6µg/L. Mercury concentrations exceeded both ISQG and PEL guidelines at W/S-1, and exceeded the ISQG at WS-2 in 2016; all other 2016 locations were below guidelines (5b). By comparison, all locations sampled in 2012 were below both ISQG and PEL guidelines. However, it should be noted that minimum detection limits changed between 2012 (0.04µg/L) and 2016 (0.1µg/L), making direct comparison difficult.





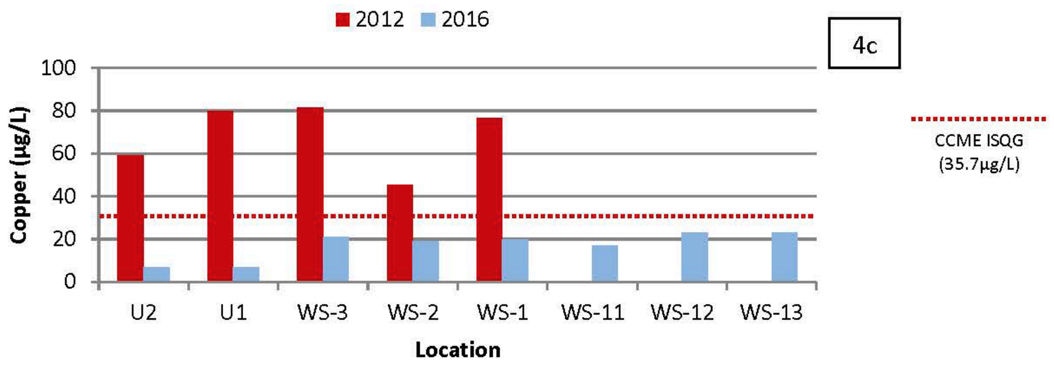
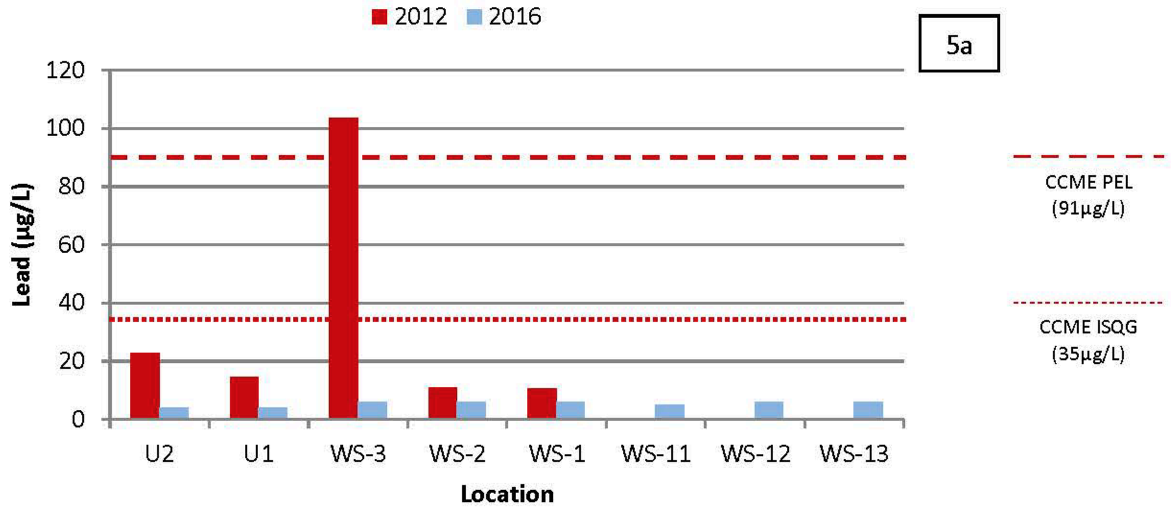


Figure 4 Comparison of the total concentrations of Arsenic (4a), Chromium (4b) and Copper (4c) for sediment samples collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Wekweètì, September 2016 and September 2012. Canadian Council of Ministers of the Environment (CCME) Sediment Quality Guidelines for the Protection of Aquatic Life interim sediment quality guidelines (ISQG) provided for Arsenic (5.9 µg/L), Chromium (37.3µg/L) and Copper (35.7 µg/L), and probable effects Levels (PEL) provided for Arsenic (17 µg/L), but not for Chromium (90µg/L) or Copper (197µg/L). Sample locations are arranged from those more upstream located east of Wekweètì (U2), to downstream west of Wekweètì (W/S-13); refer to Figure 1



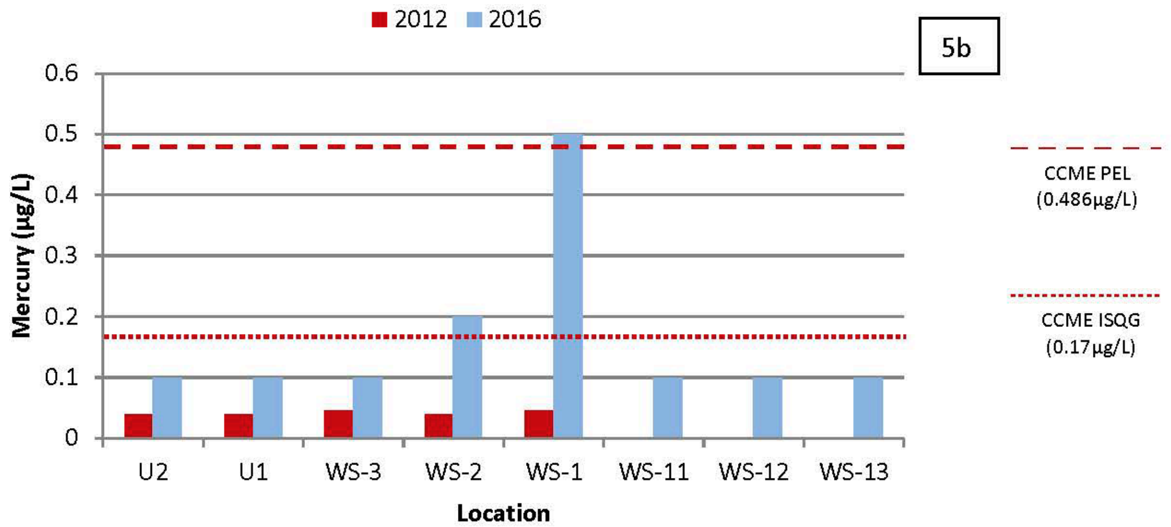


Figure 5 Comparison of the total concentrations of Lead (5a), and Mercury (5b) for sediment samples collected during the on-the-land component of the Tłįchǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Wekweètì, September 2016 and September 2012. Canadian Council of Ministers of the Environment (CCME) Sediment Quality Guidelines for the Protection of Aquatic Life interim Sediment quality guidelines (ISQG) for Lead (35µg/L), and Mercury (0.17µg/L), and probable effects Levels (PEL) for Lead (91µg/L), and Mercury (0.486µg/L) provided. Sample locations are arranged from those more upstream located east of Wekweètì (U2), to downstream west of Wekweètì (W/S-13); refer to Figure 1.

