

## Technical Memorandum

Date: March 28, 2022

To: Lou Kamermans and Connor Devereaux, Baffinland Iron Mines Inc.

From: Samantha Burke and Paul LePage, Minnow Environmental Inc.

Cc: Emma Malcolm

**RE: Milne Inlet Freshwater Fish Health Assessment Preliminary Results**

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Minnow Environmental Incorporated (Minnow) is pleased to present Baffinland Iron Mines Corporation (Baffinland) with preliminary results for the Milne Inlet Freshwater Fish Health Assessment conducted in August 2021. The objective for the Milne Inlet Freshwater Fish Health Assessment (the assessment) is to evaluate the potential effects of the Baffinland Milne Port site operations on the health of Arctic Char from freshwater systems that flow into Milne Inlet based on various physical measures and fish tissue chemistry. Additionally, the assessment was designed to satisfy Term and Condition 48(a) required of Project Certificate No. 005 for the Baffinland Mary River Project (the Project).

The design for the assessment was developed following consultation with the Mittimatalik Hunters and Trappers Organization (MHTO) in February 2021. Based on this consultation, a before-after study approach was determined appropriate for evaluating whether the health of Arctic Char from the Tugaat, Qurluktuk, and Ikaluit freshwater systems (Figure 1) differed between the time prior to commencement of Milne Port operations in 2015 and currently in 2021, following approximately seven years of port operations. Historical information for the assessment was retrieved from Department of Fisheries and Oceans (DFO) reports (Moshenko 1981; Read 2004) that included Arctic Char age and body measurement data collected from the Robertson (Qurluktuk) and Tugaat river systems in the 1970s and 1990s, respectively (i.e., well prior to Baffinland's construction of the port). Through consultation with the MHTO, mid- to late August was identified as the optimal timing for the field study portion of the assessment, and therefore the field study was conducted between August 12<sup>th</sup> and 19<sup>th</sup>, 2021. The field crew included representatives from the MHTO/community of Pond Inlet (Mr. Robert Aglak), Qikiqtani Inuit Association (QIA; Mr. Tom Williamson), and Minnow (Dr. Samantha Burke and Mr. Paul LePage; Photo 1).

The fish health assessment followed methods similar to those used for Environmental Effects Monitoring (EEM) under the Metal and Diamond Mining Effluent Regulations (MDMER) to

conform with an accepted standard. Based on this approach, age, body length, body weight, reproductive organ weight, and liver weight measurements were collected as the basis for assessing growth and condition in fish captured in 2021 compared to the historical information, as well as the basis for tracking changes in fish health over time. Prior to sampling, the field team consulted with Mr. Aglak regarding safety considerations and appropriate fishing locations and techniques at each river system (Photo 2). Sampling was conducted at Tugaat Lake on August 16<sup>th</sup> and 17<sup>th</sup> and at Qurluktuk Lake on August 18<sup>th</sup> and 19<sup>th</sup> (Figure 1). Due to unsafe helicopter travel conditions related to weather during the field program, Ikaluit Lake was not able to be sampled in 2021. Arctic Char were captured using gillnets (4" and 5" mesh size) and dispatched in the field. The sampled char were transported to a field laboratory located at the Mary River Project Mine Site for processing (Photo 3). Fish processing included measurements of length and weight, determination of sex, removal and weighing of sex organs and livers, and removal of otoliths, fin rays, and scales for later age determination at an analytical laboratory. Muscle and liver tissues were collected for metals analysis, and sub-samples of ovary tissue (females only) were collected for later analysis of fecundity and egg size at an analytical laboratory.

The initial step required for data analysis included extraction of historical fish measurements from the DFO reports (i.e., Moshenko 1981; Read 2004)<sup>1</sup>. Summary statistics information presented in the DFO reports (i.e., mean length and weight for various size and age intervals) was reviewed, and for any intervals that included a single individual or two individuals in which an accompanying standard deviation was presented, individual age, fork length, and body weight data were extracted for the comparative analyses. Fish measurement data collected in 2021 were compared to information from the historical studies based on evaluation of plotted data and statistics that included Student's t-tests (in some cases based on means and standard deviations of the data) and analysis of covariance (ANCOVA). Based on the information available from the historical reports, the endpoints examined for the measurement data included fork length, body weight, growth (i.e., age-at-length relationship), and/or condition (i.e., weight-at-length relationship). These endpoints were analyzed separately for males and females in comparisons between data collected in 2021 and historically to assess for adverse Project-related effects on health Arctic Char since the commencement of port operations. These measurements were also compared separately for males and females between the Tugaat and Qurluktuk river systems using the 2021 data to provide information on general population features. No historical fish tissue chemistry data were available, and therefore the assessment of metal concentrations in muscle and liver tissue of Arctic Char from the Tugaat and Qurluktuk river systems in 2021 were

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<sup>1</sup> Historical data for comparison to fish captured at Qurluktuk Lake in 2021 were from char captured in the Robertson River in 1979, and thus could include char that overwintered in waterbodies other than Qurluktuk Lake in the Robertson River system. However, it was reasoned that char that over-winter in Qurluktuk Lake must migrate up the Robertson River from Koluktoo Bay, and thus these fish were representative of char likely to use Qurluktuk Lake.



compared to Health Canada consumption guidelines for mercury (i.e., 0.5 mg/kg wet weight). Although mercury has not been identified as a contaminant of potential concern at Baffinland's Milne Port and Mine Site (i.e., the Baffinland operations are not a source of mercury to the environment), accumulation of mercury originating from global sources in tissues of fish and marine mammals has been an area of concern for Inuit and monitored as part of the Northern Contaminants Program (e.g., Simonee et al. 2017). Therefore, tissue sampling for mercury analysis in this assessment was included to build upon the existing data for freshwater populations of Arctic Char in the region. In Tugaat Lake, 46 fish were captured in August 2021, eight of which were juveniles and released alive upon removal from nets. Of the 38 adult fish retained, 11 were female, 24 were male, and three were undeveloped adults. Fish captured at Tugaat Lake included those with silver colouration (Photo 4) which, based on information from Mr. Aglak, indicated that these Arctic Char had recently migrated from the marine environment to freshwaters. In Qurluktuk Lake 39 fish were captured in August 2021, of which 15 were juveniles and released upon removal from the nets. Of the 24 adult char that were collected at Qurluktuk Lake, seven were female, 13 were male, and four were undeveloped adults.

