Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP)

Final Report, Gamètì 2017

June 27, 2019

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Cover Photo: GNWT / N. Dion, ENR

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Acknowledgements

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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 September 2017, a 5-day on-the-land monitoring camp returned to Rae Lakes, near the community of Gamètì, with the camp situated at the same site as the 2013 TAEMP camp was located. The 2017 participants returned to locations on Rae Lakes where sediment and water sampling occurred in 2013 to allow for comparative sampling, with the relocation of one location and the addition of two new locations as requested by community members. Elders and community members spoke about fish and aquatic ecosystem health, passed on their knowledge to participants, and ensured safe camp operations and transport to and from sampling locations. Science-based methods for processing fish and collecting water and sediment samples for lab analyses were demonstrated on shore, and field sampling provided youth with hands-on experience in scientific sampling methods. As well, youth participated in cultural activities, including making dry fish and dry meat, which were demonstrated by Gamètì elders. A results workshop open to the public was scheduled in Gamètì in June 2018 to present the results to camp participants and to interested community members; unfortunately, no one attended.

Fish tissue analysis indicated mercury levels were low in *Łıh* (Lake Whitefish); while in *Łıwezǫ̨ǫ̀ (*Lake Trout), the mercury levels were close to or slightly exceeded Canadian Food Inspection Agency guidelines. Both łıh and łıwezǫ̨ǫ̀ did not show levels of mercury that were considered abnormal for northern lakes. Comparison of 2017 results to 2013 results showed no appreciable change in mercury concentration for łıh and fewer łıwezǫ̨ǫ̀ exceeding the guidelines. Water and sediment results supported the expectation that water and sediment quality is “good” (i.e. not abnormal) in Rae Lakes.

Introduction

The purpose of the Tłı̨chǫ 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 Tłı̨chǫ 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 Tłı̨chǫ communities. There are historic, currently operating, and proposed developments in Wek’èezhìı, and there is concern in Tłı̨chǫ 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 2015, 2017), 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 Tłı̨chǫ 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 Tłı̨chǫ 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 Tłı̨chǫ communities once every four years. In 2013, the TAEMP completed its initial baseline sampling phase near Gamètì. In 2017, the comparative sampling phase was completed near Gamètì. The comparative sampling phase has built on work carried out since 2010 and allows for comparative analysis of sampling results collected in each of the four communities. The comparative sampling provides 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 Tłı̨chǫ Government (TG); the Wek’èezhìı Land and Water Board (WLWB); the Department of Fisheries and Oceans (DFO); the Government of the Northwest Territories Department of Environment and Natural Resources Water Resources Division (GNWT ENR); Department Health and Social Services (GNWT HSS); Environment and Climate Change Canada (ECCC); Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC); and Golder Associates.

Methods

The 2017 TAEMP consisted of three main phases:

1. Introductory and planning workshops in Gamètì;

2. On-the land camp near Gamètì on Rae Lakes where samples were collected; and,
3. Results workshop in Gamètì.

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 early August and September of 2017 to discuss the TAEMP with community members in Gamètì. The meetings provided a means to reacquaint community members with objectives/ approach of the TAEMP (i.e. the TAEMP had last occurred near Gamètì in 2013), and to begin planning for the on-the–land camp. During the planning meetings, there was compromise on the timing of the camp, given the schedules of support staff and availability of community participants. Selection of participants was discussed, and preliminary selection was determined based on relevant expertise/need/availability.

2. On-the-land Monitoring Camp – Rae Lakes

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 (now Crown-Indigenous Relations 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 WLWB Regulatory Manager; 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.

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 taken on the day of departure delivered to the lab in Yellowknife on the same day. 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; now Environment and Climate Change Canada), 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 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 as top and bottom.

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, ultra-low-detection mercury, and microbiological analysis. All bottles (except sterile bottles) were rinsed three times with sample water before filling. Sediment sampling was led by the

Wek’èezhìı Land and Water Board (WLWB) Regulatory Manager.

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. Seven gillnet sets were conducted over the course of the camp on Rae Lakes (Figure 1, Table 1). The 6.0-inch and 3.5-inch nets were used to target larger fish such as ***Łıwezǫ̀*** (Lake Trout; LKTR) and ***Łıhłih*** (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, measured for total length 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 łiwezǫ̀ (LKTR) and 20 łih (LKWH) to replicate samples sizes from 2013. The species sampled also represented those typically consumed by community members, and sampling of the two species also provided a way to account for differences between benthic (bottom feeding) and predatory (feeding on smaller fish) strategies.

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 łiwezǫ̀ (LKTR) estimated at 10 years on the left and a łih (LKWH) estimated at 8 years shown on the right.

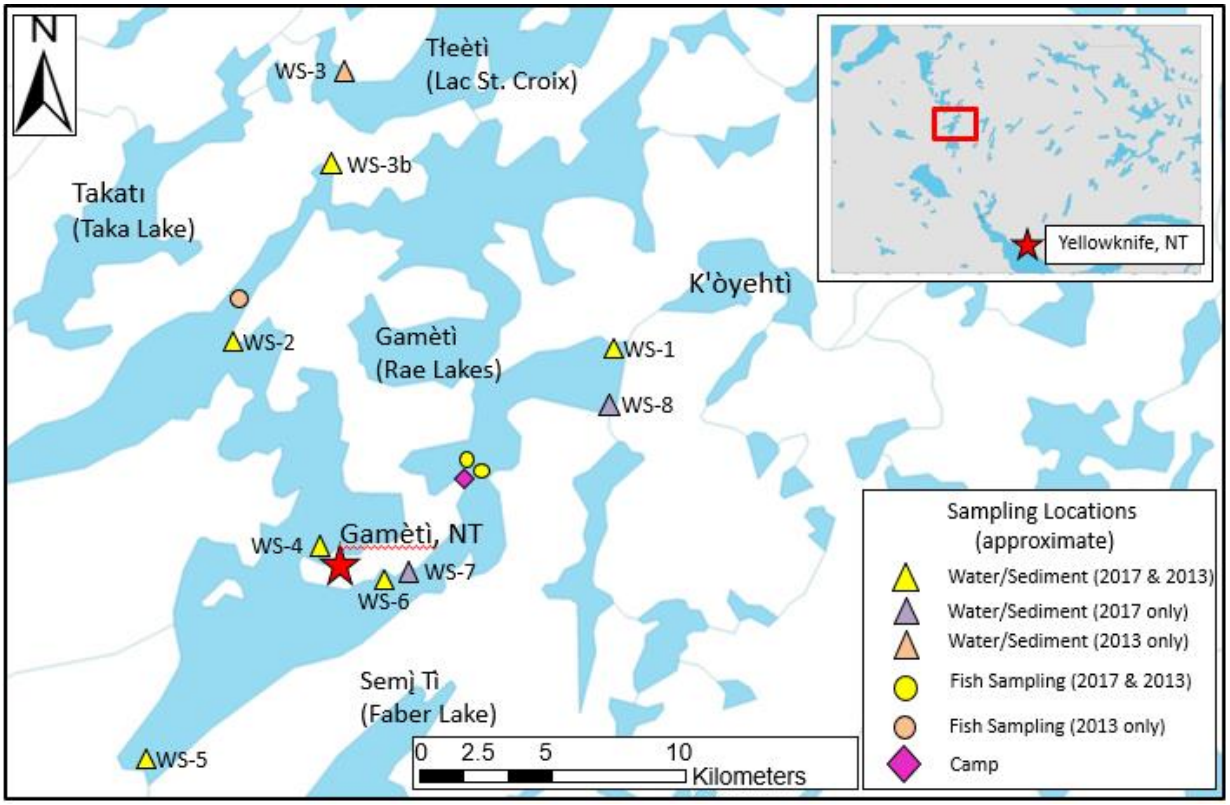

Figure 1 Location of the on-the-land camp, and locations where samples of fish, water, and sediment were collected on Rae Lakes during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near the community of Gamètì, September 2013 and 2017.