d. Fish Species Diversity

Three species of fish were caught on Snare Lake (Table 3); 22 łih (Lake Whitefish; LKWH), 24 łiwezǫ̀ǫ̀ (Lake Trout; LKTR), and 11 *įhdaa* (Northern Pike; NRPK), for an overall total of 57 fish caught over a combined total of 28.5 hours of net sets. The łiwezǫ̀ǫ̀ (LKTR) and įhdaa (NRPK) represented the common top predators, and łih (LKWH) represented benthic invertebrate feeders. Smaller fish fauna could not be effectively sampled with the mesh size in the gillnets used.

e. Fish Tissue Analysis

The two fish species which had tissues collected for contaminant analyses were łiwezǫ̀ǫ̀ and łih. These two species are regularly used for consumption in Wekweètì and were the same species for which analyses occurred in 2012.

<u>2016 łiwezǫ̀ǫ̀ results</u>

In 2016 Mercury concentrations in tissues were on average 0.399mg/kg wwt (wet weight; 95% CI+/-0.045, α=0.05) ranging from 0.18 to 0.56mg/kg wwt, with three of the twenty fish sampled over the guideline for mercury of 0.5 mg/kg, (wet weight, wwt; Health Canada, 2016). Review of mercury concentrations in muscle tissue in relation to fork length and weight suggest positive relationships (Figures 6a, 6b), with the strongest positive relationship suggested with regards to age (Figure 6c).

<u>Łiwezǫ̀ǫ̀ comparison between 2016 and 2012</u>

In 2016 Mercury concentrations in tissues were on average 0.566mg/kg wwt (wet weight; 95% CI+/-0.313) ranging from 0.001 to 3.39mg/kg wwt. However, the result of 3.39mg/kg was from the longest (FL=718mm) and heaviest fish (7500g) sampled in 2012, and this individual is not included in the figures as it is approximately 7x the guideline. By removing this individual (n=18), the average length becomes 568mm (95% CI+/-19.04.96) ranging from 497 to 649mm, the average weight becomes 2161g (95% CI+/-240.25,), and the average mercury concentration becomes 0.41mg/kg (95% CI+/-0.06) ranging from 0.001 to 0.640. Comparison of 2012 results to 2016 results suggests no appreciable change in mercury concentration in tissue, as scatterplots and confidence intervals show a high degree of overlap between sampling years (Figures 6a, 6b and 6c). Of note, with the removal of the individual with the concentration of mercury at 3.39mg/kg wwt, only 7 of the 38 Lake Trout sampled in 2016 and 2012 were above the guideline for mercury.

<u>2016 łih results</u>

In 2016 mercury concentrations in tissues were on average 0.163mg/kg wwt (wet weight; 95% CI+/-0.049) ranging from 0.037 to 0.453mg/kg wwt, and none of the fish sampled were over the guideline for mercury of 0.5 mg/kg, (wet weight, wwt; Health Canada, 2016). Review of mercury concentrations in muscle tissue in relation to fork length, weight and age suggest positive relationships (Figures 7a, 7b and 7c).

<u>Łih comparison between 2016 and 2012</u>

In 2012 mercury concentrations in tissues were on average 0.134mg/kg wwt (wet weight; 95% CI+/-0.036) ranging from 0.004 to 0.341mg/g wwt. All of the łih sampled fell below the guideline for mercury. Comparison of 2012 results to 2016 results suggests no appreciable change in mercury concentration in tissue, as scatterplots and confidence intervals show a high degree of overlap between years (Figures 7a, 7b and 7c).

Comparison of the cumulative data sets (2016 and 2012) for Lake Trout and Lake Whitefish show positive relationships between mercury concentration in tissue and weight, length, and age (Figures 8a, 8b and 8c). Lake Whitefish consistently show lower concentration in their tissues than Lake Trout, with the clearest differentiation visible with regards to age (4c).

No deformities/abnormalities were noted in any of the fish sampled; parasites (e.g. worms and cysts) were found in majority of individuals, though not at levels considered to be abnormal. Łiwezǫ̀ǫ̀ stomach contents included *Dahts'a* (Ninespine Stickleback), *Łìhtsoa* (cisco), and łih. Łih stomach contents included invertebrates and dahts'a.

It should also be noted that the Health Canada Guidelines provided are for retail fish (Health Canada 2016). There are no Health Canada Guidelines for fish caught for recreational or subsistence purposes.

Other fish species

There were 11 ı̨hdaa (NRPK) caught in 2016; tissue samples were not collected for analyses. No other species were caught. By comparison, in 2012, 3 ı̨hdaa (NRPK) were caught along with one round whitefish (note: both Lake Whitefish and Round Whitefish are known as łih; please also refer to the field guide: *Common Fish in the Tlicho Region*, available via the WRRB website: https://wrrb.ca/sites/default/files/Tlicho%20Fish%20Guide%202016_final_for%20posting_1.pdf).

Table 3 Date and duration of net sets, and number of, łih (LKWH), łiwezǫ̀ǫ̀ (LKTR), and įhdaa (NRPK) caught on Snare Lake near the community of Wekweètì during the TAEMP, September 19-23, 2016.

Net set / pull date	Location (Lat/long)	LKWF	LKTR	NRPK
Sept 20/ Sept 20	Locations not available given issues with transcription of GPS locations. Figure 1 provides approximate locations of all sets	6	8	2
Sept 20 / Sept 21	See above	3	8	9
Sept 21 / Sept 21	See above	6	4	0
Sept 22 / Sept 22	See above	0	0	0
Sept 22 / Sept 22	See above	7	4	0
	Totals	22	24	11

Note: Lat/Long are NAD 83

Table 4 Comparison of 2012 and 2016 average mercury concentrations in tissue samples (mg/kg +/- 95% CI, -α=0.05) collected from łih (LKWH), łiwezǫ̀ǫ̀ (LKTR caught on Snare Lake near the community of Wekweètì during the TAEMP, September 19-23, 2016. Note: two sets of values are provided for LKTR in 2012 to indicate influence of a single trout with very high concentration (3.39mg/kg).