In Tugaat Lake in August 2021, sampled female char had a mean fork length of 61.1 cm, mean body weight of 2.6 kg, and were 11 years old on average (Table 1). Male char captured at Tugaat Lake were slightly smaller and younger than female char with a mean fork length of 56 cm, mean body weight of 2.1 kg, and mean age of 9.9 years (Table 1). Male and female Arctic Char captured at Tugaat Lake in August 2021 were significantly shorter and lighter than those captured historically in August (Table 2). Body condition (i.e., weight-at-length) was significantly lower in female char from August 2021 than historically (i.e., -12%; Table 2; Figure 2). Condition of male char from Tugaat Lake in 2021 did not differ significantly from fish captured historically (Table 2; Figure 2). There was no significant difference in growth (i.e., length-at-age) of females indicated between August 2021 and the historical data (Table 2; Figure 3). However, growth of males was significantly greater in 2021 compared to those sampled historically, suggesting no adverse effects on char growth following the commencement of Milne Port operations Table 2; Figure 3).

At Qurluktuk Lake, male char sampled in August 2021 were slightly larger and older than females (Table 1). Body condition of male and female char were significantly greater in 2021 than historically (Table 2; Figure 4). Similarly, length-at-age was significantly greater in male and female individuals sampled in 2021 than those assessed in 1979 (Table 2; Figure 5). In turn, this indicated that, like the situation at Tugaat Lake, Milne Port operations had not adversely affected condition and growth of Arctic Char from Qurluktuk Lake in 2021.

Comparisons of char health endpoints between Tugaat and Qurluktuk river systems based on sampling conducted in August 2021 indicated that males and females captured at Qurluktuk Lake



were significantly larger and older than those captured at Tugaat Lake ( $p < 0.05$ ; Tables 1 and 2), but no significant difference in condition was demonstrated between lakes for either sex ( $p > 0.05$ ). In male fish, length-at-age was significantly greater for fish captured at Qurluktuk Lake than at Tugaat Lake ( $p < 0.05$ ), however no difference in length-at-age of females was indicated between these lakes in 2021 ( $p > 0.05$ ).

In both Qurluktuk and Tugaat lakes, mean mercury concentrations in muscle tissue of Arctic Char were below the Health Canada consumption guideline of 0.5 mg/kg wet weight except for a single sample from a 20-year-old fish from Qurluktuk Lake that contained a mercury concentration slightly above the guideline (Figure 6). Overall, mean mercury concentrations in char muscle tissue were higher in fish sampled from Qurluktuk Lake (mean = 0.11 mg/kg wet weight) than those sampled from Tugaat Lake (0.04 mg/kg wet weight;  $p < 0.05$ ; Figure 6). These data are similar to the findings of Simonee et al. (2017), who also showed higher mercury concentrations in char tissues from Qurluktuk Lake than those at Tugaat Lake. Fish accumulate mercury over their lifetime, so older fish often have higher mercury concentrations in their tissues than younger conspecifics (Sanderich and Weiner 2011). Char sampled from Qurluktuk Lake were an average of approximately five years older than those sampled from Tugaat Lake in 2021, so this difference in age likely accounted for the observed difference in concentrations of mercury in muscle tissue of char between lakes.

The assessment carried out in August 2021 represented the first year of the Milne Inlet Freshwater Fish Health Assessment. The objective of the program is to determine whether the Milne Port operations have had any negative effects of Arctic Char health. Given the comparison of endpoints between 2021 and historical data, the Milne Port operations did not appear to result in adverse effects on Arctic Char health from the Tugaat and Qurluktuk river systems. Fish growth (length-at-age) of fish captured from both Tugaat and Qurluktuk lakes in 2021 was either greater or not significantly different from those captured historically. Additionally, char body condition was significantly greater in males and females captured from Qurluktuk Lake in 2021 compared to those assessed historically, and no significant differences in condition were indicated between 2021 and historically at Tugaat Lake for males. Finally, the concentrations of mercury in char muscle tissue samples collected in 2021 at both Tugaat and Qurluktuk lakes were generally below federal consumption guidelines, and consistent with baseline values. Moving forward, further consultation with the MHTO is recommended to inform on additional analysis of the 2021 data prior to report finalization, and to provide input regarding future monitoring as part of the Milne Inlet Freshwater Fish Health Assessment.