Table 1 Details for gillnet sets used to collect all fish samples at the TAEMP on Rae Lakes near the community of Gamètì, September 26-28, 2017.

Net set / pull date	Set Length (hrs)	Start Coordinates (11W)		End Coordinates (11W)		Net Length / Width (m)	Mesh size (in)
		Easting	Northing	Easting	Northing		
Sept. 26/ Sept. 27	25:34	0488876	7112492	0488904	7112407	100/1.8	6
Sept. 26 / Sept. 26	5:35	0489172	7112204	0489140	7112249	50/1.8	3.5
Sept. 26 / Sept. 27	18:00	0489172	7112204	0489140	7112249	50/1.8	3.5
Sept. 27 / Sept. 27	5:45	0489172	7112204	0489140	7112249	50/1.8	3.5
Sept. 27/ Sept. 28	21:10	0489172	7112204	0489140	7112249	50/1.8	3.5
Sept. 27/ Sept. 28	20:26	0489700	7115975	0489607	7115946	100/1.8	6
Sept. 28/ Sept. 28	21:25	0489172	7112204	0489140	7112249	50/1.8	3.5

LKTR LKWF

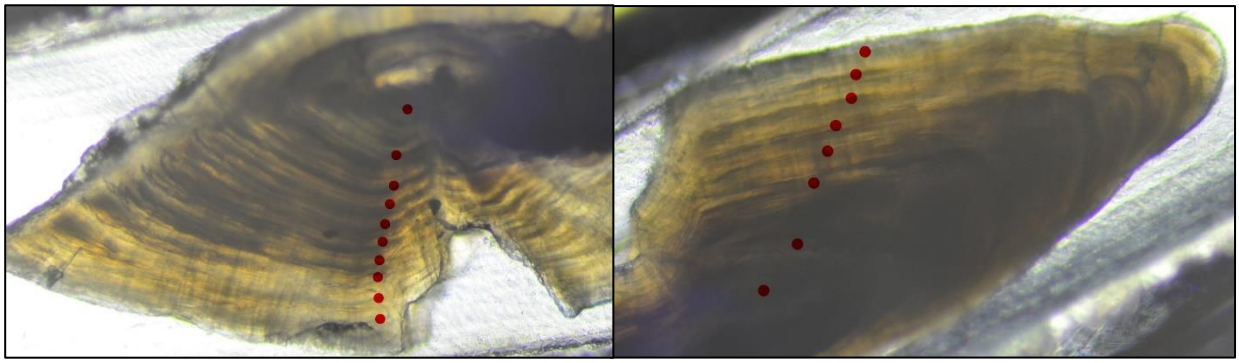

Figure 2 Two examples of otolith cross-sections, obtained from samples collected on Snare Lake, September 2016 (not to scale); a łiwezǫ̀ǫ̀ (LKTR) estimated at 10 years on the left and a łih (LKWH) estimated at 8 years shown on the right. Photos and interpretation provided by North/South Consultants Inc.,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

e. Fish Tissue Analysis

To determine current levels of contaminants in fishes consumed regularly by the community members in Gamètì, fish tissue samples were collected from 16 łiwezǫ̀ǫ̀ (LKTR) and 21 łih (LKWH), the fish species regularly consumed by Gamètì residents. Fish processing was led by Golder Associates Ltd. and DFO biologists, and samples were collected under the guidelines established by Environment Canada for sampling for metals (Environment Canada 2012; now Environment and Climate Change Canada) and the Golder Associates Ltd. technical protocol “Fish Health Assessment-Metals”.

3. Results Workshop

After analyses of fish, water and sediment samples are completed and support staff had an opportunity to review the results, a public meeting is held in the to review the goals and objectives of the program, as well as present the results of the analyses, including a comparison to the baseline results to see if any changes have occurred. Importantly, the results workshop provides an opportunity for community members to ask questions and gain clarification(s). An open format has proven 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, ensures appropriate messaging and communication strategies regarding the presentation of results. This collaboration ensures 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 2016, 2017). A results meeting was scheduled in Gamètì for June 19, 2018; unfortunately, many participants were unexpectedly out of town and, therefore, no one attended. Materials with TAEMP information were left at the Community Government offices.

Results

1. Introductory / Planning Workshops

On August 9, 2017, a one-day workshop was held with community members from Gamètì to discuss the TAEMP, where support staff and community members discussed the TAEMP camp near Gamètì in 2013, and re-visited concepts related to Tłı̨chǫ and scientific knowledge relevant to water, sediment and fish, and concerns regarding potential contaminants. The meeting provided a means to reacquaint community members with objectives/ approach of the TAEMP and to begin planning for the on-the–land camp. During the planning meeting, there was compromise on the timing of the camp, given the schedules of support staff and availability of community participants. Selection of participants was discussed, and preliminary selection was determined based on relevant expertise/need/availability. Options for sampling locations were discussed, as were options for the location of the camp given considerations such as water levels and available shelter for boats. There was agreement that sampling should concentrate on łıwezǫ̀ǫ̀ and łih based on primary consumption and health concerns. It was understood that late September was the available window for the camp, and that community support would be required, including the selection of engaged youth. A short visit to Jean Wetrade School provided indication from the principal and science teacher that finding youth who will be engaged should be no problem. There was agreement that camp should occur September 25-29 (Monday-Friday). It was agreed that next planning meeting should occur on September 6, 2017 in Gamètì.

On September 6, 2017, a second workshop was held in Gamètì to finalize planning for the on-the-land 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. Workshop participants developed a list of elders and community members who would participate in the fish camp with an understanding of who would be responsible for what duties. It was clarified that camp participants from Gamètì would consist of 9 elders (male and female), 4 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 2013 location for the camp, as it would enable elders to safely return to Gamètì easily if it was medically required.

A key outcome of the workshops was advance planning of a 5-day on-the-land monitoring camp on Rae Lakes at a location selected by community members from Gamètì in 2013, Louie and Therese Zoe's camp. After discussion amongst the elders, six sites sampled in 2013 were revisited, with one site relocated near a recent burn. Two new sites were added; one site where the water levels in 2013 prevented sampling, and one site that was opportunistically sampled. Water and sediment sampling locations were located as close as possible to six of the 2013 sampling locations. (Figure 1). Participants agreed that monitoring fish, water, and sediment quality continues to be

important to monitor changes near Gamètì 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, fish demonstrations) and that time will be allocated accordingly. There was a strong desire to ensure as much youth participation as possible. Discussion continued on how best to coordinate with school, TSCA, community members and support staff, and to find options for ensuring safety and meeting safety requirements.