Fish species	2012 Average Mercury concentration (+/- 95% CI)	2016 Average Mercury concentration (+/- 95% CI)
łih (Lake Whitefish)	0.1340mg/kg (+/-0.0362); n=20	0.1634mg/kg (+/-0.0486); n=20
łiwezǫ̀ǫ̀ (Lake Trout); with outlier	0.5655mg/kg (+/-0.3130); n=19	0.3991mg/kg (+/-0.0450); n=20
łiwezǫ̀ǫ̀ (LKTR); no outlier	0.4086mg/kg (+/-0.0616); n=18	n/a

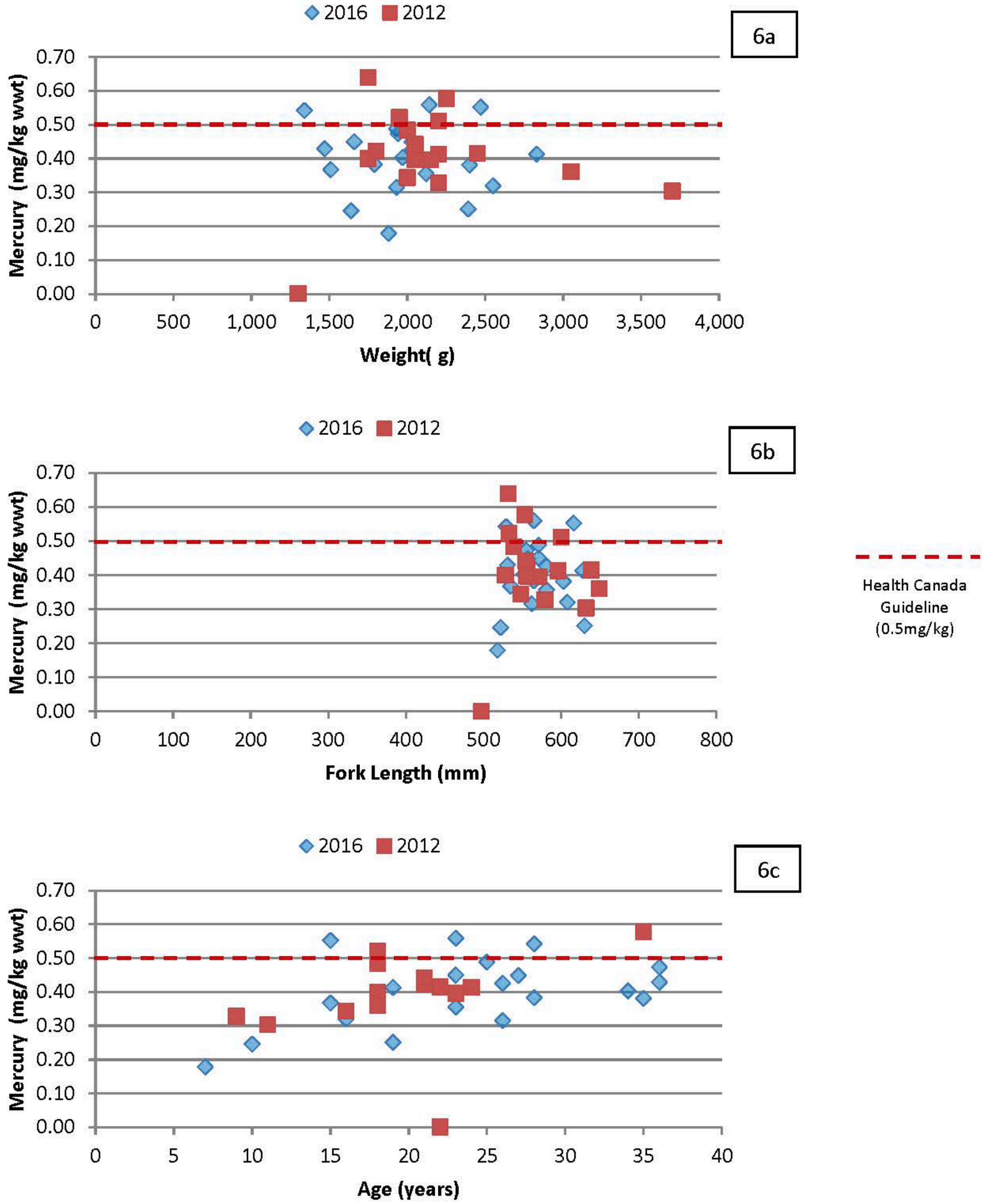


Figure 6 Comparison of the relationships between mercury concentration in tissues (mg/kg; wet weight) and body weight (g) (6a), fork length (mm) (6b), and age (years; estimated via otolith aging) (6c) of łiwezǫ̀ǫ̀ (Lake Trout; LKTR) collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Wekweètì, September 2016 and September 2012. Note: a łiwezǫ̀ǫ̀ collected in 2012 (718mm 7,500g, and 27 years of age) with a mercury concentration of 3.39 mg/kg not shown (see text in report for details). Health Canada Maximum Level for mercury concentration in commercial fish (0.5mg/kg) provided.