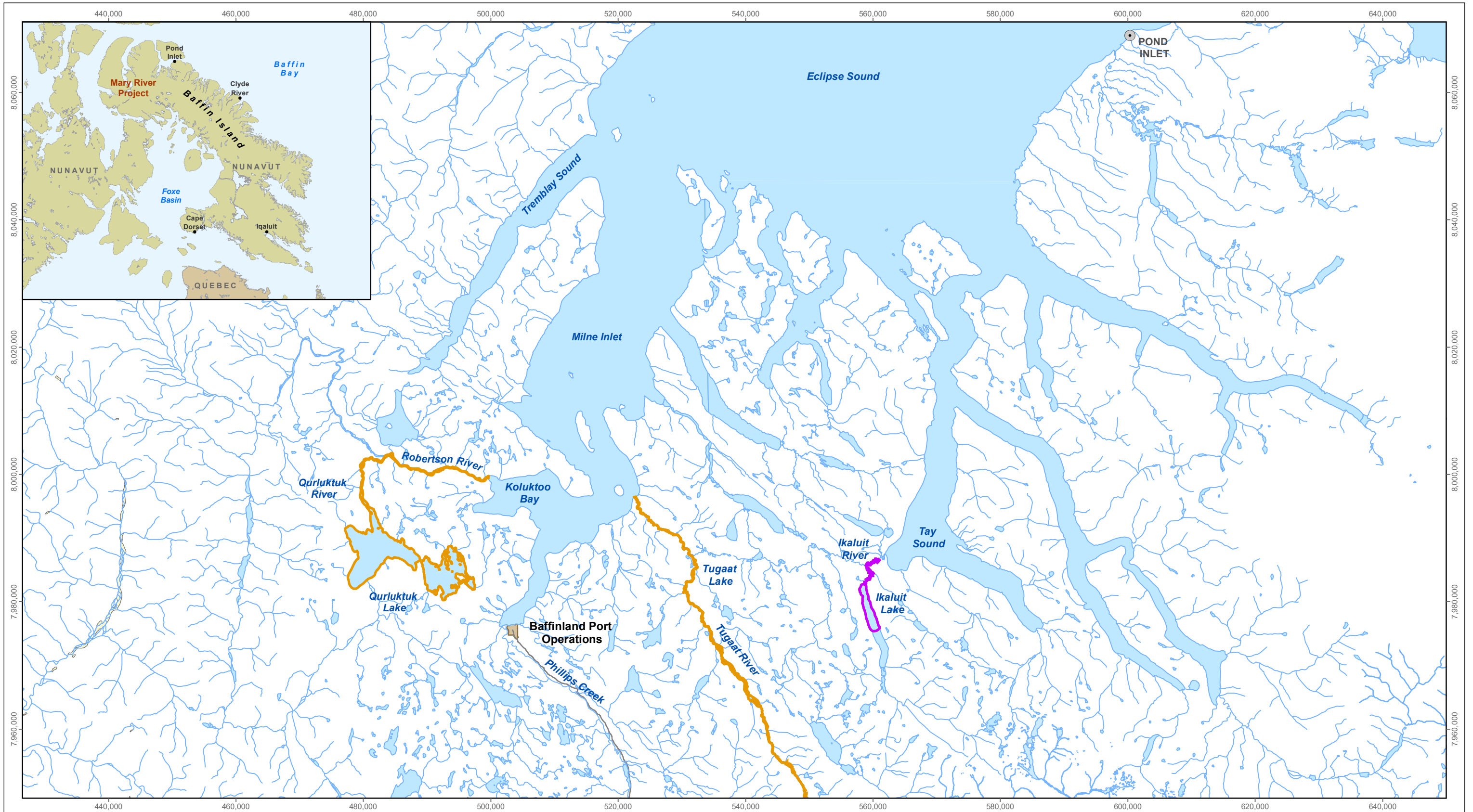


## References

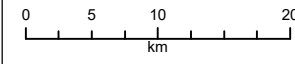
- Alberta Health Services. 2018. Nutrition Guide Iron [online] Available from <https://www.albertahealthservices.ca/assets/info/nutrition/if-nfs-ng-iron.pdf> [accessed 18 March 2022]
- Health Canada. 2019. Iron [online]. Available from <https://www.canada.ca/en/health-canada/services/nutrients/iron.html> [accessed 18 March 2022]
- Read, C.J. 2004. An Assessment of the Arctic Char Population of Tugaat River. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2699.
- Sandheinrich, M. B. Wiener, J. G. 2011. Methylmercury in freshwater fish: recent in assessing toxicity of environmentally relevant exposures. Environmental contaminants in biota, 169-192
- Simonee, J. (2017, September). Developing local research capacity for the monitoring of marine resources near Pond Inlet, Nunavut. Poster Presented at ArcticNet Annual Scientific Meeting, Quebec City, Quebec.