2. On-the-land Monitoring Camp – Rae Lakes

a. Overall

The on-the-land phase of the TAEMP occurred from September 25 to 29, 2017. Travel to Gamètì occurred on September 25 while sampling and other activities occurred September 26-28, and participants returned to Gamètì on September 29. At camp, there were regular morning and evening briefing and debriefing meetings. 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 six of the 2013 sampling locations, with the relocation of one location and the addition of two new locations as requested by community members (Figure 1). 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 16 łiwezǫ̀ǫ̀ (LKTR) and 21 łih (LKWH) (see Results Section E. Fish Tissue Analysis). Water samples were also collected near the community dock and analysed for bacteria, total coliforms and faecal coliforms.

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). 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. Including how 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 Jean Wetrade Gamètì School also collected water and sediment samples using scientific equipment and techniques. 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 Gamètì provided a demonstration of dry fish and dry meat preparation techniques, visited gravesites and shared their Tłįchǫ knowledge and cultural practices with the youth and other participants.

b. Water Quality

Final locations for all water and sediment samples collected in 2017 are provided in Table 2, with five of the six same locations sampled in 2013 in addition to one site relocation and two sites added in 2017 (see also Figure 1). Nutrient and physical parameters were measured at all sample sites in 2013 and 2017 sampling programs and no noticeable difference was noted between the two sampling years. Nutrient and physical parameters were found to be similar at all sites.

Analysis of water samples indicated no noticeable difference between 2017 and 2013 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 2017 indicated pH ranged from 7.43 to 8.28, 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 7.43 to 8.23 in 2013 (n=5).

Most metal concentrations in Rae Lakes were very low with many measuring below method detection limits (MDL).

The 2017 water samples were all better than FAL guidelines, while 2013 water samples had a few metal concentrations greater than FAL guidelines (e.g. aluminum, mercury, and silver).

In 2017, bacteria (*Escherichia coli* (*E. coli*), Enterococci, and Fecal Coliforms) were not detected at WS-7, or by WS-4. In 2013, bacteria were not detected at WS-6; in 2017, the bacteria counts were very low. Total coliform counts were similar at all three sites sampled in 2017, suggesting that WS-6 has not significantly affected Rae Lakes.

Table 2 Details for water and sediment sampling locations at the TAEMP on Rae Lakes near the community of Gamètì, September 2017.

ID	Description	Location (Lat/Long)
WS-1 / S-1	Bay near Tea water spot	N64.20188 W117.11516
WS-2 / S-2	Near Joe Zoe's cabin	N64.18725 W117.42664
WS-3b / S-3	Near recent burn area	N64.25288 W117.363615
WS-4	Community dock	N64.11646 W117.3519660
WS-5 / S-5	Faber Lake outlet	N64.04180 W117.46316
WS-6	Bay near sewage lagoon	N64.10691 W117.32798
WS-7	Community water intake	N64.10950 W117.31906
WS-8	Tea Water Creek	N64.17648 W117.12056

Note: Lat/Long are NAD 83;

c. Sediment Quality

Sediment samples collected in 2013 and 2017 from WS-3 had the highest percentage of organic carbon (Figure 3). This was expected as these sites were chosen near recent burn areas.

In 2017, sediment samples from WS-1 and WS-3 had arsenic concentrations of 7.0µg/L and 6.0µg/L, respectively, and, in 2013, WS-2 was 7.3µg/L (Figure 4); these are above the CCME Sediment Quality Guidelines for the Protection of Aquatic Life interim Sediment quality guidelines (ISQG) of 5.9µg/L (CCME 2014). No locations sampled in 2013 or 2017 exceeded the CCME Probable Effects Levels (PEL) guidelines of 17µg/L (CCME 2014).

Chromium concentrations exceeded the ISQG guideline of 37µg/L, but not the PEL guideline of 90µg/L, at WS-1 (38µg/L) and WS-2 (82.2µg/L) in 2017 (Figure 5); concentrations at the remaining sampling locations ranged from 18.5 to 34.5µg/L. No locations sampled in 2013 exceeded the ISQG or the PEL guidelines.

Copper concentrations exceeded the ISQG guideline of 36µg/L at WS-2 (52µg/L) and WS-3 (46µg/L) in 2013, and in 2017 at WS-3 only (38µg/L; Figure 6). No locations sampled in 2013 or 2017 exceeded the PEL guideline of 197µg/L (CCME 2014).

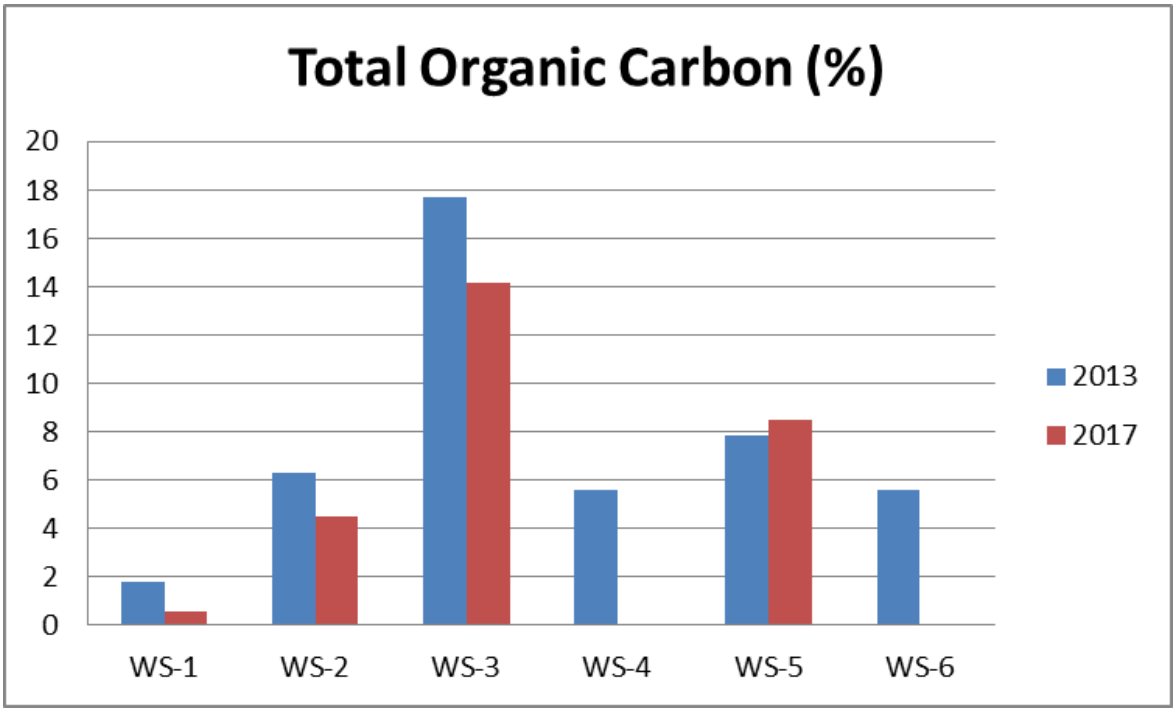

Figure 3 Comparison of the Total Organic Carbon in sediment samples collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Gamètì, September 2013 and 2017.