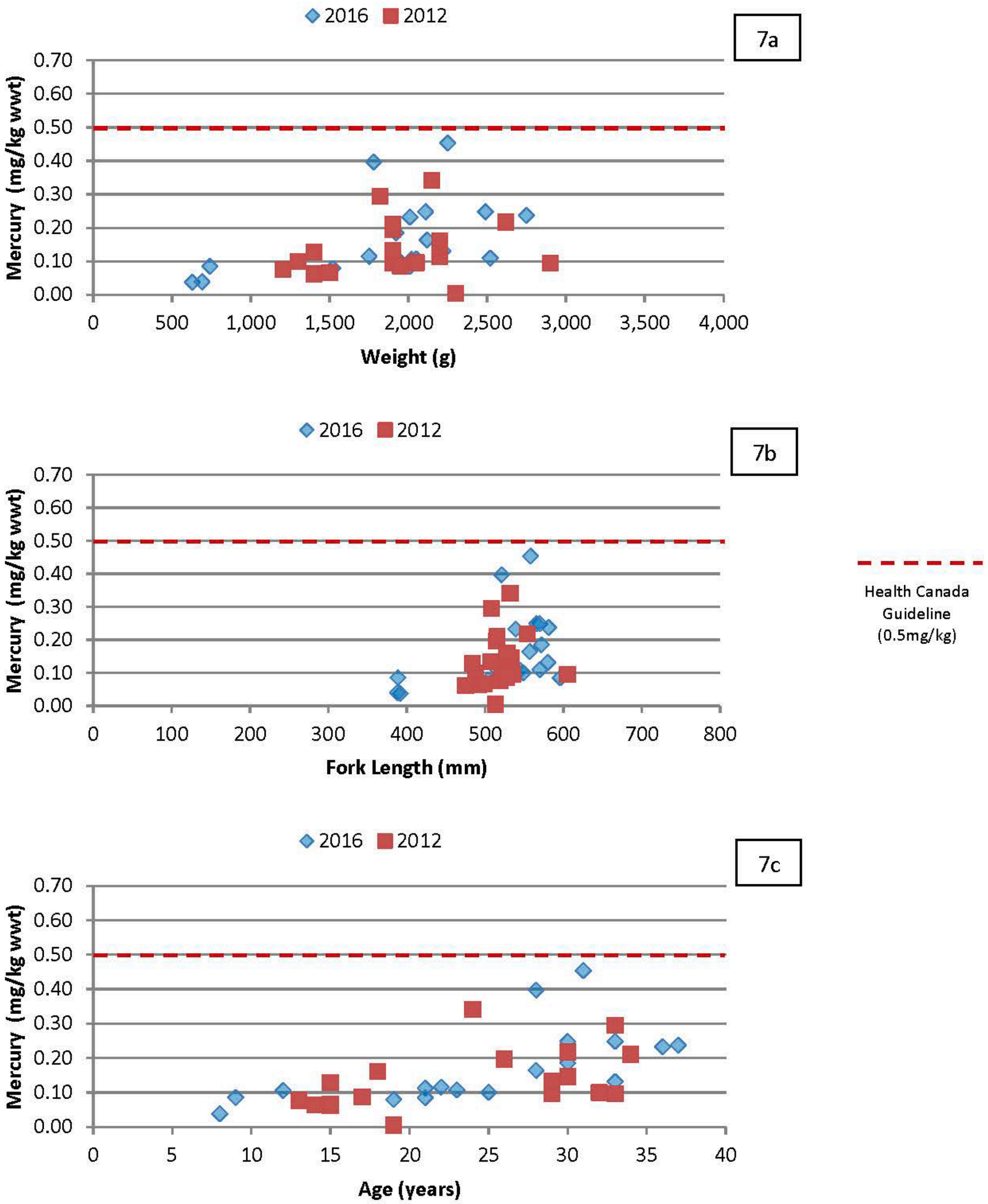


Figure 7 Comparison of the relationships between mercury concentration in tissues (mg/kg; weight) and body weight (g) (7a), fork length (mm) (7b), and age (years; estimated via otolith aging) (7c) of łih (Lake Whitefish; LKWF) collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Wekweètì, September 2016 and September 2012. Health Canada Maximum Level for mercury concentration in commercial fish (0.5mg/kg) provided.

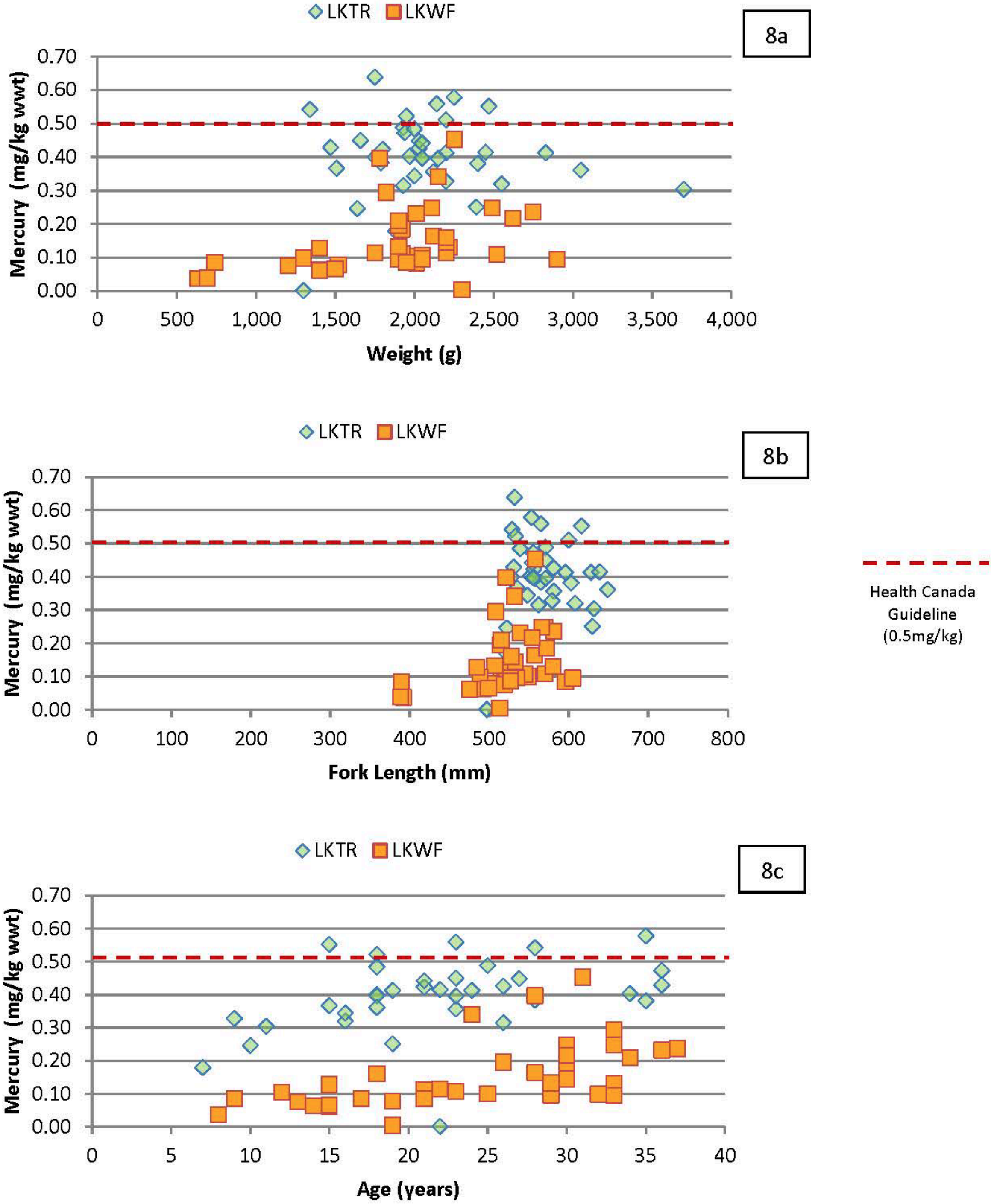


Figure 8 Comparison of the relationships between mercury concentration in tissues (mg/kg; wet weight) and body weight (g) (8a), fork length (mm) (8b), and age (years; estimated via otolith aging) (8c) for łiwezǫ̀ǫ̀ (LKTR) and łih; (LKWH) using cumulative data for each species collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Wekweètì, September 2016 and September 2012. Note: a łiwezǫ̀ǫ̀ collected in 2012 (718mm 7,500g and 27 years of age) with a mercury concentration of 3.39 mg/kg not shown. Health Canada Maximum Level for mercury concentration in commercial fish 0.5mg/kg) provided.

f. Fish Growth

Overall, review of age in relation to length for the łıwezǫ̀ǫ̀ and łih caught in Snare Lake suggest rapid growth in approximately the first 5 years, followed by no appreciable increase in size from 10 years to maximum age (Figure 9); no regression analyses were performed.