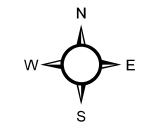
## FIGURES



**LEGEND**  
— 2021 Study Area  
— Future Study Area



Map Projection: UTM Zone 17 W NAD 1983  
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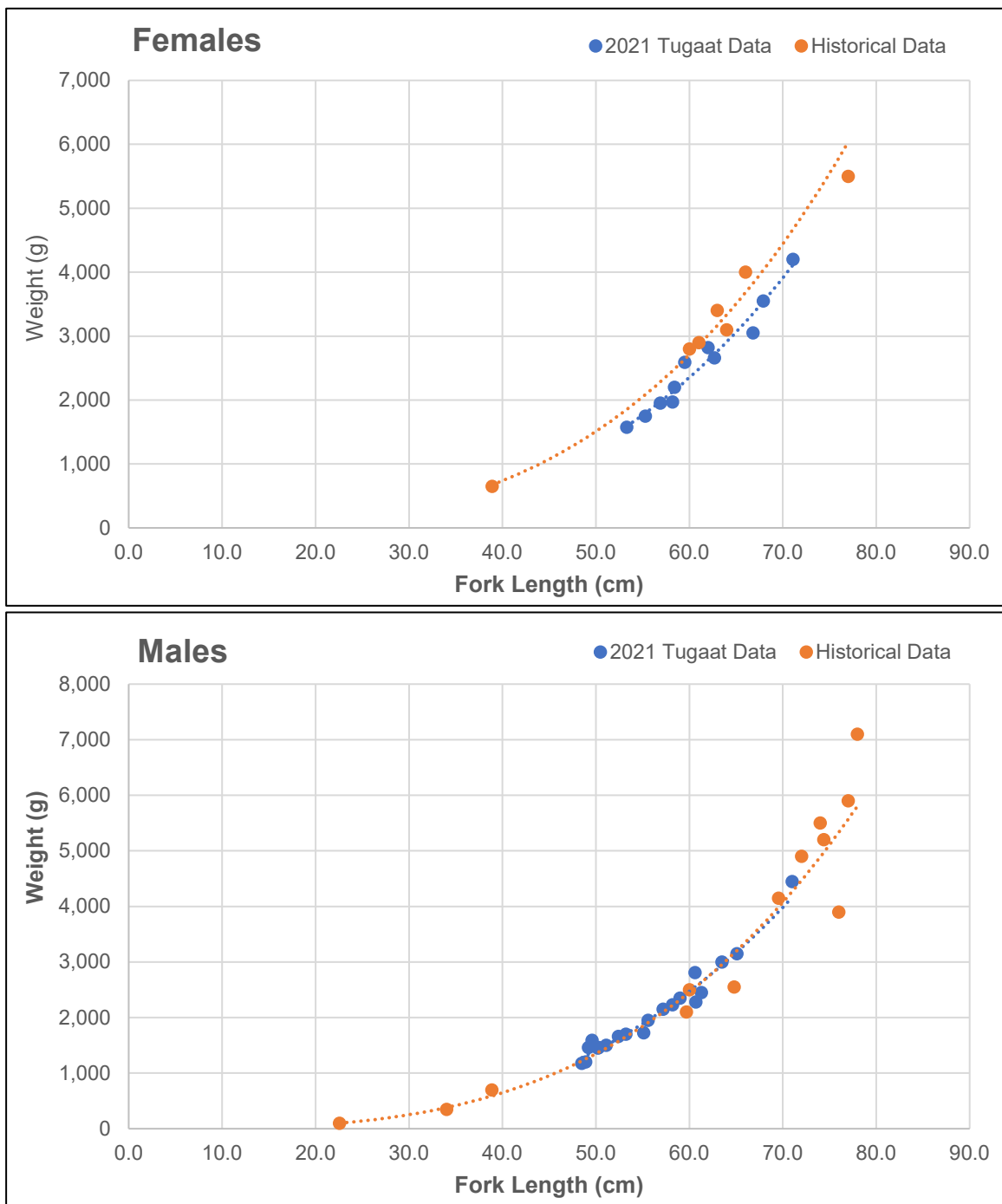