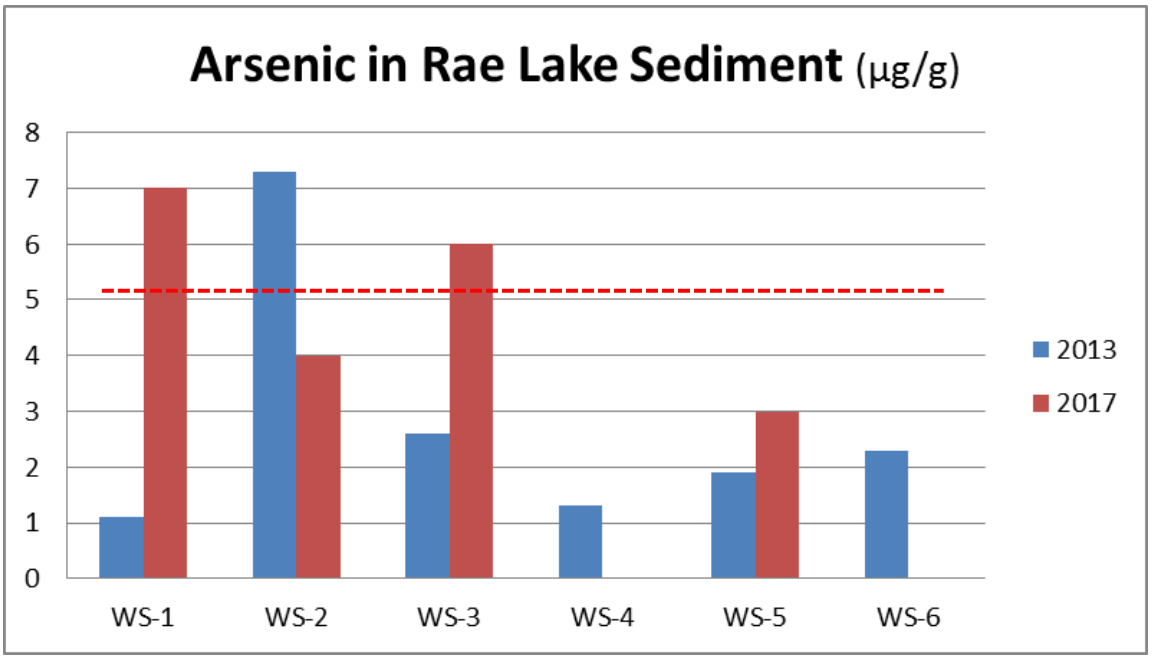

Figure 4 Comparison of the total concentrations of Arsenic for sediment samples collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Gamètì, September 2013 and 2017. Canadian Council of Ministers of the Environment (CCME) Sediment Quality Guidelines for the Protection of Aquatic Life interim sediment quality guidelines (ISQG) for Arsenic (5.9 µg/L).

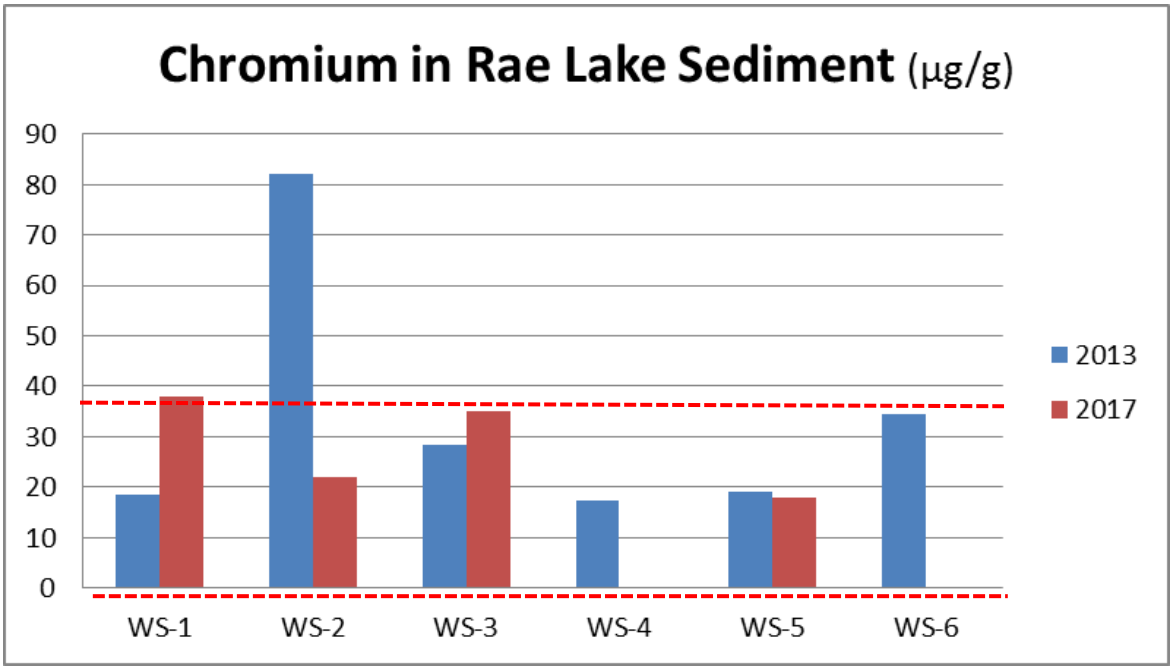

Figure 5 Comparison of the total concentrations of Chromium for sediment samples collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Gamètì, September 2013 and 2017. Canadian Council of Ministers of the Environment (CCME) Sediment Quality Guidelines for the Protection of Aquatic Life interim Sediment quality guidelines (ISQG) for Chromium (37µg/L) provided.