<u>Łiwezǫ̀ǫ̀</u>

Łiwezǫ̀ǫ̀ (LKTR)from which tissues were sampled for analyses in 2016 (n=20) were on average 569mm in length (fork length; 95% CI+/-14.95) ranging from 518 to 630mm. They weighed on average 2001g (total weight; 95% CI+/-169.28) ranging from 1340 to 2830g, and were on average 24 years old (via otolith aging; 95% CI+/-3.65) ranging from 7 to 36 years

By comparison, łıwezǫ̀ǫ̀ sampled in 2012 (n=19) were on average 576mm in length (fork length; 95% CI+/-14.95) ranging from 497 to 718mm. They weighed on average 2422g (total weight; 95% CI+/-595.78) ranging from 1300 to 7500g, and were on average 20 years old (via otolith aging; 95% CI+/-2.96) ranging from 9 to 35 years (n=16; 3 of the 19 fish could not be aged due to damaged otoliths).

<u>Łih</u>

Łih (LKWF) sampled in 2016 (n=20) were on average 527mm in length (fork length; 95% CI+/-28.06) ranging from 388 to 596mm. They weighed on average 1870g (total weight; 95% CI+/-254.72) ranging from 630 to 2749g, and were on average 25 years old (via otolith aging; 95% CI+/-4.03) ranging from 8 to 37 years (n=18; 2 of the 20 fish could not be aged due to damaged otoliths).

By comparison, łih sampled in 2012 (n=20) were on average 519mm in length (fork length; 95% CI+/-12.34, α=0.05) ranging from 475 to 605mm. They weighed on average 1910g (total weight; 95% CI+/-195.90) ranging from 1203 to 2900g, and were on average 24 years old (via otolith aging; 95% CI+/-3.38) ranging from 13 to 34 years.

<u>Other fish species</u>

Įhdaa (NRPK) caught (n=11) were on average 668mm in length (95% CI+/-22.39) ranging from 611 to 741mm. They weighed on average 1924g (total weight; 95% CI+/-204.92,) ranging from 1550 to 2570g. Neither clethria for aging or tissue samples for contaminant analyses were collected (no tissue analyses were conducted on įhdaa in 2012).

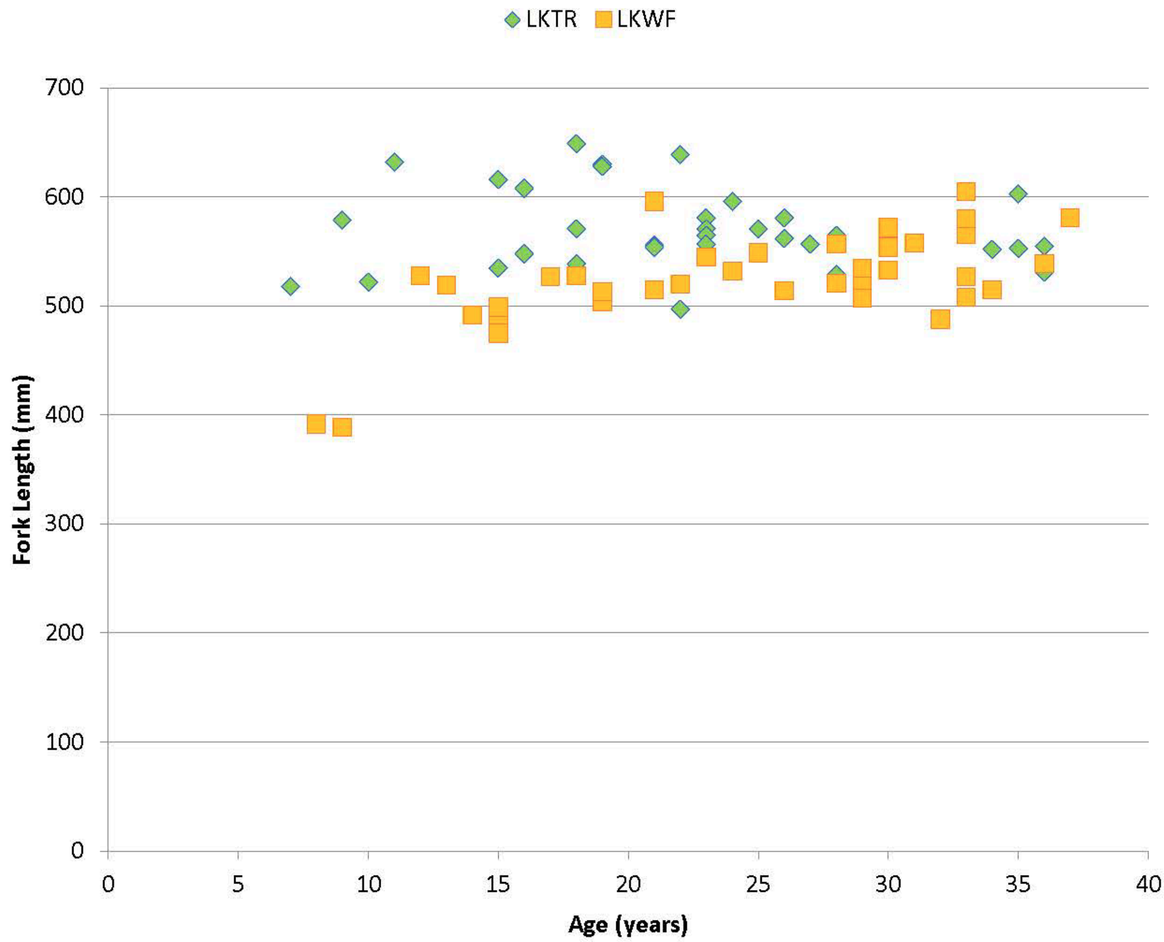


Figure 9 Relationships between fork length (mm) and age (years; estimated via otolith aging) in łiwezǫ̀ǫ̀ (LKTR) and łih (LKWH) that were collected on Snare Lake during the TAEMP near Wekweètì, September 2016 and September 2012 (cumulative data).

g. Cultural / Educational Activities

Elders and youth were exposed to, and participated in, scientific sampling methods typically used to monitor aquatic ecosystems, including the following: sediment and water quality sampling as well as fish tissue sampling for contaminant analysis. On shore demonstrations and field-based activities built on knowledge transferred to community members in 2012, increased understanding of standard methods used to assess contaminants in aquatic environments, and allowed community members to have increased knowledge with regards to monitoring and research activities near Tłįchǫ communities.

Elders and other community members guided all aspects of the project, with Tłįchǫ knowledge (i.e. Traditional knowledge, or TK) incorporated throughout by design. The on-the-land component of the TAEMP provided an opportunity for youth to engage with their community elders, assisting in the youth's education in observing, monitoring and understanding the aquatic ecosystem from a Tłįchǫ perspective. The TAEMP also offered an opportunity for visiting researchers to learn from traditional knowledge holders in a culturally appropriate on-the-land context. This form of engagement allows for building of mutual respect and trust through exchange of TK and science-based information while completing the required sampling and the various tasks needed for the operation of a traditional camp.