**Study Areas for the Baffinland Milne Inlet  
 Freshwater Fish Health Assessment in 2021**

Date: March 2022  
 Project 217202.0023

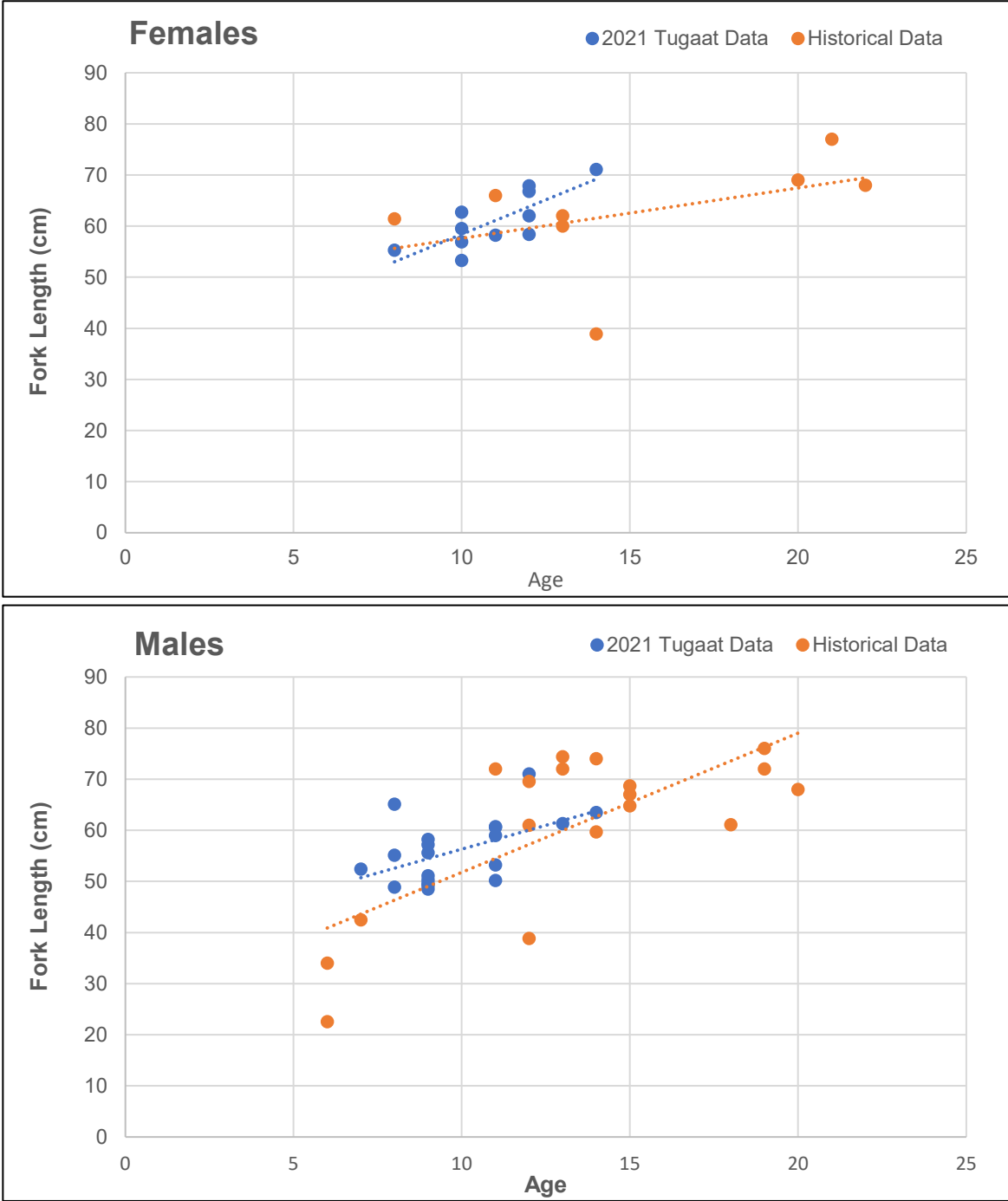


**Figure 1**

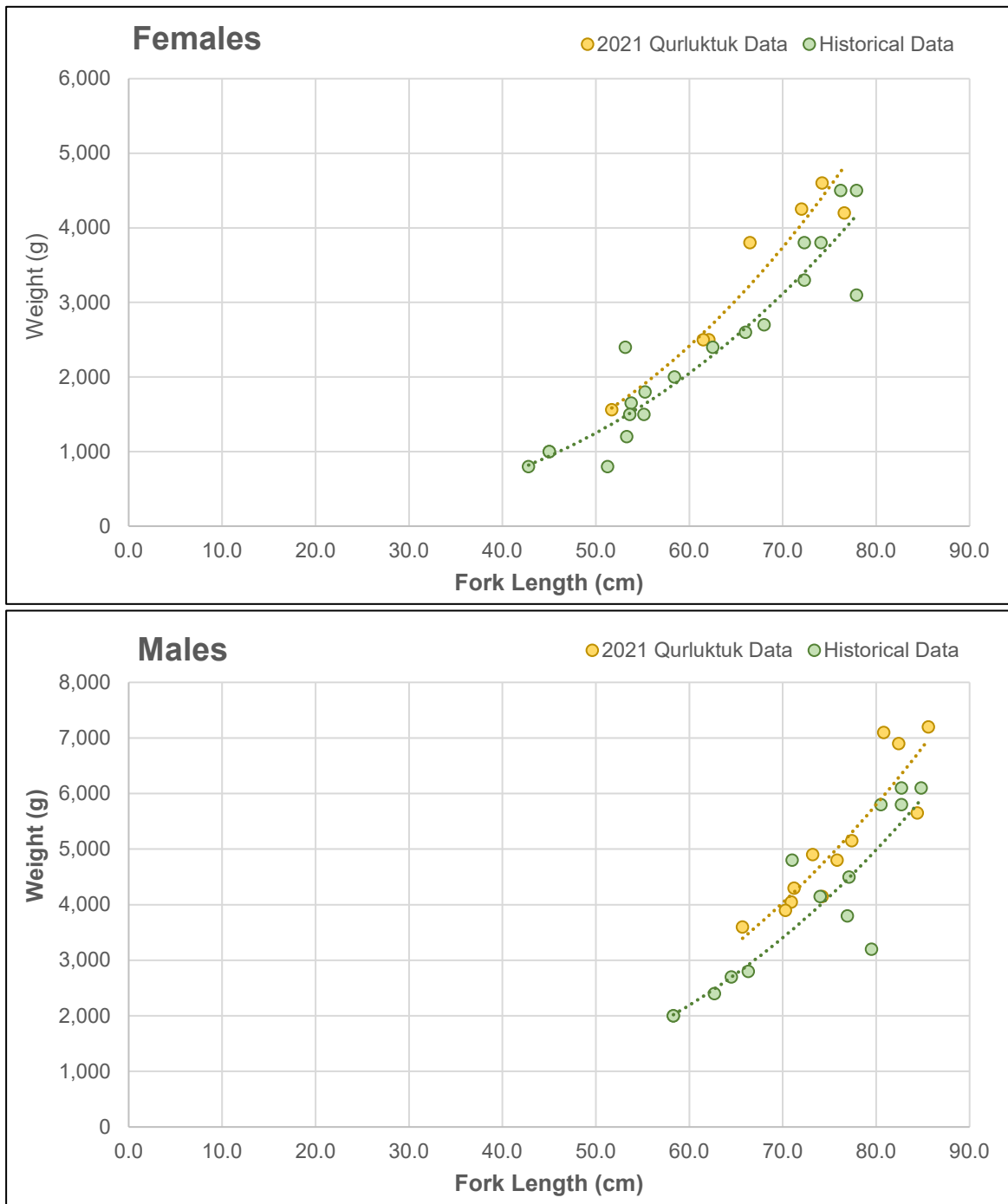


**Figure 2: Condition (Weight-at-Length Relationship) for Female (top) and Male (bottom) Arctic Charr Sampled at Tugaat Lake in August of 2021 and Historically (1992, 1995 Data)**