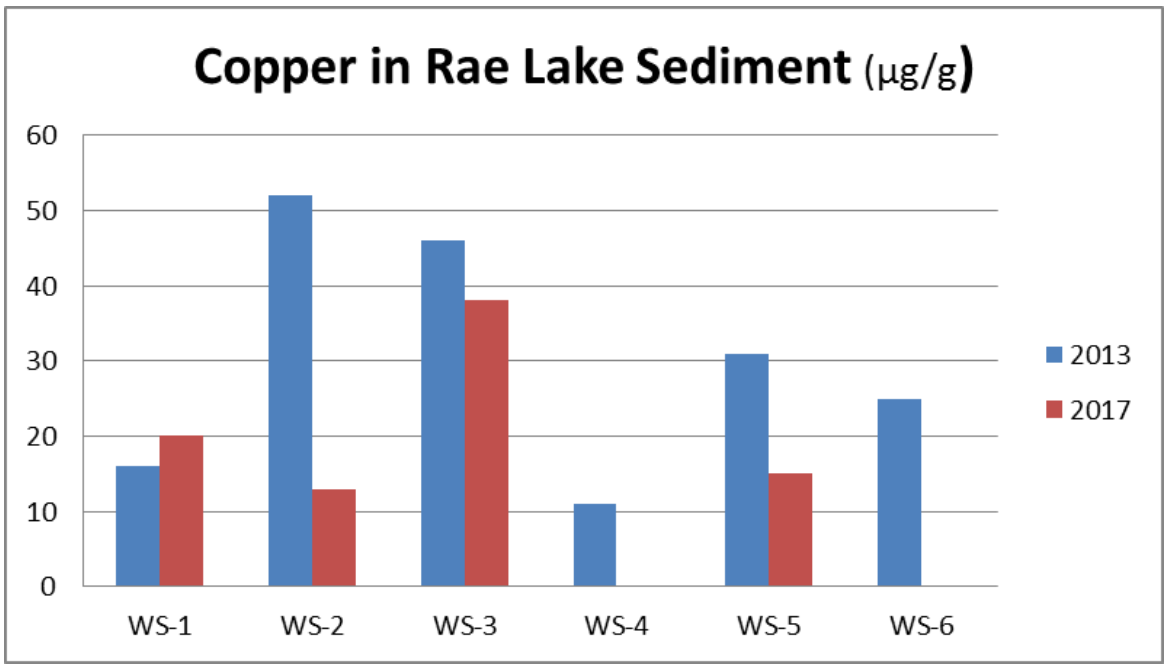

Figure 6 Comparison of the total concentrations of Copper for sediment samples collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Gamètì, September 2013 and 2017. Canadian Council of Ministers of the Environment (CCME) Sediment Quality Guidelines for the Protection of Aquatic Life interim Sediment quality guidelines (ISQG) for Chromium (36µg/L) provided.

d. Fish Species Diversity

Five species of fish were caught on Rae Lakes (Table 3); 53 łih (Lake Whitefish; LKWH), and 16 łiwezǫ̀ǫ̀ (Lake Trout; LKTR), 2 *Dehdoo* (Longnose Sucker; LNSC), 1 *Nǫhkwèe* (Burbot, BRBT) and 1 ı*ĮIhdaa* (Northern Pike; NRPK), for an overall total of 73 fish caught over a combined total of 117.92 hours of net sets. The łiwezǫ̀ǫ̀ (LKTR) and ịhdaa (NRPK) represented the common top predators, while the nǫhkwèe (BRBT), łih (LKWH) and dehdoo (LNSC) 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 Gamètì and were the same species for which analyses occurred in 2013.

2017 łiwezǫ̀ǫ̀ (LKTR) results

Lab analyses indicated that mercury concentrations in tissues were on average 0.388mg/kg wwt (wet weight; 95% CI+/-0.042) ranging from 0.258 to 0.523mg/kg wwt, with one of the sixteen fish sampled over the guideline for mercury of 0.5 mg/kg, (wet weight, wwt; Health Canada, 2017). Figures 7a, 7b, and 7c show the relationship of mercury concentrations in muscle tissue in relation to weight, fork length and age, with a strong positive relationship suggested with regards to age.

Łiwezǫ̀ǫ̀ (LKTR) comparison between 2017 and 2013

Lab analyses from 2013 indicated that mercury concentrations in tissues were on average 0.468mg/kg wwt (wet weight; 95% CI+/-0.066) ranging from 0.251 to 0.825kg/kg wwt. Seven of the twenty fish were found to be above the mercury concentration guideline of 0.5mg/kg, (wet weight, wwt; Health Canada, 2014a). Six of the twenty łıwezǫ̀ǫ̀ showed mercury concentrations close to the guideline (falling between 0.4 and 0.5), with the remaining seven łıwezǫ̀ǫ̀ all under 0.4mg/kg ww. Of note, the oldest (35 and 30 years), the longest (802 and 774mm), and the heaviest (5380 and 4570g) łıwezǫ̀ǫ̀ did not show the highest concentrations of mercury. Compared to the 2013 results trend, mercury levels reflect similar patterns seen in data collected in 2017 (Figures 7a, 7b,7c).

2017 łih (LKWH) results

Lab analyses indicated that mercury concentrations in tissues were on average 0.12mg/kg wwt (wet weight; 95% CI+/-0.078) ranging from 0.042 to 0.682mg/kg wwt, and none of the fish sampled were over the guideline for mercury of 0.5 mg/kg, see Table 4 (wet weight, wwt; Health Canada, 2017). Figure 8a, 8b, and 8c show the relationship of mercury concentrations in muscle tissue in relation to weight, fork length and age, with a positive relationship suggested with regards to age.

Łih (LKWH) comparison between 2017 and 2013

Lab analyses indicated that mercury concentrations in tissues were on average 0.133mg/kg wwt (wet weight; 95% CI+/-0.038) ranging from 0.004 to 0.341mg/g wwt. All of the łıh sampled fell below the guideline for mercury. Comparison of the 2013 results to the 2017 results show similar patterns reflected in mercury levels (Figures 8a, 8b, 8c).

Comparison of the cumulative data sets (2017 and 2013) for łıwezǫ̨ and łıh suggest positive relationships between mercury concentration in tissue and weight, length, and age (Figures 9a, 9b and 9c). Łıh consistently show lower concentration in their tissues than łıwezǫ̨, with the clearest differentiation visible with regards to weight (9a).

It should also be noted that the Health Canada Guidelines provided are for retail fish (Health Canada 2017). There are no Health Canada Guidelines for fish caught for recreational or subsistence purposes.

Other Analyses

No deformities/abnormalities were noted in any of the fish sampled; parasites (e.g. worms and cysts) were found in the majority of individuals, though not at levels considered to be abnormal. łıwezǫ̨ stomach contents included Ninespine Stickleback, cisco, and small fish. Łıh stomach contents included invertebrates and Ninespine Stickleback.

Other fish species

There were 2 Dehdoo (LNSC), 1 nǫhkwèe (BRBT) and 1 ¡hdaa (NRPK) caught in 2017; tissue samples were not collected for analyses. No other species were caught. By comparison, in 2013, 51 ¡hdaa (NRPK) and 1 Round Whitefish (RHWH; also *łih*) were caught.

Quality Assurance

Duplicate fish tissue samples were taken for both łıwezǫ̨ and łıh. Duplicate results are within normal limits and indicate that the samples were taken and analysed with precision.

Table 3 Date and duration of net sets, and number of, łih (LKWH), łiwezǫǫ̀ (LKTR), nǫhkwèe (BRBT), dehdoo (LNSC) and ịhdaa (NRPK) caught on Rae Lakes near the community of Gamètì during the TAEMP, September 26-28, 2017.