TAEMP staff asked community members about their perspectives regarding how to properly utilize TK within the project. Perspectives were shared at meetings, camp, and via answers to a series of interview questions. In general, elders were pleased with their involvement at camp and with the opportunities provided to pass on TK, for example through a gravesite visit, dryfish preparation, net repair, and teachings related to proper behaviours while at camp and on-the-land, and the history of the struggles people underwent to survive. However, elders were disappointed with youth leaving a day early (as mentioned, the youth left for a handgames tournament, and camp participants were not informed of the departure until the day before), which had a noticeable impact on the transfer and integration of TK at the 2016 camp. Camp participants had agreed to concentrate on TK-related activities on the last day (additional gravesite visits, time for storytelling, further demonstrations and additional teaching on how to survive and show proper forms of respect) and all camp participants recognized the lost opportunity. Youth who responded to interview questions, indicated that they had fun learning at fish camp, though they also understood that the loss of a day of activities prevented them from gaining additional knowledge from their elders. As a direct result of the lost opportunity, Alexis Arrowmaker School was visited the day after the results meeting (for more details: refer to 3. Results Workshop p. 24).

The *Common Fish of the Tłįchǫ Region*, a basic field guide to fish found in Wek'èezhìı, was provided to participants at camp; it is available through the WRRB website (https://wrrb.ca/sites/default/files/Tlicho%20Fish%20Guide%202016_final_for%20posting_1.pdf) In addition to providing the updated fish guide, educational videos highlighting activities at the on-the-land camps specific to each Tłįchǫ community have been developed by NWT-based filmmakers with assistance from WRRB staff. All have been shown and are currently available on the WRRB website (https://www.wrrb.ca/news/taemp-fish-camp-videos). In addition, two educational videos have been developed that provide demonstrations of fish, water and sediment sampling. All the videos have been printed on DVD and have been provided to all four the Tłįchǫ schools along with the updated fish guides. The sampling videos are also be available on the WRRB website (https://wrrb.ca/news/new-educational-videos-fish-water-and-sediment-sampling-taemp-fish-camps).

3. Results Workshop

A results meeting open to the public was held in Wekweètì in March 2017, and a presentation providing a comparison of the 2012 to 2016 results for fish, water and sediment was given. The results meeting was attended by a few elders who participated in the 2016 camp, as well as a few number of interested community members. Unfortunately, community members were not available overall given travel commitments, and winter road availability.

Paul Vecsei (Golder Associates Ltd.) presented the results related to fish, and Sean Richardson (TG) and Ryan Gregory (GNWT ENR) presented the water and sediment results. Participants were interested in the results and asked questions of clarification. The issue of mercury contamination was discussed, and community members were relieved to hear fish from Snare Lake continue to be healthy food choices. Part of the presentation also provided information on parasites commonly found in fish, their life cycles and their potential impacts to human health. Additional information on healthy traditional food choices was provided via GNWT HSS Traditional Food Fact sheets (GNWT HSS 2014), and clarification was provided on the potential differences between consumption of the predatory fish (łıwezǫ̀ǫ̀; LKTR) and the benthic strategist (łih; LKWF). Importantly, community members were also pleased to hear that there were no appreciable differences between the 2012 and 2012 results for mercury concentrations in fish tissues, and that sediment and water analyses also indicated no appreciable differences between 2012 and 2016.

With the support of school staff, elders Jimmy and Noella Kodzin, two elders present at camp, shared their perspectives with the kindergarten to grade 10 students at Alexis Arrowmaker School. Speaking in Tłįchǫ (with translation) they shared their experiences and knowledge with the students. They spoke about the health of the water and fish in Wekweètì, traditional practices (e.g. preparing dry fish), and the importance of safety. The elders were thankful for the good weather and for how the camp allowed people to work together and understand each other, and of their enjoyment of being on the land with the students and being able to teach the youth their traditional way of life. Noella mentioned how it would have been good to have the students participate more fully in drying the fish (i.e. it takes a long time and the group didn't have that much time out at the camp). Jimmy closed his talk by saying how important school is, so a person could be “strong like two people” (a Tłįchǫ philosophy), and if you have a good education you will succeed and have a successful life. Paul Vecsei also gave an engaging presentation to the students which included a slideshow with some of his photos of fish underwater. Paul spoke to fish behaviour, what they eat, how they protect themselves, etc. The students were interested in the images Paul showed and what he had to say.

Discussion

Overall, results from the 2016 TAEMP near Wekweètì indicated that fish are healthy, and habitat is clean in Snare Lake. The message provided to the community was that water, fish and sediment quality are good, where “good” indicates that results were not abnormal and that there were no health concerns highlighted. Also, comparison between the 2012 and 2016 results suggested that there was no appreciable change in the fish, water or sediments.

Fish tissue analysis indicated mercury levels were low in łih (LKWF), with all tissue samples showing mercury concentrations below the Health Canada guideline. Łiwezǫ̀ǫ̀ (LKTR) samples had higher concentrations overall, which was not unexpected given that they are predatory fish which commonly exhibit higher levels due to bioaccumulation and biomagnification, while łih primarily feed on small fish and arthropods and typically show lower levels of contaminants (GNWT 2016a, b, Health Canada 2011, Cabana et al. 1994). On average the concentration of mercury in łıwezǫ̀ǫ̀ tissue was below the guideline, and none of the tissue samples for either species showed levels of mercury that were considered abnormal for northern lakes. Further, when comparing fish tissue results from 2016 to 2012, no appreciable differences were noticed between years for either łıwezǫ̀ǫ̀ or łih. The one exception was the large old łıwezǫ̀ǫ̀ sampled in 2012, which had a mercury tissue concentration of 3.39mg/kg; no results from 2016 were remotely close, which was viewed as positive by TAEMP staff and community members. No statistical analyses of mercury concentrations in muscle tissue in relation to age, fork length, and weight were conducted, given that examination of the scatter plots suggest positive relationships (as expected). Statistical analyses are expected through collaboration with Environment and Climate Change Canada, examining data in the context of the TAEMP, as well as comparing TAMEP data to surrounding lakes which have not been sampled as part of the TAEMP (please refer to the State of the Environment Report, 10.4 Status of Mercury in Fish; GNWT 2015). On a related data-use note, discussions with Tłı̨chǫ government, Tłı̨chǫ community members, Environment and Natural Resources Water Resources Division and other water partners continue regarding use of TAEMP data in supporting implementation of the Water Strategy and related initiatives (such as the Mackenzie DataStream, which was officially launched in November 2016 (Mackenzie DataStream 2018). Interest has been expressed regarding the use of TAEMP fish data as a “pilot” to test the capacity of DataStream. Use of TAEMP data in an open source format may help to address some of the data gaps in Wek’èezhìı, for as mentioned in the WWF Freshwater Health Assessments for Watersheds in Canada (WWF 2016, 2015), there is a general lack of information on the fish and water quality metrics used to help determine freshwater health in watersheds associated with Wek’èezhìı.