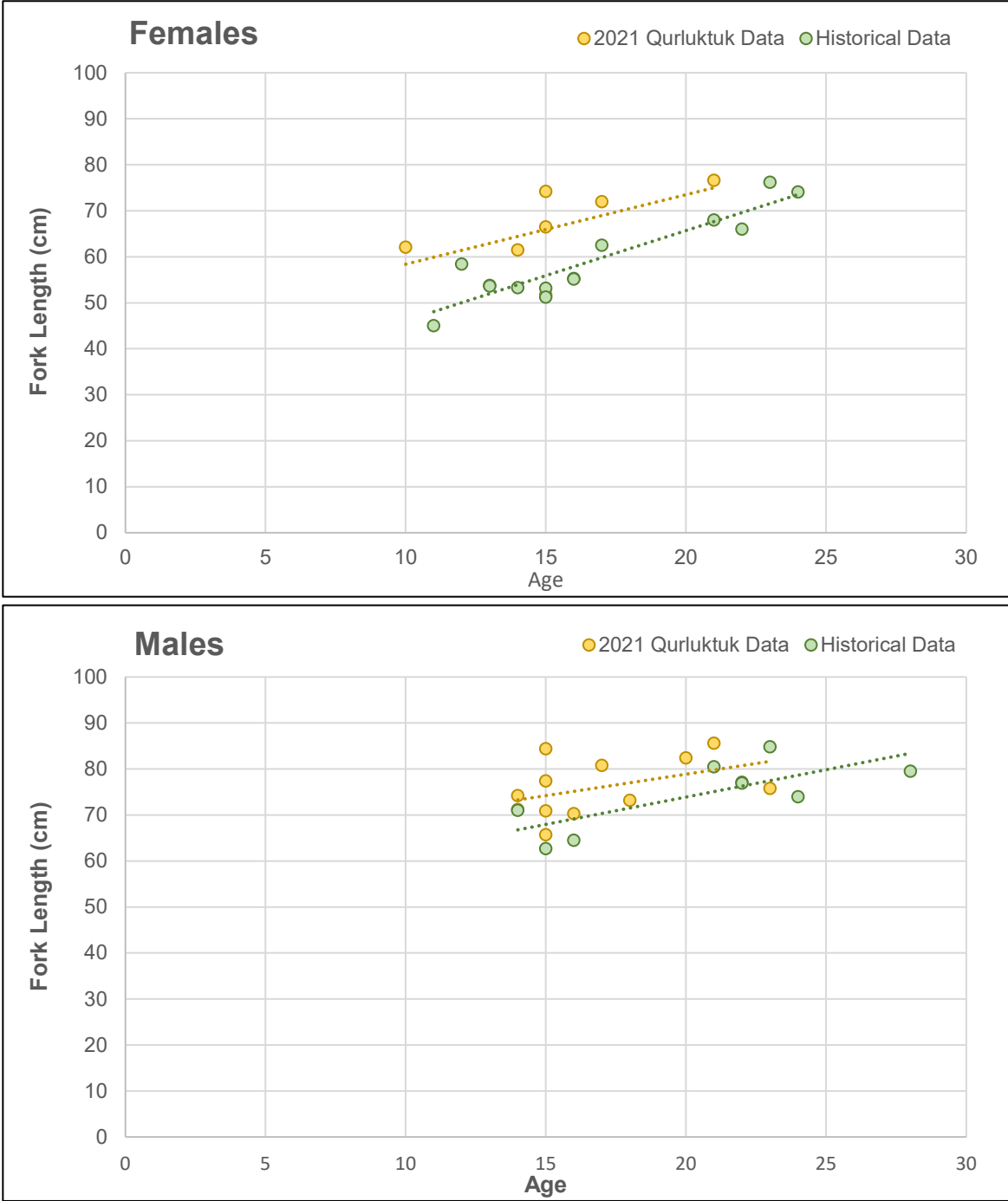




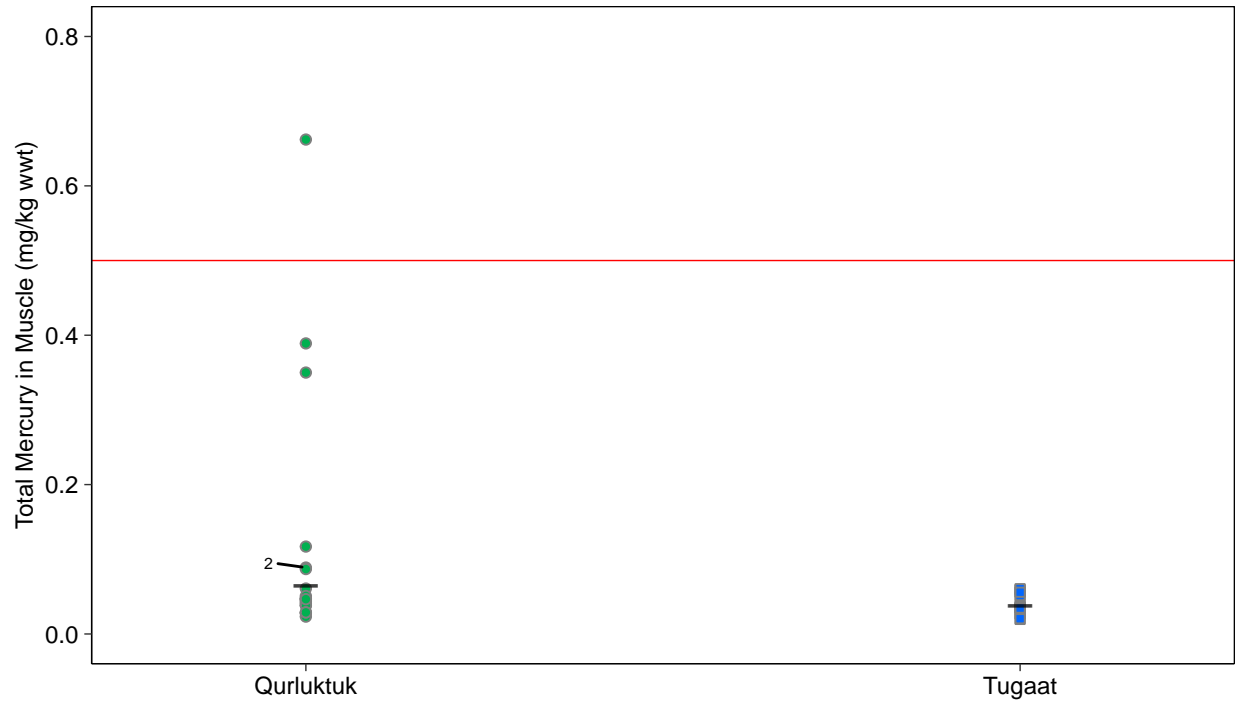
**Figure 3: Length-at-Age Relationships for Female (top) and Male (bottom) Arctic Charr Sampled at Tugaat Lake in 2021 and Historically**