Net set / pull date	Start Coordinates (11V)		End Coordinates (11V)		LKWH	LKTR	BRBT	NPRK	LNSC
	Easting	Northing	Easting	Northing					
Sept. 26/ Sept. 27	0488876	7112492	0488904	7112407	7	2	1	0	0
Sept. 26 / Sept. 26	0489172	7112204	0489140	7112249	6	0	0	0	0
Sept. 26 / Sept. 27	0489172	7112204	0489140	7112249	12	6	0	0	0
Sept. 27 / Sept. 27	0489172	7112204	0489140	7112249	5	1	0	0	0
Sept. 27/ Sept. 28	0489172	7112204	0489140	7112249	9	1	0	0	0
Sept. 27/ Sept. 28	0489700	7115975	0489607	7115946	6	3	0	1	2
Sept. 28/ Sept. 28	0489172	7112204	0489140	7112249	8	3	0	0	0
				TOTALS	53	16	1	1	2

Table 4 Comparison of 2013 and 2017 average mercury concentrations in tissue samples (mg/kg +/- 95% CI, -α=0.05) collected from łih (LKWH), łiwezǫǫ̀ (LKTR) caught on Rae Lakes near the community of Gamètì.

Fish species	2013 Average Mercury concentration (+/- 95% CI)	2017 Average Mercury concentration (+/- 95% CI)
łih (Lake Whitefish)	0.133mg/kg (n=19)	0.12mg/kg (n=21)
łiwezǫǫ̀ (Lake Trout); with outlier	0.468mg/kg (n=20)	0.388mg/kg (n=16)

f. Fish Growth

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

Łiwezǫ̀ǫ̀ (LKTR)

Łıwezǫ̀ǫ̀ from which tissues were sampled for analyses in 2017 (n=16) were on average 592.8mm in length (fork length; 95% CI+/-13.12) ranging from 530 to 645mm. They weighed on average 2325g (total weight; 95% CI+/-206.04) ranging from 1700 to 3100g, and were on average 17 years old (via otolith aging; 95% CI+/-2.31) ranging from 10 to 30 years (n=15; 1 of the 16 fish could not be aged due to damaged otolith).

By comparison, łıwezǫ̀ǫ̀ sampled in 2013 (n=20) were on average 596.3mm in length (fork length; 95% CI+/-31.62) ranging from 511 to 802mm. They weighed on average 2354g (total weight; 95% CI+/-421.04) ranging from 1510 to 5380g, and were on average 20 years old (via otolith aging; 95% CI+/-3.30) ranging from 8 to 35 years.

Łih (LKWF)

Łıh sampled in 2017 (n=21) were on average 589.3mm in length (fork length; 95% CI+/-17.8) ranging from 520 to 668mm. They weighed on average 2746.7g (total weight; 95% CI+/-313.6) ranging from 1920 to 4810g, and were on average 15 years old (via otolith aging; 95% CI+/-1.45) ranging from 7 to 23 years.

By comparison, łıh sampled in 2013 (n=19) were on average 604mm in length (fork length; 95% CI+/-13.08) ranging from 560 to 660mm. They weighed on average 3158.4g (total weight; 95% CI+/-248.1) ranging from 2310 to 4620g, and were on average 19 years old (via otolith aging; 95% CI+/-4.19) ranging from 12 to 48 years.

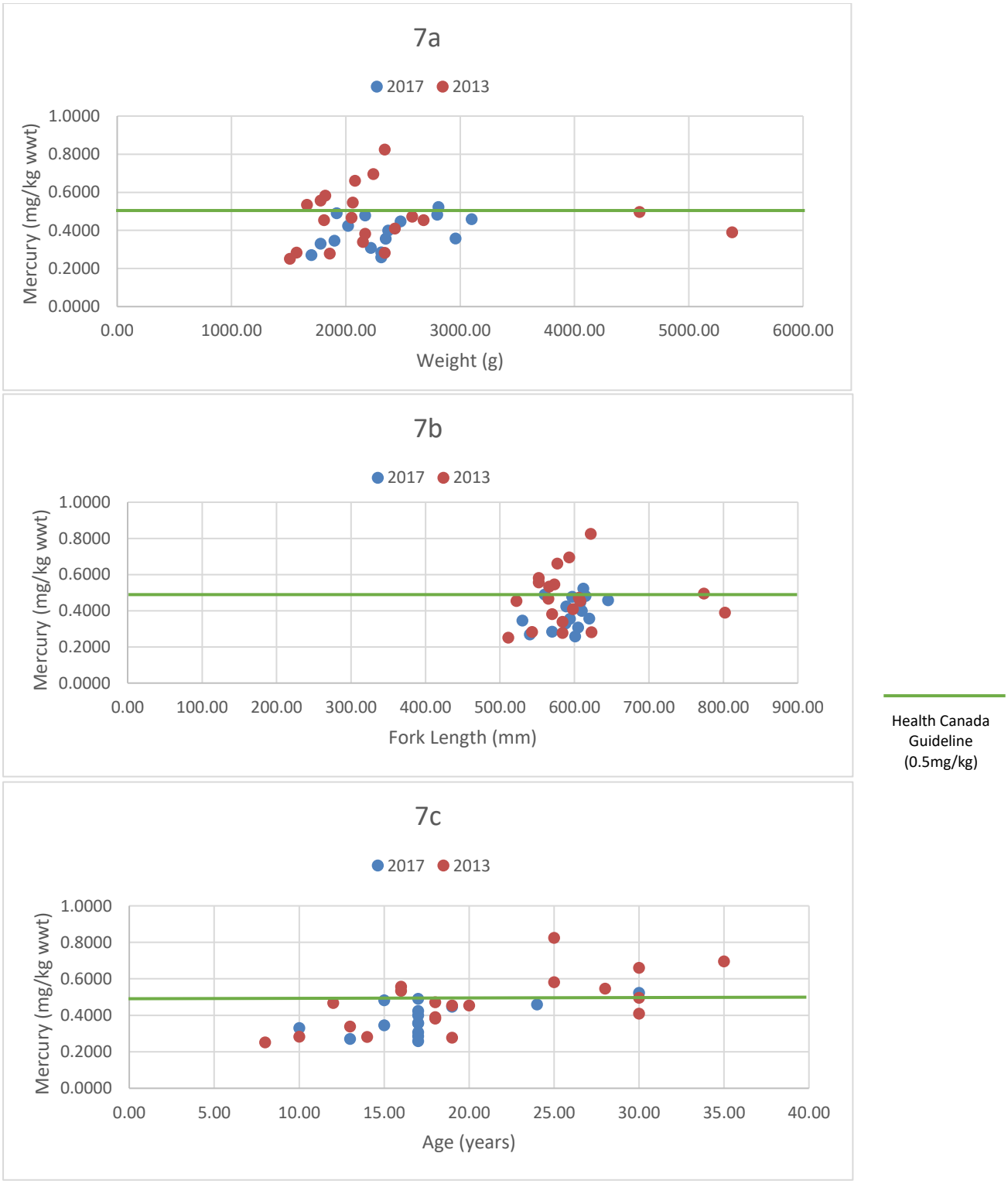

Figure 7 Comparison of the relationships between mercury concentration in tissues (mg/kg; wet weight) and body weight (g) (7a), fork length (mm) (7b), and age (years; estimated via otolith aging) (7c) of Łıwezǫ̀ǫ̀ (Lake Trout) collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Gamètì, September 2013 and 2017. Health Canada Maximum Level for mercury concentration in commercial fish (0.5mg/kg) provided.