Analyses of water and sediment results supported the expectation that water and sediment quality is “good” (i.e. not abnormal) in Snare Lake. Basic interpretation of the water and sediment quality results involves comparison of results to CCME Guidelines for the Protection of Aquatic Life, for water, and the CCME Sediment Quality Guidelines and Probable Effects Level, for sediment (CCME 2014). The guidelines are based on a thorough review of information on the toxicity of different parameters (e.g. metals, nutrients, etc.) and indicate the concentration of a parameter below which no adverse effects are expected. CCME guidelines are not site-specific; they are meant to be applied as Canada-wide standards for freshwater to protect all forms of aquatic life, including the most sensitive life stage of the most sensitive species. If a guideline value is exceeded, that does not necessarily indicate that a particular parameter is having a negative effect on aquatic organisms; it suggests that there is potential for an effect, depending on the species present and the natural background characteristics of the water and sediment. These national guidelines are used in absence of baseline or control data to use as a comparison.

Overall, the sampling results indicate there was no appreciable change in the water quality and sediment quality between 2012 and 2016, with the understanding that some variation of parameters is to be expected with varying natural conditions and low frequency sampling. In short, Snare Lake water is typical of water originating on the Precambrian Shield and would be classified as an oligotrophic lake. Nutrients are the building blocks for productivity and growth of phytoplankton, algae and other aquatic plants. Lakes are often categorized according to their productivity as oligotrophic (low productivity), mesotrophic (moderate productivity) or eutrophic (high productivity). While many nutrients are required for plant growth, nitrogen and phosphorus are frequently the controlling factors for productivity (Wetzel 2001). Nutrient and physical parameters were measured at all sample sites and were found to be similar at all sites. The results of Snare Lake are typical of water originating on the Precambrian Shield and would be classified as an oligotrophic lake.

The impacts of field conditions, field sampling methods, contamination, and lab methods were also noted as potential contributing factors to some of the results observed. For example, on the last day of sampling in 2016, sediment and water sampling was not possible by boat given wind conditions, and sample collection by wading out close to shore may have disturbed the sediment, affecting results (see location s U1, U2 and W/S-3; see Figure 1, p.4). This was similar to 2012, where samples were collected by wading into the water at three of the sites. This type of sampling can easily contaminate the water being collected due to capturing the suspended sediments which influence analysis and interpretation. Also, the composition of the sediment can reflect what is found in the water due to suspension and re-suspension of particles resulting from disturbance of the bottom; for example, chromium can be associated with silty sediment. The importance of repeat sampling, sufficient replicates per sample site, as well as incorporation of additional sampling methods (e.g. sediment cores vs. Ekman sediment samples) was acknowledged. Further, discussion regarding the use of sediment cores to supplement and further contextualize information gathered via grab samples has been discussed with Tłı̨chǫ Government and research staff involved with the Marian Lake Stewardship Program, along with elders from each of the four Tłı̨chǫ communities. Lastly, to determine if water bodies are being affected by industry and human activities, comparison of the study area water quality data to water quality data collected from a water body of roughly the same size in the same area of the study area would be appropriate. Though this was not done in 2012 or 2016, this practice would provide the best representation of natural, unaffected water quality data. The hope is, with collaboration with academic partners and GNWT Waters Division staff, that such comparisons will occur.

There has been ongoing concern among the Tłı̨chǫ people regarding whether fish are healthy and safe to eat, and Tłı̨chǫ elders continue to emphasize that up-to-date studies documenting contaminant levels to determine the health of fish are needed. Previously, Lockhart et al. (2005) reported elevated mercury in fish collected in Marian River and Slemon Lake in 1979 and 1983 (respectively), and in Lake Trout sampled from Rae Lakes in 2000. Continued standardized sampling at lakes near Tłı̨chǫ communities in Wek'èezhìı will help to track environmental changes. This will help to address concerns identified by Tłı̨chǫ people, and assist other NWT decision-makers by providing locally-collected data. For example, the

Marian sub-watershed contains the Fortune Minerals NICO mine location, and a proposed all-season road currently undergoing an Environmental Assessment (MVEIRB 2016) which may also have impacts (Cott et al. 2015). The general lack of information on the fish and water quality metrics used to help determine freshwater health in various sub-watersheds in the NWT is highlighted in the WWF Freshwater Health Assessments for Watersheds in Canada (WWF 2016, 2015); the TAEMP will also help address gaps in watershed knowledge associated with Wek'èezhìı. The TAEMP also broadens the geographic coverage of sampling for mercury, as recommended in the Aboriginal and Northern Development Canada (now Indigenous and Northern Affairs Canada) State of Knowledge Report (AANDC 2012).

With the conclusion of the TAEMP near Whatì in 2014, baseline sampling was completed near all four Tłı̨chǫ communities. In 2015, when the TAEMP returned to Behchokǫ̀, a new phase began: the first round of comparative sampling. The comparative sampling phase (2015-2018) will provide data that may indicate changes and provide relevant information to assist in cumulative effects analyses and informed decision-making. The TAEMP will contribute to the implementation of the NWT Water Stewardship Strategy and Action Plan, and the continuing assessment of contaminant levels in traditional foods through collaboration with Health and Social Services and the Northern Contaminants Program. TAEMP will also complement the Tłı̨chǫ Government's ongoing Marian Watershed Stewardship Program in establishing baseline datasets and evaluating cumulative effects that may occur due to climate change, industrial activities (e.g. Fortune Mineral's proposed NICO project and the related proposed Tłı̨chǫ All-season Road), and/or natural disturbances. Finally, TAEMP continues to assist in the promotion, understanding, and protection of source water for Tłı̨chǫ communities.

Conclusions and Next Steps

The Tłı̨chǫ Aquatic Ecosystem Monitoring Program has been developed and modified continuously through a collaborative relationship among communities and agencies based in the NWT. By design, the TAEMP is based on consultation with communities near which sampling occurs. The TAEMP Partners will continue to use a collaborative approach in the future through face-to-face meetings, conference calls, and workshops, culminating in the on-the-land "fish camp" at which dialogue with community representatives occurs constantly to ensure the Program continues to meet its objectives.

The TAEMP provides an opportunity for youth and community members to conduct scientific fish monitoring at an on-the-land camp and allows their experience(s) to be combined with their Tłı̨chǫ knowledge of the environment near communities. This increases the capacity of Tłı̨chǫ people to understand the science-based methods used to assess the current and potential effects of contaminants within various ecosystems across their lands and how the results are interpreted, while simultaneously sharing Tłı̨chǫ knowledge and allowing for clarification of concepts in an on-the-land setting (e.g. similar to a field course-based approach). The TAEMP also offers an opportunity for researchers to learn from traditional knowledge holders in a culturally appropriate on-the-land context. This form of engagement allows for building of mutual respect and trust – as scientists and knowledge holders learn from one another while out on the land, recognizing each other's capabilities through regular camp operations (e.g. net setting, fish collection, fish processing for samples and food).