**Figure 4: Condition (Weight-at-Length Relationship) for Female (top) and Male (bottom) Arctic Charr Sampled at Qurluktuk Lake in August of 2021 and Robertson River Historically (1979)**

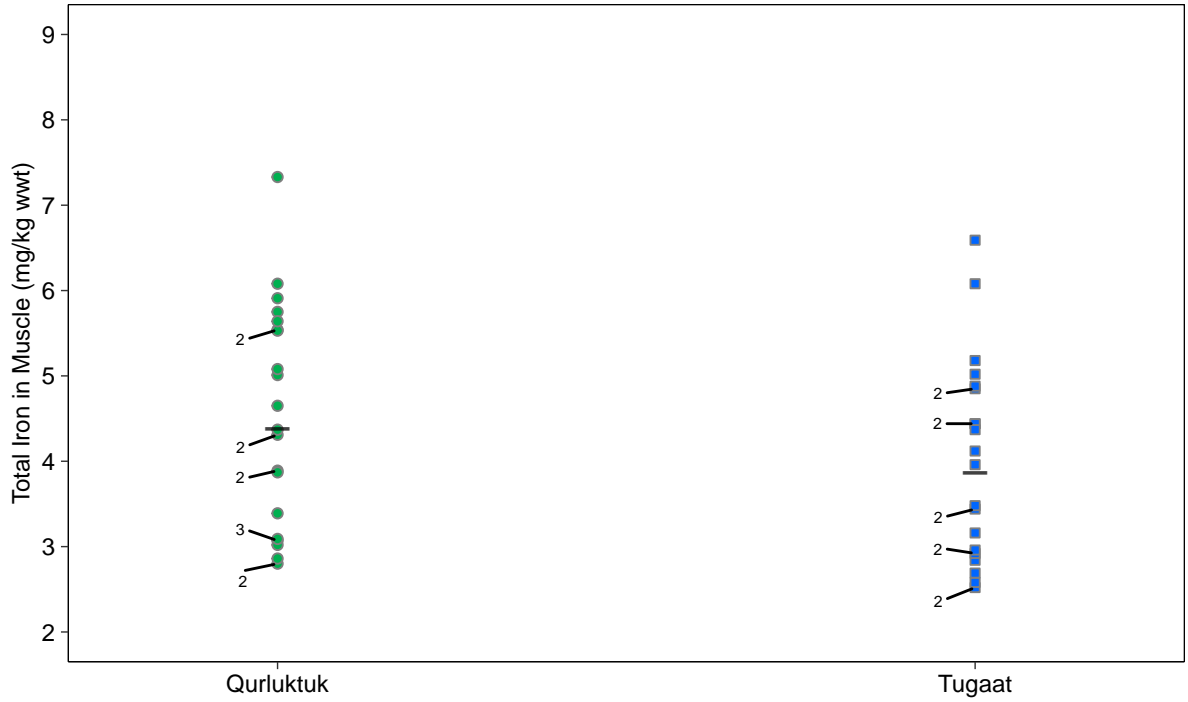


**Figure 5: Length-at-Age Relationships for Female (top) and Male (bottom) Arctic Charr Sampled at Qurluktuk Lake in 2021 and Robertson River Historically (1979)**



**Figure 6: Mercury Concentration (mg/kg) in Arctic Char Muscle (Top) and Liver (Bottom), 2021**

Note: Black bars denote measure of central tendency related to the statistical analyses. Red solid line represents Fish Total Mercury Concentration Guideline (0.5 mg/kg ww).



**Figure 7: Iron Concentration (mg/kg) in Arctic Char Muscle (Top) and Liver (Bottom), 2021**

Note: Black bars indicate geometric means.