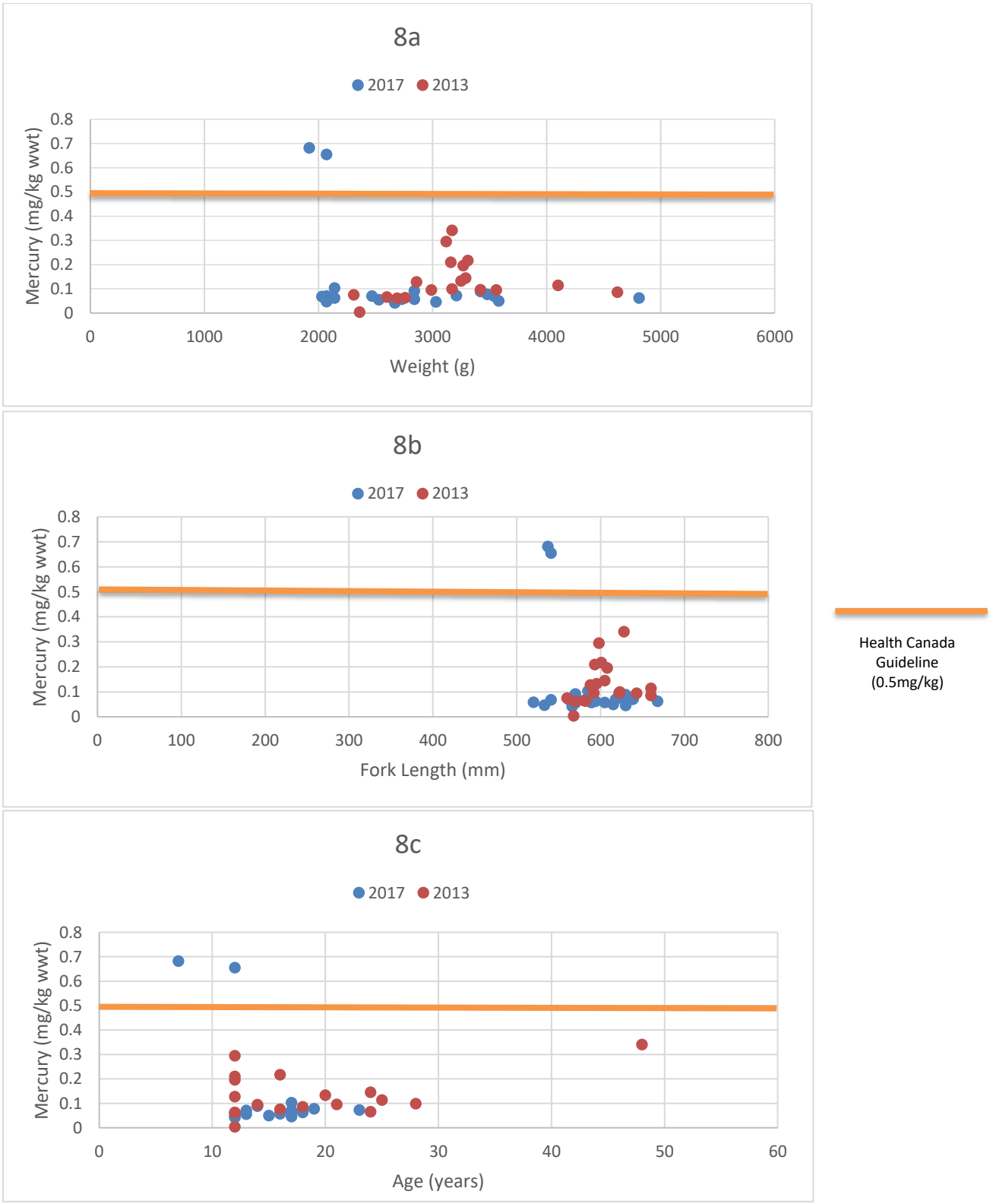

Figure 8 Comparison of the relationships between mercury concentration in tissues (mg/kg; wet weight) and body weight (g) (8a), fork length (mm) (8b), and age (years; estimated via otolith aging) (8c) of Łıh (Lake Whitefish) collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Gamètì, September 2013 and 2017. Health Canada Maximum Level for mercury concentration in commercial fish (0.5mg/kg) provided.