The TAEMP also involves staff from organizations inherently linked to Tłı̨chǫ communities, including the WRRB, WLWB and the TG. Long-term capacity building occurs in these organizations through continued support by their trained staff, some of whom are also Tłı̨chǫ citizens living in communities. A four-year rotation through Tłı̨chǫ communities also allows for the potential that community members will repeatedly participate in, contribute to, and learn from the TAEMP – notably the youth. The possibility for youth continuing with more specific environmental monitoring-related training is strengthened by the availability of the Marian Watershed Stewardship Program led by the TG and WLWB.

With the conclusion of the TAEMP near Whatì in 2014, baseline sampling was completed near all four Tłı̨chǫ communities. In 2015, when the TAEMP returned to Behchokǫ̀ the first round of comparative sampling began. The comparative sampling will provide data that will continue to assist addressing community concerns related to changes in the environment, and the TAEMP will continue to build on work carried out since 2010. The information collected during the comparative phase (2015-2018) may indicate changes and may provide relevant information to assist in cumulative effects analyses and informed decision-making. For example, the TAEMP will contribute to the implementation of the NWT Water Stewardship Strategy (WSS) and Action Plan, and the continuing assessment of contaminant levels in traditional foods through collaboration with Health and Social Services and the Northern Contaminants Program. TAEMP will also complement the Tłı̨chǫ Government's ongoing Marian Watershed Stewardship Program in establishing baseline datasets and evaluating cumulative effects that may occur due to climate change, industrial activities (e.g. Fortune Mineral's proposed NICO project and the related Tłı̨chǫ All-Season Road), and/or natural disturbances such as fire (Baltzer 2015). Finally, TAEMP continues to assist in the promotion, understanding, and protection of source water for Tłı̨chǫ communities.

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Appendix 1 – Project Participants

Introductory Workshop (August 5, 2015)

Community Members
Joseph Judas
Madeline Judas
Charlie Football
Marie Adele Football
Jimmy Kodzin
Noella Kodzin

Support Staff:

Adeline Football	TG (Wekweètì)
Roberta Judas	WLWB (Wekweètì)
Sean Richardson	TG (Behchokǫ̀)
Boyan Tracz	WRRB (Yellowknife)

Translation:
Jonas Lafferty
James Rabesca

Planning Workshop (September 2, 2016)

Community members:
Joseph Judas
Charlie Football
Marie Adele Football
William Quitte
Eric Laboline
Gilbert Boline
Beazoa Football
Virginia Lamouelle

Support Staff:

Roberta Judas	WLWB (Wekweètì
Sean Richardson	TG (Behchokǫ̀)

Translation:
Jonas Lafferty
James Rabesca

Fish Camp (September 19-23, 2016)

Wekweètì Elders:

- Charlie Football,
- Marie Adele Football
- Joseph Judas,
- Madeline Judas,
- Jimmy Kodzin,
- Noella Kodzin.

Wekweètì Youth:

- Layden Judas
- Noah Kodzin,
- Simon Lamouelle
- Melvin Tom,

Wekweètì Community Support:

- Gilbert Boline Foreman
- Beazoa Football Camp Assistant
- Eric Laboline Camp assistant
- Virginia Lamouelle Cook
- Betty Pea'a Cook
- William Quitte Foreman
- Noel Quitte Cooks Helper:

Partners:

- Ryan Gregory ENR
- Cecilia Judas TSCA (Wekweètì)
- Roberta Judas WLWB (Wekweètì)
- Sean Richardson TG (Behchokǫ̀)
- Boyan Tracz WRRB
- Paul Vecsei Golder Associates

Translation

- Jonas Lafferty
- James Rabesca

Additional Support:

- Shannon Barnett-Aikman	TSCA (Yellowknife)
- Susan Beaumont	WRRB
- Michael Birlea,	TG (Behchokǫ̀)
- Nicole Dion	ENR
- Kathy Dryneck,	TCSA (Alexis Arrowmaker School Wekweètì)
- Adeline Football	TG (Wekweètì)
- Jennifer Fresque-Baxter	GNWT
- Hayley Frost,	TCSA (Alexis Arrowmaker School Wekweètì)
- Linsey Hope	TCSA (Behchokǫ̀)
- Jessica Hum.	TG (Behchokǫ̀)
- Linna O'Hara	HSS
- Jody Pellissey	WRRB
- Rachel Ressor	TCSA (Alexis Arrowmaker School Wekweètì
- Stephanie Staller	TCSA (Alexis Arrowmaker School Wekweètì
- Sjoerd van der Wielen	TG (Behchokǫ̀)

Results Workshop (March 7-8. 2017)

Elders and camp participants

- Gilbert Boline
- Charlie Football
- Jimmy Kodzin
- Noella Kodzin
- Eric Laboline

Community Members

- Cathy Dryneck
- Chris Football
- Georgie Kodzin
- Gordon Judas
- Roy Judas
- Brian Kodzin
- Nick Lamouelle
- Robert Moretti?

Partners:

- Ryan Gregory ENR
- Roberta Judas WLWB (Wekweètì)
- Pricilla Lamouelle TG (Behchokǫ̀)
- Sean Richardson TG (Behchokǫ̀)
- Boyan Tracz WRRB
- Paul Vecsei Golder Associates Ltd.

Translation:

- Jonas Lafferty
- James Rabesca

Appendix 2 – Results from Water Quality Travel and Field Blanks

Field quality assurance/quality control (QA/QC) measures carried out for this program consisted of a travel blank and a field blank. These QA/QC samples were incorporated into the study to ensure that no contamination was introduced through the collection, handling, shipping and analysis of the samples.

Travel blanks were prepared by Taiga Labs (Yellowknife) and field blanks were prepared on site, using Type 1 water provided by Taiga. The blanks were carried and analyzed the same as samples which were collected on site.

The presence of measurable total metals in the field blank samples, i.e., concentrations above the method detection limit, may indicate contamination during sample preparation in the field. Measurable total metals in the travel blank may indicate contamination in the lab.

Results available upon request.

Appendix 3 – Surface Water Physical and Nutrient Analysis Results

Results available upon request

Appendix 4 – Surface Water Metal Analysis Results

Results available upon request

Appendix 5 – Sediment Metals Analysis Results

Results available upon request

Appendix 6 – Fish species diversity, length and weight

Results available upon request

Appendix 7 – Metals analysis for fish tissue samples

Results available upon request

Appendix 8 – Age analysis for fish otolith samples

Results available upon request