## PHOTOS

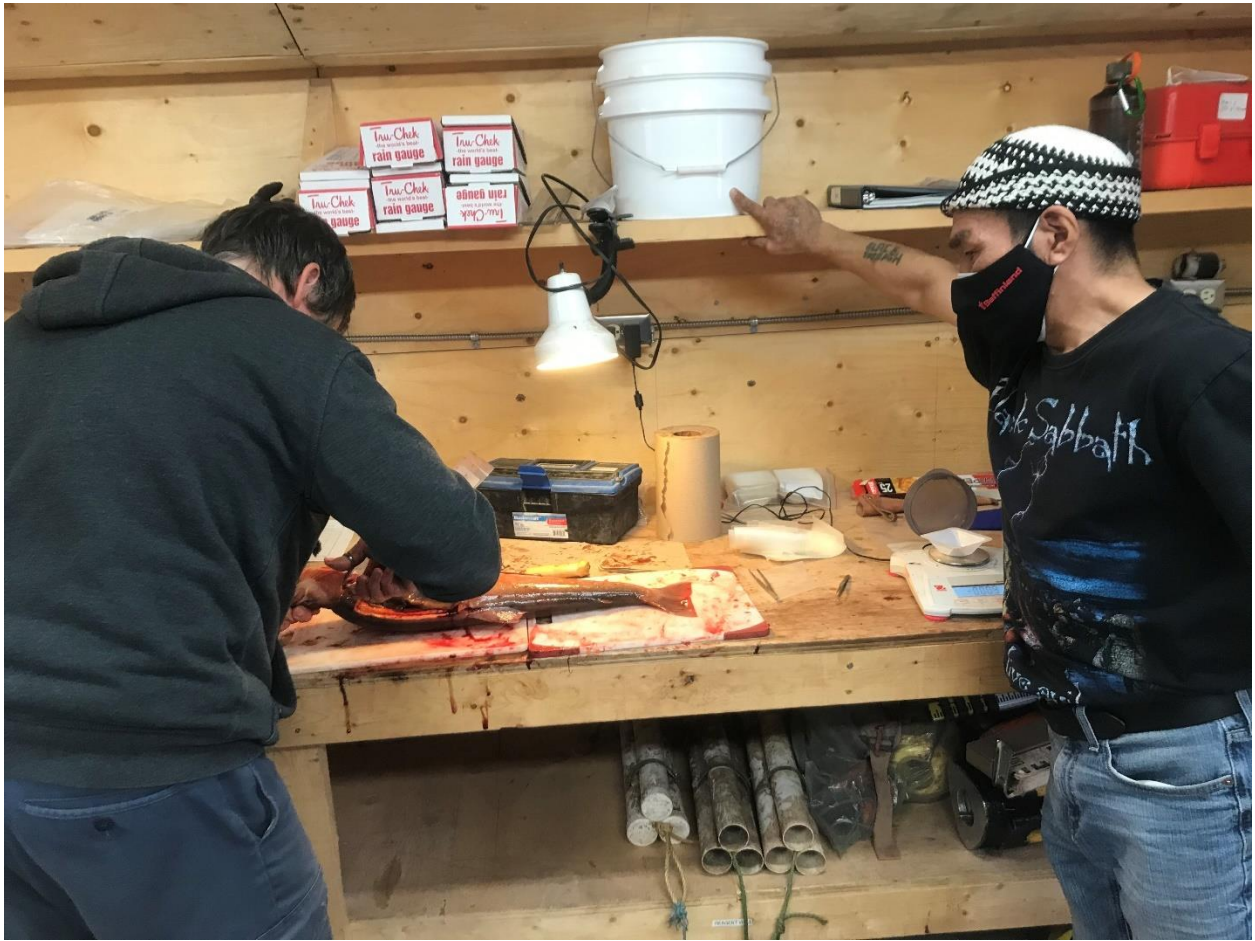


**Photo 1:** Milne Inlet Freshwater Fish Health Project Team (left to right: Tom, Sam, Robert, Paul) at Tugaat Lake



**Photo 2:** Milne Inlet Freshwater Fish Health Project Kickoff Meeting





**Photo 3:** Paul and Robert Processing Fish



**Photo 4:** Robert Holding Silver Coloured Sea-run Charr

## **TABLES**

**Table 1: Summary Statistics of Fish Health Endpoints for Arctic Charr, Milne Inlet Freshwater Fish**

Area	Sex	Endpoint	Mean	SD	SE	Minimum	Median	Maximum
Tugaat	Male (n=24)	Age	9.85	1.81	0.406	7.00	9.00	14.0
		Fork Length (cm)	56.0	6.31	1.41	48.5	55.4	71.0
		Body Weight (g)	2,087	802	179	1,175	1,838	4,450
		Gonad Weight (g)	70.5	27.1	6.07	34.3	61.5	133
		Liver Weight (g)	24.5	10.3	2.30	13.0	20.7	45.9
	Female (n=11)	Age	11.0	1.61	0.486	8.00	11.0	14.0
		Fork Length (cm)	61.1	5.59	1.69	53.3	59.5	71.1
		Body Weight (g)	2,574	804	242	1,575	2,590	4,200
		Gonad Weight (g)	300	177	53.4	5.63	310	600
		Liver Weight (g)	49.9	17.3	5.21	21.8	48.6	70.6
	Total Fecundity	3,986	1,111	335	2,671	3,582	6,335	
	Individual Egg Weight (g)	0.0910	0.0130	0.00392	0.0715	0.0947	0.108	
Qurluktuk	Male (n=13)	Age	16.9	2.97	0.857	14.0	15.5	23.0
		Fork Length (cm)	76.0	6.23	1.80	65.7	75.0	85.6
		Body Weight (g)	5,142	1,293	373	3,600	4,850	7,200
		Gonad Weight (g)	103	39.4	11.4	58.4	96.4	181
		Liver Weight (g)	59.2	22.4	6.46	33.5	49.5	97.1
	Female (n=7)	Age	15.3	3.30	1.25	10.0	15.0	21.0
		Fork Length (cm)	66.4	8.71	3.29	51.7	66.5	76.6
		Body Weight (g)	3,344	1,151	435	1,560	3,800	4,600
		Gonad Weight (g)	425	306	116	6.43	560	720
		Liver Weight (g)	49.8	20.0	7.55	27.5	40.5	72.8
	Total Fecundity	5,599	1,266	478	3,694	5,982	6,854	
	Individual Egg Weight (g)	0.105	0.00988	0.00373	0.0938	0.105	0.118	

**Table 2: Summary of Arctic Charr Endpoint Statistical Comparison Results for Tugaat Lake and Qurluktuk Lake between 2021 and Historical Data**

Endpoint <sup>a</sup>	Tugaat Lake 2021 versus historical <sup>a</sup>		Qurluktuk Lake 2021 versus historical <sup>a</sup>	
	Males	Females	Males	Females
Fork Length	Significantly Shorter	Significantly Shorter		
Body Weight	Significantly Lighter	Significantly Lighter		
Growth (length-at-age)*	Yes (13% greater)	Not Different	Yes (8% greater)	Yes (15% greater)
Energy Storage (body weight at length)*	Not Different	Yes (12% lower)	Yes (19% greater)	Yes (22% greater)

<sup>a</sup> Significant difference indication (yes/no) is presented with the percent difference of the 2021 data compared to the historical data (in parentheses), where applicable.