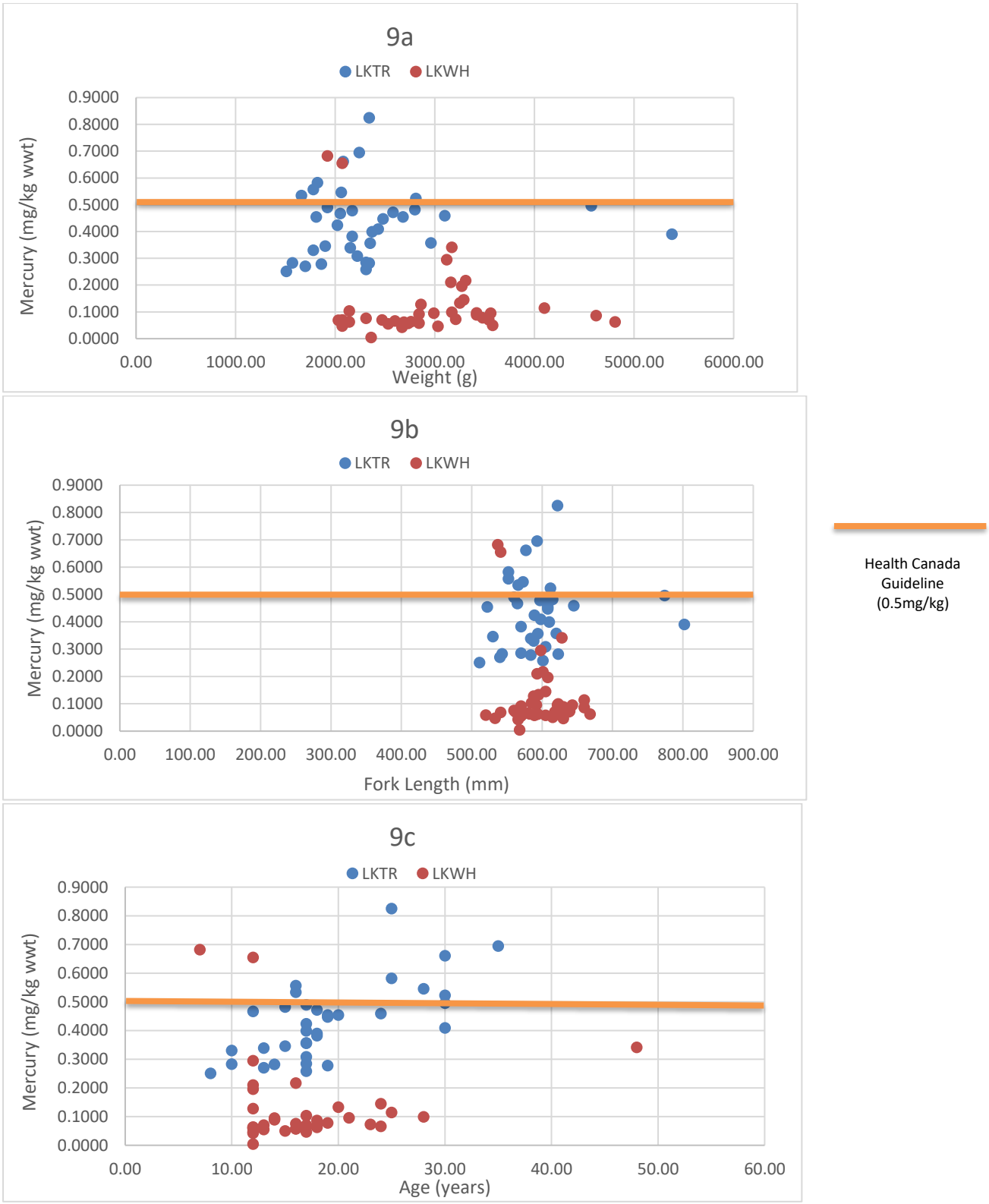

Figure 9 Comparison of the relationships between mercury concentration in tissues (mg/kg; wet weight) and body weight (g) (9a), fork length (mm) (9b), and age (years; estimated via otolith aging) (9c) for Łıwezǫ̀ǫ̀ (Lake Trout) and Łıh (Lake Whitefish) using cumulative data for each species collected during the on-the-land component of the Tłı̨chǫ Aquatic Ecosystem Monitoring Program (TAEMP) near Gamètì, September 2013 and 2017. Health Canada Maximum Level for mercury concentration in commercial fish 0.5mg/kg) provided.

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 2013, 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 Tłı̨chǫ communities.

Elders and other community members guided all aspects of the project, with Tłı̨chǫ 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 Tłı̨chǫ 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, net repair, storytelling, and teachings related to proper behaviours while at camp and on-the-land, and the history of the struggles people underwent to survive. Youth and visiting researchers were able to observe traditional methods of preparing and cooking fish, and were able to practice these skills at the camp.

The *Common Fish of the Tłı̨chǫ 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 Tłı̨chǫ community have been developed by NWT-based filmmakers with assistance from WRRB staff. All 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 Tłı̨chǫ 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 scheduled in Gamètì for June 19, 2018; unfortunately, many elders and participants were unexpectedly out of town and, therefore, no one attended. Materials with TAEMP fish, water and sediment results were left at the Community Government offices, along with Traditional Food Fact sheets that provide additional information on healthy traditional food choices (GNWT HSS 2014).

Discussion

The main objective of the 2017 fish, water and sediment quality monitoring program was to repeat the sampling that was done in 2013 to see if any changes had occurred; this objective was achieved.

Fish tissue analysis indicated mercury levels were low in łıh, with all tissue samples showing mercury concentrations below the Health Canada guideline (GNWTHSS, 2017). Łıwezǫ̀ǫ̀ 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 łıh primarily feed on small fish and arthropods and typically show lower levels of contaminants (GNWT 2017a, 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 2017 to 2013, no appreciable differences were noticed between years for either łıwezǫ̀ǫ̀ or łıh. No statistical analyses of mercury concentrations in muscle tissue in relation to weight, fork length, and age were conducted, given that examination of the scatter plots suggest positive relationships. Statistical analyses are expected through collaboration with Environment and Climate Change Canada, examining data in the context of the TAEMP, as well as comparing TAEMP 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 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 2017 (Mackenzie DataStream 2017). Recently, interest was 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 2015, 2017), 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 Rae Lakes. Overall, the sampling results indicate there was no appreciable change in the water quality and sediment quality between 2013 and 2017, with the understanding that some variation of parameters is to be expected with varying natural conditions and low frequency sampling. In short, Rae Lakes water is typical of water originating on the Precambrian Shield and Rae Lakes would be classified as an oligotrophic lake. 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, 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 2013 or 2017, 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 łıwezǫǫ̀ 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 awaiting construction from the GNWT’s Minister of Lands (MVEIRB 2018) 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 2015, 2017); 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 (CIRNAC) State of Knowledge Report (AANDC 2013).

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, 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 GNWT HSS and the Northern Contaminants Program. TAEMP will also complement the TG'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/or natural

disturbances. 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

Preliminary Planning Meeting (August 9, 2017)

Gamètì Community Members
Joe Mantla
Therese Zoe
Charlie Gon
Francis Zoe
Nelson Zoe

Support Staff:

Sean Richardson	TG – Behchokǫ̀
Boyan Tracz	WRRB – Yellowknife

Translation:
Jonas Lafferty
James Rabesca

Planning Workshop (September 6, 2017)

Gamètì Community members:
Alphonse Apples
Rosie Mantla
Joe Mantla
Marion Apples
Gabriel Apples
Celine Koyina
Charlie Gon
Marie Adele Wetrade
Dakota Wetrade
Nelson Zoe
Hunter Mantla

Support Staff:

- Roberta Judas — WLWB – Wekweètì
- Sean Richardson — Tłı̨chǫ Government – Behchokǫ̀

Translation:

- Jonas Lafferty
- James Rabesca

Fish Camp (September 25-29, 2017)

Gamètì Elders:

- Alphonse Apples
- Marion Apples
- Therese Arrowmaker
- Therese Gon
- Joe Mantla
- Rosie Mantla
- Joe Zoe
- Louie Zoe
- Therese Zoe

Gamètì Youth:

- Rebecca Black
- Steve Etsemba
- Skyden Koyina
- Josiayiah Wetrade

Gamètì Community Support:

- Mary Chocolate
- Charlie Gon
- Hunter Mantla
- Janelle Nitsiza
- Danny Rabesca
- Dakota Wetrade
- Marie Adele Wetrade
- Eric Zoe
- Forrest Zoe
- Nelson Zoe

Partners:

- Nicole Dion ENR
- Anneli Jokela WLWB
- Roberta Judas WLWB
- Patricia Lamouelle TG
- Francois Laroche Golder Associates
- Boyan Tracz WRRB

Translation

- Jonas Lafferty
- James Rabesca

Additional Support:

- Jody Pellissey WRRB
- Sean Richardson Tłı̨chǫ Government – Behchokǫ̀
- Susan Beaumont WRRB
- Jennifer Frsque-Baxter GNWT
- Linna O'Hara HSS
- Jessica Hum Tłı̨chǫ Government
- Gloria Ekendia-Gon Tłı̨chǫ Government – Gamètì
- Michael Birlea Tłı̨chǫ Government – Behchokǫ̀
- Margaret Phillips Staff at Jean Wetrade Gamètì School

Results Workshop (June 19, 2018)

Gamètì Elders and camp participants:

- None

Community Members:

- None

Partners:

- Sean Richardson (TG)
- Priscilla Lamouelle (TG)
- Joline Huskey (TG)
- Laura Meinert (WRRB)
- Aimee Guile (WRRB)
- Jody Pellissey (WRRB)

Translation:

- Jonas Lafferty
- James Rabesca

Appendix 2 – Results from Water Quality Travel Blanks and Duplicates

Field quality assurance/quality control (QA/QC) measures carried out for this program consisted of a travel blank and a duplicate. 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 duplicates were taken on site. 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. The 2018 travel blank results do not indicate that there was any contamination in the field. The 2018 duplicate results are within expected margins and do not indicate that there was any sampling or lab cross-contamination.

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